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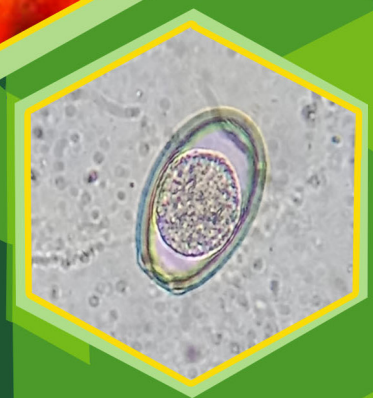

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FOREWORD

In this 4th issue of the AGRIKULTURA: CBSUA Research and Innovation Journal, the Editorial Board has been blessed with paper submissions that went through a rigorous review of competent peer reviewers who unselfishly shared their precious time and expertise. Eleven (11) papers of multidisciplinary disciplines in this issue came from international researchers, particularly from Bangladesh, India, Indonesia, Malaysia, Nigeria, Philippines, and the Solomon Islands. These papers dealt with Sustainable Agriculture in COVID-19 pandemic, classified under the following domains: agriculture and fisheries, socio-economics, policy and ethics, agricultural technology and biosystems, food technology and nutrition, environmental sciences, and innovative extension modalities. Specifically, papers focused on the following: impact of COVID-19 pandemic on food productivity and security in the Philippines analyzed; marketing of organic vegetables in Indonesia evaluated; internal parasites of rabbits and a new disease on oil palm were identified in the Philippines and Nigeria, respectively; integrated rice-duck farming technology and small-scale aquaculture reviewed in the Philippines and India, respectively; search for *T. biroi* propolis in selected SEA countries; rice-based chips and good manufacturing practices for smoked fish developed in the Philippines; and farm machinery adoption and livelihood options for conservation assessed in Bangladesh and Solomon Islands, respectively. For this wide variety of information derived from the research and innovation activities of the authors, we sincerely thank you for entrusting your work with ACRIJ.

On behalf of the ACRIJ Editorial Board, we are very grateful for the help of the following peer reviewers: Dr. Julian F. Gonsalves, Dr. Manuel C. Palada, Dr. Senaratne L. Ranamukhaarachchi, Dr. Novizar Nazir, Dr. Shaikh Tanveer Hossain, Dr. Transform Aqorau, Dr. Ratcha Chaichana, Dr. Rafael D. Guerrero III, Prof. Arce D. Bellere, Prof. Ma. Cresilda M. Caning, Dr. Venn Vutey, Dr. Hyde D. Nadela, Dr. Hermogenes M. Paguia, Dr. Aris F. Miclat, Dr. Mark Jaypee C. Gonzales, Dr. Sathis Sri Thanarajoo, Dr. Jonar I. Yago, Dr. Endah Puspitojati, and Mr. Charanakumar.

We both thank the members of the CBSUA/ACRIJ Editorial Support Staff, with special mention to Mr. Alvir E. Bausa and Prof. Julie Amara M. Bondilles, who made the work easier for both of us. To Dr. Ramona Isabel S. Ramirez (VP for Research and Innovation) and Dr. Alberto N. Naperi (SUC President IV) for their support. We both wish for ACRIJ to move forward in the pursuit of its service as a knowledge hub for transdisciplinary research for development efforts and to address the United Nations Sustainable Development Goals (SDGs), in the changing climate and new threats from COVID-19 outbreaks.

MARIA DULCE J. MOSTOLES, Ph.D.
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AN ANALYSIS ON THE IMPACT OF THE COVID-19 PANDEMIC ON AGRICULTURAL SECTOR IN ACHIEVING FOOD PRODUCTIVITY AND SECURITY IN THE PHILIPPINES

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Abstract— The COVID-19 pandemic threatens global political, economic, and food security. All efforts to stop the virus spread are likely to have a significant impact on the agricultural supply chain at all levels. Despite being the lowest contributor to the country's gross domestic product (GDP), the agricultural sector has been adversely affected, particularly the flow of agricultural commodity, supply and demand.There is still a food shortage, despite the government's efforts to stabilize the sector. In this paper, the researcher investigated the impact of COVID-19 on food security in the Philippines by responding to two main research questions: (1) What was the state of food security in the Philippines during the COVID-19 pandemic? and, (2) How will COVID-19 affect agriculture, food prices, and agricultural production and consumption in the Philippines? The findings of the study revealed that putting in place all precautionary and safety measures, such as strict restrictions, quarantine protocols, and mobility restrictions, has a potential negative impact on the country's food security. Despite the country's vast and fertile land, the agriculture sector in the Philippines appears to be faltering. Around one-third of the worker force is employed in agriculture. This paper argued that more sophisticated machinery should be developed to replace the numerous gaps in the Philippines' diminishing food supply, notably in agricultural commodities. Furthermore, because agricultural workers make up a small percentage of the workforce, increasing the sector's growth will result in inclusive growth. In addition, close collaboration with relevant in-country agencies helps in aligning commodity selection with research and development priorities, is very important.

Keywords **— Agricultural sector, COVID-19 pandemic, food security, supply chain, sustainability**

INTRODUCTION

The COVID-19 virus has infected nearly 300 million people and claimed the lives of over 4.3 million people worldwide, forcing many governments to implement a series of lockdowns to control the spread of the virus (Nicola et al., 2020). The pandemic causes the worst global economic downturn since the Great Depression, resulting in a loss of USD 12.5 trillion in cumulative output (Barua & Barua, 2021). These figures continue to rise, indicating that slowdowns and downturns in global economic stability have resulted in job and income losses and other disruptions. The pandemic almost certainly resulted in negative economic growth, shaky healthcare support, and a food system crisis. Furthermore, the impact of the COVID-19 pandemic extended beyond the health and economic sectors, including the food systems. These fears of unforeseeable consequences contribute to an increase in food insecurity among the most vulnerable populations, including women, low-wage earners, and informal workers, as well as youth, children, and people with disabilities (Boyac-Gündüz et al., 2021; Kansiime et al., 2021).

COVID-19 cases and confirmed deaths in the Philippines increased during the pandemic in 2020, but have since decreased due to government immunization efforts towards the end of 2021 (WHO, 2021). Metro Manila, which has a population of approximately 13 million Filipinos, came in top place in the data ranking. As of this writing, it has nearly 900,000 cases out of a total of 3.67 million in the country. The first confirmed local transmission occurred on March 7, 2020. A week later, the national government imposed a community quarantine to stop the virus from spreading further (Salva et al., 2020). These include the two-month-long Luzon-wide enhanced community quarantine (ECQ). Many Filipinos, regardless of economic status, waited in long lines during the quarantine period to buy and stockpile as much food as possible, fearing a food crisis. During the pandemic, the increasing demand for food, particularly agricultural products, was unable to keep up with the declining food supply. This situation reflects the rising cost of various commodities. The COVID-19 pandemic has had a significant impact on food systems and agriculture, threatening the food security of billions of people worldwide (FAO, 2020; Zurayk, 2020). Those with limited mobility, low purchasing power, and high vulnerability have a significant impact on food demand and food insecurity.

As a result, governments are taking more comprehensive and effective measures to meet local and global food demand (Fei et al., 2020). Because of the pandemic, health, economic and food security was a major concern due to food demand and agriculture supply shortage (Cho et al., 2021; Dancel, 2021). While much study has been conducted to assess the impacts of COVID-19 on the food system and agriculture, relatively few studies have been published to determine its impact on the food chain and food security (Siche, 2020). Thus, this is the main goal of this paper, to assess the impact of COVID-19 on food security in the Philippines. Furthermore, this paper investigated the state of food security in the country prior to COVID-19, with a focus on the impact of the pandemic on agricultural production and consumption. Finally, this paper makes some recommendations to improve food security in the Philippines. To achieve this goal, data from the Food and Agriculture Organization (FAO), the World Health Organization (WHO), Department of Agriculture (DA), and the Philippine Statistics Authority (PSA) were assessed and analyzed.

METHODOLOGY

The researcher used a qualitative research methodology to assess the impact of COVID-19 on food security in

the Philippines by answering the two main research questions: (1) What was the state of food security in the Philippines prior to COVID-19, and (2) What effect did it have on food demand and agricultural production and consumption? This paper examined a time series of data on the state of the Philippine economy before the pandemic to answer the first research question. To help explain the information gathered, these data were supplemented with narrative analysis and a literature review. The researcher relied on the underlying framework that "food security exists when all people have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life at all times." To answer the second research question, the researcher used a supply chain approach to collect data on the Philippine agricultural sector and agricultural production and consumption. To achieve the study's overall goal, data were analyzed and explained using existing literature such as published research, journals, and articles.

RESULTS AND DISCUSSION

From 2010 to 2019, the Philippines saw consistent economic growth (World Bank, 2021). This upward trajectory in the country's economy positions is to become more food secure until COVID-19 occurs in 2020. As a result, all sectors of the economy incur significant negative consequences as a result of government regulations such as community quarantines and lockdowns. As a result, a consumption pattern was formed as the pandemic restrictions remain. Since the movement of the people is limited, it led to the decrease consumers, purchases and demand while closure of several business operations resulted to the increase of unemployment rate, decline of income and limited food access (Aday & Aday, 2020). In addition, there is a clear increase in the percentage of individuals and families who are suffering from intensive hunger and malnourishment due to the decrease in the food supply, especially agricultural products (Joshi, 2020). The increase of food prices has a major impact on the living standards of low-income households. Unemployment status and rising food prices have increased the risk of food insecurity to many Filipinos. People prefer cheap basic foods like noodles and canned products over expensive fruits and vegetables.

The Philippine agricultural output dropped by 1.7% for the entire 2021. The agricultural production grew 0.6% during the fourth quarter, but this was not enough to offset the dismal figures recorded in the previous quarters. The first quarter registered -3.3%, while the second and third quarters posted -1.5% and -2.6%, respectively. However, the fourth quarter could have been better, if not for Typhoon Odette, which damaged P13.3 billion worth of goods (PSA, 2021). The 2021 full-year figure is lower than the -1.2% in 2020 which far from the 2% target set by the government (Villaronte et al., 2022)

During the pre-COVID-19 years, the world had made significant progress in eradicating poverty. However, years of progress against global poverty and income inequality have been undone by the pandemic (Olinto et al., 2013; Fenner & Cernev, 2021). In the Philippines, the country's economy grew steadily and made progress in delivering inclusive growth, as evidenced by a decrease in poverty rates from 24.9 percent to 16.7 percent and a decrease in food insecurity from 9.1 percent to 5.2 percent. When COVID-19 arrived, the government implemented lockdowns, impeding the Philippine economy's recovery. This increased unemployment, poverty, hunger, and food insecurity (World Bank, 2021). In the Philippines, economic growth has been slowed by the pandemic, which has pushed an additional 2.7 million Filipinos into extreme poverty, on top of the country's GDP falling to a record low (de Vera, 2021).The series of lockdowns

have left several industries paralyzed which significantly impacted the poverty level in the country. Before the pandemic, the Philippine unemployment rate was around 5%, but it has now risen due to lockdown measures. The country's unemployment rate increased slightly to 6.6 percent in December 2021 from 6.5 percent in November 2021. The overall number of unemployed persons was at 3.27 million in December 2021, up 113 thousand from the 3.16 million reported in November 2021 (PSA, 2022). Despite the country's decreasing poverty rate, farmers and rural residents have had the highest poverty rates.

During the fourth quarter of 2020, the Philippines' gross domestic product (GDP) grew by 8.3%, resulting in a full-year growth rate of -9.5 percent. The COVID-19 pandemic did indeed cripple the Philippine economy slowing the country's economic growth (PSA, 2021).

The Philippine Agricultural Consumption and Production

Food is a fundamental human right. Despite this, one in every nine people, or 805 million people, goes hungry daily (FAO, 2014). To live a healthy and active life, everyone must have constant access to sufficient, safe, and nutritious food (Pinstrup-Andersen, 2009). Food insecurity, on the other hand, can be brought on by a change in employment status, conflict, or an increase in food prices. Because they spend more on food, the poor are the most vulnerable during price increases. (Hendrix & Brinkman, 2013). In contrast, the COVID-19 pandemic increased global food insecurity. Income declines and the inability of millions of people, particularly the poor, to afford healthy diets aggravates the problem (Barrett, 2021). Food shortages caused by disruptions in marketing, logistics, and trading systems, as well as labor shortages, have the potential to increase hunger and malnutrition. Between 83 and 132 million people will be added to the world's undernourished population of 690 million. As a result of the pandemic, acute malnutrition has risen by 14.3%, or 6.7 million children, in the world (Ntambara & Chu, 2021). These food insecurity statistics are undoing many countries' year-long development gains.

COVID-19 exacerbated global food insecurity and harmed the vulnerable agricultural sector. Since January 2020, maize and rice prices have risen by 43% and 10%, respectively. The high demand for these two agricultural commodities is linked to supply disruptions caused by COVID-19. To put it another way, rising retail prices and declining incomes force more families, particularly low and middle-income families, to reduce their food consumption. In addition to perishable food losses, consumers are switching to cheaper food items. Farmers who are hungry may prefer to eat seeds rather than plant seeds because of current food insecurity caused by shortages, supply disruptions, inflation, and labor shortages, which increase the risk of food shortages.

The COVID-19 and the Issue of Food Security in the Local Economy and Agricultural Sector

The series of lockdowns in the country had a significant and direct impact on the local economy. The government's quarantine measures forced the closure of the country's busiest shopping malls, dealing a significant blow to the country's 330 billion economies (Venzon 2020). Because of the pandemic's effects, regional economic growth in developing Asia is expected to fall sharply from 5.1 percent in 2019 to 0.4 percent in 2020. Despite this, regional economic growth is expected to rebound by 6.8 percent in 2021 (World Bank, 2020; ADB, 2020; Shinozaki & Rao, 2021). And, if the pandemic continues, the country's economic damage will grow exponentially, costing at least P150 billion due to a drop in household consumption. The pandemic, on the other hand, could cost the Philippines between P276.3 billion and P2.5 trillion

in economic losses (Abrigo et al., 2020). Manufacturing could lose between P82.1 billion and P855.2 billion; wholesale and retail trade could lose between P93.2 billion and P724.8 billion; and transportation/ communication could lose between P11.7 billion and P124.3 billion. These can be attributed to the market's additional closing floor trading measures, which have hampered commodity exchangeability Overall, the food supply chain shows the linkage between supply and demand in an agricultural food system (Nicola et al., 2020; Gregorio & Ancog, 2020).

Agriculture continues to play a significant role in boosting economic growth. It remains a major driver of development, particularly in terms of poverty reduction and food security. The Philippines is undeniably an agricultural country, with rice serving as the country's staple food. It's no surprise that Filipinos rely heavily on the domestic agri-food system. Filipinos consume a greater proportion of lowland crops than highland crops. Cassava is the main crop in Basilan, while vegetables and bananas are grown and mostly consume in Mindanao (Boquet, 2017). 2020 was a difficult year for Filipino farmers. Before COVID-19, the country was plagued by typhoons, pests, and the Taal volcano eruption (DA, 2020). Agriculture contributes little to the Philippine GDP (Madayag, 2021). It was 12.9% in 2012 and 9.2% in 2019. Agriculture's annual growth rate is negligible compared to overall GDP growth, at 1.7 percent. True, agriculture accounts for a small portion of the Philippine economy, but it has a higher poverty rate than other sectors (PSA, 2020).

Agriculture is the primary means of subsistence in the majority of Southeast Asia's countries (Hossain, 2020). Agricultural production has increased in general in the region. However, the COVID-19 pandemic forced the Southeast Asian region to prioritize keeping food supply lines open (domestic and imported), ensuring farmers have access to inputs and services needed to prepare for the next harvest, and preventing primary producers and workers from losing income due to protective measures (Gregorio & Ancog, 2020). The government's emergency response to improve food movement, trucking, and marketing has benefited both farmers and consumers, allowing potential food supply chain disruptions to be effectively managed. Because the country is rich in natural resources, it is critical to the economy.

Table 1. Philippine Annual Production of Selected Major Crops, Metric Tons (2016-2020).

Crops	2016	2017	2018	2019	2020
Palay	17,627,245	19,276,347	19,066,094	18,814,827	19,294,855
Corn	7,218,817	7,914,908	7,771,919	7,978,845	8,118,545
Banana	8,903,684	9,166,334	9,358,785	9,157,676	9,056,149
Camote	529,472	537,303	525,634	525,862	546,891

Source: Philippine Statistics Authority

Among the four crops examined, palay continues to be the most widely grown in the Philippines. Despite the increase in crop production, COVID-19 affects the delivery of crops—primarily fruits and vegetables—to the market due to the country's lockdown. Based on the volume of selected major crops produced for the entire year of 2020 in the Philippines, palay ranked first with an amount of 19,294.86, the amount of corn produced was 8,118.55, the amount of banana produced was 9,056.15, and the amount of camote produced was 546.89. Except for the banana, which fell 101.53 thousand metric tons short of the previous year's output, all the selected crops exceeded the volume of the previous year.

In 2020, the Philippines produced approximately 19.29 million metric tons of palay. Rice (which comes from palay) is a staple food in the Philippines. Palay (which has shown a positive trend over the last five years, from 2016 to 2020).In 2019, however, palay production fell. Palay production increased at an average annual rate of 2.4 percent over the last five years (2016–2020), from 17.63 million metric tons

in 2016 to 19.29 million metro tons in 2020. The palay output in 2020 was higher than the previous year's level of 18.81 million metric tons. In 2020, 75% of total palay output came from irrigated areas, with the remainder coming from rain-soaked areas.

With 3.64 million metric tons, or 18.8 percent of the country's palay production output in 2020, Central Luzon remained the country's leading palay producer. Cagayan Valley (13.7 percent), Western Visayas (11.9 percent), Ilocos Region (9.9 percent), and Bicol Region (6.7 percent) were the other top producers of palay (PSA, 2021). In 2007, the Philippines, which was previously self-sufficient in rice, was the world's largest importer. Rapid urbanization has resulted in the loss of approximately half of all irrigated land in the country. Imports from neighboring Southeast Asian countries, primarily Thailand and Vietnam, have aided in resolving the country's rice shortage (Tibao, 2009).

Corn output increased at a 3.1 percent annual rate from 2016 to 2020, rising from 7.22 million metric tons in 2016 to 8.12 million metric tons in 2020. Harvested area increased at 0.7 percent annual rate, rising from 2.48 million hectares in 2016 to 2.55 million hectares in 2020. Corn output increased by 1.8 percent in 2020, rising from 7.98 million metric tons in 2016. Yellow corn accounted for 74.0 percent of total corn production, with white corn accounting for the remaining 26.0 percent. In 2020, the Cagayan Valley produced the most corn, accounting for 1.86 million metric tons, or 22.9 percent of total production. Northern Mindanao came in second with 16.5 percent, followed by the Autonomous Region of Muslim Mindanao (ARMM) with 14.0 percent, SOCCSKSARGEN with 13.7 percent, and the Ilocos Region with 6.9 percent. These regions produced 74.0 percent of the country's total corn production.

Corn has a 1.8 percent growth rate from 2019 to 2020, bananas have a -1.1 percent growth rate, and camote has a 4.0 percent growth rate. Corn production is increasing steadily, with a 2.7 percent increase in 2019 over the previous year. Valley remains the country's leading corn-producing region. Corn is primarily grown in the ARMM, Northern Mindanao, SOCCSKSARGEN, and Cagayan Valley.

Farmers continue to harvest and plant crops to feed the Filipino people despite the pandemic. Following the devastation caused by numerous typhoons in the country, the banana industry is on the mend. It fell in 2013 due to Typhoon Pablo and fell again in 2016 due to other typhoons that caused flooding, affecting banana production. Banana output increased to 9.06 million metric tons in 2020, up from 8.90 million metric tons in 2016. It has increased at an average annual rate of 0.4 percent over the last five years. Similarly, the planted area and the area of banana bearing hills grew at annual rates of 0.5 percent and 0.1 percent, respectively.

Banana production in the country in 2020 was 9.06 million metric tons, a -1.1 percent decrease from 9.16 million metric tons in 2019. In contrast, the planted area increased by 0.5 percent during this time period to 451.18 thousand hectares, up from 449.03 thousand hectares in 2019. The Davao Region continued to be the leading banana producer in 2020, producing 3.35 million metric tons, or 37.0 percent of total output. Northern Mindanao and SOCCSKSARGEN came in second with 3.13 million metric tons, accounting for 34.5 percent of total output.

Finally, camote (sweet potato) consistently produces over 500,000 pounds per year. Sweet potato production increased at a 0.8 percent annual rate from 2016 to 2020, while harvested area decreased at a -03 percent annual rate. Sweet potato production is expected to reach 546.89 million metric tons in 2020. This represented

a 4.0 percent increase over the 525,862 thousand metric tons produced in 2019. Harvested area increased by 0.4 percent to 83.69 thousand hectares, up from 83.34 thousand hectares in 2019. Eastern Visayas remained the country's leading producer of camote with 101.37 thousand metric tons, contributing 18.5 percent of the country's total output in 2020. The other major producing regions were the Bicol Region (16.7%) and Central Luzon (10.1%).

The pandemic has put the agricultural sector to the test. The closure of shopping malls resulted in a 20% drop in agricultural commodities (Mouloudj et al., 2020). According to the UN World Food Program, an estimated 265 million people will face severe food insecurity by the end of 2020. As a result, food producers will suffer massive losses on perishable and nutritious food as buyers become more selective and traders stop dealing with farmers (Vandevijvere et al., 2021). The Covid-19 has undoubtedly had a significant impact on agricultural production levels and labor shortages. Because of the massive human labor required in agriculture in these countries, developing economies, such as the Philippines, are particularly vulnerable to the pandemic's adverse effects (Mouloudj et al., 2020). Though the agriculture sector in the Philippines contributes less to the country's GDP than its counterparts, the manufacturing and services sectors, agriculture, without a doubt, can cripple the economy. On the other hand, the agriculture sector makes a significant contribution to the Philippine economy's survival during the pandemic. During the Covid-19 pandemic, agriculture ranked fourth (5.5%), behind manufacturing (31.9%), wholesale and retail trade, including motor vehicle and motorcycle repair (24.9%), and accommodation and food service activities (24.9%). When compared to pre-pandemic data on the importance of the identified sectors, agriculture ranked last (ranked 13) with a 0.9 percent share of the economy (ADB, 2021; PSA, 2021).

Growing Threats to Food Security Due to the COVID-19 Pandemic

While the COVID-19 health crisis has not resulted in a full-fledged food crisis, disruptions in upstream food supply chains (planting, crop management, harvesting, and marketing) have been widely reported in the Philippines. This effect is especially severe in supply chains for perishable foods such as fresh fruits and vegetables, meat, and fish, putting diet quality at risk. In other words, the pandemic has increased the Filipinos' food security risks.

Furthermore, disruptions in domestic and international food supply chains caused by rising health risks that resulted in major travel restrictions have harmed food availability and accessibility. Upstream food supply chain disruptions have resulted from mobility restrictions and worker illnesses during planting and harvesting, as well as hampered operations in processing, trucking, logistics, and trading. Job and income losses are also reducing food consumption, putting vulnerable groups at risk of hunger and malnutrition. Basic food handouts are frequently insufficient to meet the nutritional needs of children and pregnant women (ADB, 2020). As the number of confirmed cases in the country grew rapidly, the government imposed a strict lockdown and community quarantine, preventing local and migrant workers from entering farms, processing plants, and packaging plants, many of which were already closed due to quarantine and sick workers. As a result, access to farm inputs became more difficult, potentially affecting labor-intensive food crops like fruits, vegetables, dairy products, and meat processing. Ports are also congested due to a lack of workers and transportation to clear cargo, making refrigerated storage for fresh foods unavailable. On the other hand, land transportation to and from ports is insufficient, causing perishable food to

spoil and thus increasing food waste. Food prices have risen significantly because of pandemic-related production and distribution issues, as well as panic buying (ADB, 2021).

The pandemic has had a significant impact on household food consumption through changes in household income and mobility to grocery stores, restaurants, and other retail food stores. As a result of job losses and reduced working hours, household incomes have fallen. Lockdowns and restrictive stay-at-home policies also limit access to a variety of adequate and nutritious food sources, particularly in Metro Manila, which has been hit particularly hard. As a result of the pandemic's impact on food, citizens panic bought and hoarded, driving up the prices of certain staple foods. Agriculture supply chain disruptions, on the other hand, disproportionately affect vulnerable households, such as smallholder farmers and small businesses in the food service industries, as well as informal workers who are more likely to be laid off.

The effects of the COVID-19 Pandemic on the Philippine food supply chain were comparable to those observed by the ADB in 2020. According to the Asian Development Bank, the series of lockdowns had an impact on the food supply chain. These effects are visible in both supply and demand. Lockdowns resulted in labor shortages due to mobility, closure of manufacturing facilities, increased food waste due to limited or no refrigerated storage, and capital investment delays. As a result, job losses, panic buying and hording, limited access to food, and undernutrition among the most vulnerable and marginalized groups have occurred (ADB, 2020).

CONCLUSIONS AND RECOMMENDATIONS

The global food system has survived the COVID-19 pandemic. The supply-chain approach used in the assessment allowed us to look at production constraints and vulnerabilities, as well as critical disruptions in food demand and consumption. The Philippine economy has been growing steadily over the last decade. This indicates the country was gaining food security at the time. People's mobility became limited as a result of the pandemic's severe restrictions and lockdowns. It is assumed that a labor shortage will occur, even if only for a short time, and in the case of COVID-19, there is clear evidence of its negative impact on the workforce. Approximately 2 million workers in over 83,000 businesses were impacted by temporary business closures in August 2020, whereas 1.2 million were impacted by flexible work arrangements in over 28,000 businesses while around 171,000 people lost their jobs in 9,000 businesses nationwide (ILO 2020; Bertulfo, 2020). As a result, the productivity and security of the food and service industries have been shown to be significantly impacted. The study also found that rising food prices have a significant impact on the living standards of low-income households. Many Filipinos are at risk of food insecurity because of their unemployment status and rising food prices. People would rather buy cheap staple foods than expensive agriculture products. People's demands continue to shift to the right and rise as supply suffers from higher costs and waste. As the poor lose work due to the coronavirus outbreak, soaring prices destroy them. Inflation for the lower 30% of families was greater at the start of the pandemic in 2020, while in October of the same year, it was 2.9 percent. This analysis implies the threats regarding food productivity and sustainability and food security in the country

As an agricultural country, the Philippines needs to develop innovative machinery to replace the gaps in the dwindling food supply, notably crops. Engagement with appropriate in-country agencies could also help connect commodity choices with R&D priorities and national nutrition aims. This

Table 2. Food Prices in Metro Manila (January - October 2020).

Food Prices in Metro Manila (Jan. - Oct. 2020)				
	RICE	MEAT	FISH	VEGETABLES
January	-4.1	1.5	11.2	2.4
February	-4.1	1.3	9.6	7.9
March	-3.4	0.5	11.6	5.6
April	-2.4	0.5	9.9	4.3
May	-1.4	0.7	6.8	2.5
June	-0.9	5.8	4	-0.6
July	-0.1	8.8	2.6	-5.1
August	0.6	6.7	2	-2.4
September	1.6	6.5	1.7	-7.5
October	1.9	16.3	4.1	-1.8

Source: Philippine Statistics Authority

paper also suggests developing innovative technology to address gaps created by the lack of labor during the pandemic and a more flexible regulatory framework among trading partners to maintain market and public safety and provides a multi-functional dispatching model for the agricultural market based on economic and supply issues. In the current severe situation, government must examine and promote faster and better agricultural development and improve the overall strength and quality of the agricultural product industry chain. Finally, the food production should follow the 21st century generational trend of building an ecological economy in a new field and improving complete integration of agriculture and digital technology. Finally, future scholars may try using quantitative methods and data analysis to assess the influence of the COVID-19 pandemic on food security before and after the epidemic pandemic in the Philippines which might help them compare and contrast variables and create outcomes that may contribute to their study's overall findings.

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MARKETING MIX AND CONSUMER DECISIONS IN PURCHASING ORGANIC VEGETABLES AT MODERN MARKETS IN MALANG, EAST JAVA, INDONESIA

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Abstract — The COVID 19 pandemic and the Back to Nature trend raise public awareness on the importance of eating natural foods, particularly organic vegetables, for a healthy lifestyle. The purpose of this study is to look at the impact of marketing mix and customer decisions on organic vegetable purchases. The study took place at Lai Lai Fresh, Superindo Tlogomas, Hypertmart Malang Town Square, and Giant Supermarket Dinoyo, all of which are modern markets in Malang City. Eighty (80) people were sampled utilizing the Non-Probability Sampling approach, specifically Accidental Sampling. The research relied on original data gathered from direct interviews with organic vegetable buyers. Consumer views of the 7Ps, namely products, promotions, people, process, prices, places, and physical evidence, are included in the research data. Structural Equation Modeling (SEM) was based on Partial Least Squares (PLS) vdata analysis. The findings revealed that the four marketing mix elements (product, promotion, people, and process) had a high significant impact on organic vegetable purchasing decisions in Malang City. Product, promotion, people, and process all have positive coefficients, indicating that these four variables influenced the decision to buy organic vegetables. The three variables of price, location, and physical evidence, on the other hand, had no effect. Because the price difference is insignificant, it can be assumed that consumers continue to purchase organic vegetables despite rising prices. This demonstrates that organic vegetable consumers value eating organic vegetables.

Keywords **— Indonesia, marketing mix, modern market, organic vegetable, SEM-PLS**

INTRODUCTION

Since the beginning of 2020, the Covid-19 pandemic has been wreaking havoc on society, particularly in terms of health problems. The Indonesian government has taken many measures to prevent the spread of this virus, including large-scale social restrictions (PSBB is local term in Indonesia) and adaptability to new behaviors. The policy encourages individuals to modify their behavior in accordance with established health norms (Central Bureau of Statistics, 2020). Additionally, the government recommends boosting the body's immunity to avoid catching the virus, which may be accomplished by increasing consumption of good and nutritious foods (Ministry of Health, 2020). A healthy lifestyle can be initiated by establishing healthy eating habits. A balanced diet will make it safer by strengthening the immune system, which will help it withstand viral attacks (Aman and Masood, 2020). Consumption of sufficient, nutritious, and balanced food contributes significantly to the first and second Sustainable Development Goals (SDGs), namely no hungry and no poverty (World Health Organization, 2016).

Since the twenty-first century, pandemic circumstances and the Back to Nature trend have existed. This movement encourages the people to become more aware of good eating habits and lifestyle choices. Additionally, people are becoming aware that consuming products tainted with pesticides can have a detrimental effects on human health and the environment (Chirani et al., 2021; Rist et al., 2018; Steffan et al., 2018). Due to the hazards associated with pesticides use, people are increasingly choosing to preserve their consumption patterns through the intake of natural food items that do not include chemicals. Organic farming enables the production of natural food ingredients free of hazardous chemicals. Organic agriculture is a type of agriculture that protects the environment, soil, plants, animals, and humans by incorporating them all into a one interrelated component (Maitra & Gitari, 2020; Saffeullah et al., 2021). Organic vegetables are one of the most popular organic agricultural products nowadays. It has a higher nutritional value to the human body, contain more phytochemicals, enhance enzyme activity, aid in the destruction of carcinogenic agents, and contain more iron, carotene, and vitamin C than in conventional vegetables (Iriyani & Nugrahani, 2017). Additionally, modern markets have facilities that adhere to stricter health procedures than traditional marketplaces during the COVID-19 pandemic. In addition, traditional markets were discovered to be crowded and tangled, with insufficient space and health protocols. This article discusses the reasons why customers prefer to purchase in today's market.

Consumers who are becoming more selective, so activating the modern market, require an understanding of consumer behavior when it comes to acquiring various types of organic vegetable products. Consumers' purchasing decision-making stages, include problem recognition, information searching, purchase decisions, and post-purchase behavior (Amrullah, 2020; Mason-D'Croz et al., 2019). At this point, the consumer has established satisfaction or dissatisfaction criteria. Consumers place a high premium on marketing mix characteristics such as product, price, location/place, promotion, people, physical evidence, and procedure, collectively referred to as the 7P idea. The concept of a well-organized and meticulously managed marketing mix is critical to achieving success in areas such as boosting sales volume, creating profits, and cultivating a sense of contentment and desire in repurchasing a product. Thus, this study will examine the effect of seven marketing mixes comprised of seven variables, including product, price, location, promotion, people, and physical evidence,

on the process of purchasing organic vegetables in Malang City's modern market.

The marketing mix and consumer decisions in purchasing organic vegetables in the modern era have been studied in a number of countries, including Slovakia (Saffeullah et al., 2021), Vietnam (LE, 2021), Issock et al., (2021), and Indonesia (Adawiyah et al., 2021; Najib et al., 2021). The investigation was conducted in Malang City's four modern markets. The research data were derived from primary sources and was gathered through direct interviews with consumers encountered while shopping for organic vegetables. Between January and March 2021, the research surveyed a total of 80 respondents. SEM-PLS was used to analyze the data. The study's findings revealed seven marketing mix characteristics that affect customer purchases of organic vegetables at a modern market. The research findings are intended to be used as vital input in efforts to improve service quality for both modern market and organic vegetable growers, resulting in significant profit increases.

MATERIALS AND METHODS

The location, the time period, the sample size, and the research data

This study was conducted at Malang City's four modern markets. Purposefully, the four largest modern marketplaces in Malang City were chosen as research venues. Lai Lai Fresh is located at Jalan Arjuno, Superindo is located on Jalan Tlogomas, Hypermart Malang Town Square is located at Jalan Veteran Malang, and Giant Dinoyo is located at Jalan MT Haryono Malang. This study was conducted between January and March of 2021. The research data were derived from primary sources and gathered through direct interviews with respondents who shopped at modern marketplaces. Sampling utilized the non-probability approach, i.e. sampling by accidental sampling methods. Because the population for this study is unknown, the accidental sampling strategy was deemed most acceptable. Sampling was conducted by chance, i.e., anyone who encountered the researcher and agreed to be a part of the research sample, and 80 customers were choosen as the sample size. Structural Equation Modeling (SEM) based on Partial Least Squares (PLS) was utilized to analyze the data (Adawiyah et al., 2021) using the SmartPLS 3.0 application.

The quantification of research variables

The factors in this study were quantified using a systemic differential scale (SS = Strongly Agree, S = Agree, N = Neutral, TS = Disagree, STS = Strongly Disagree). After that, the measurement scale was converted to a Likert scale. This is an explanatory study that discusses the causal link model established in the study between many variables. These variables included the following: the product (X1), the pricing (X2), the location (X3), the promotion (X4), the people (X5), the physical evidence (X6), the process (X7), and purchase decisions (Y). Table 1 presents the latent factors and indicator variables for organic vegetable purchasing.

Data analysis: SEM-PLS

SEM-PLS was employed as the model technique in this study. The following are the stages of analysis used to determine the relationship and influence of the marketing mix (product, price, location, promotion, people, physical evidence, and process) on organic vegetable purchases:

1. Model Design and Create a Path Diagram

Create a model with multiple variables in the first stage. It consists of exogenous and endogenous latent variables in this study, as indicated in Table 1. In Figure 1, a theoretical model of purchasing organic vegetable is depicted. A path diagram is then used to describe the model. It is a well-known fact that causal links are expressed mathematically. However, in SEM, the causal relationship is depicted

Table 1. The latent factors and indicator variables for organic vegetable purchasing.

Laten variable	Indicator variables	Code
X1 (Product)	Organic vegetables supplied in current marketplaces are of a high quality.	X1.1
	Organic vegetables sold in contemporary markets are of high quality.	X1.2
	Colorful organic vegetables are readily available in modern marketplaces.	X1.3
	Organic vegetables supplied in contemporary marketplaces come in a range of sizes that are both appropriate and varied.	X1.4
	Organic vegetables sold in modern markets are packaged in an attractive manner.	X1.5
X2 (Price)	Organic vegetables available in today's market are clearly priced.	X2.1
	Organic vegetables are reasonably priced in modern marketplaces.	X2.2
	Organic vegetables available in modern markets are priced competitively with conventional vegetables.	X2.3
X3 (Place)	Modern market strategically positioned and easily accessible.	X3.1
	A modern market features a large and orderly parking lot.	X3.2
X4 (Promotion)	Discounts (discounts) have a significant impact on how organic vegetables are purchased.	X4.1
	The popularity of the business has a significant impact on how organic vegetables are purchased.	X4.2
X5 (People)	Market personnel in the modern day are quick to serve organic vegetable shoppers.	X5.1
	Employees in modern markets dressed impeccably serve consumers.	X5.2
	Modern market personnel are courteous and kind while interacting with consumers of organic vegetables.	X5.3
X6 (Physical evidence)	Organic vegetable products are organized in modern markets according to their classification.	X6.1
	A modern market maintains a high standard of cleanliness and comfort.	X6.2
	Modern markets are well-decorated and well-organized. They provide prompt service to consumers who want certain types of organic vegetables.	X6.3
X7 (Process)	Fast cashier service process and apply health protocols.	X7.1
	Consumers are satisfied buying for organic vegetables at modern markets.	X7.2
Y (Purchace decision)	In modern markets, consumers frequently/used to purchase organic vegetables.	Y1
	Consumers will encourage others to purchase organic vegetables in today's market.	Y2
	Organic vegetables will be repurchased by consumers in current markets.	Y3
	Organic vegetables supplied in current marketplaces are of a high quality.	Y4

graphically using a path diagram. Following that, the programming language will turn the image to a mathematical equation, and the mathematical equation to an estimate. In SEM, the path diagram is used to more clearly and simply illustrate or specify the SEM model than the mathematical equation model. To effectively describe an equation's path diagram, one must be familiar with SEM variables and their associated notations and symbols. The structural equation model and the measurement model then specify the link between these models. The objective of creating a path diagram is to assist researchers in visualizing the causal relationship they wish to test.

A blue circle containing X1, X2, X3, X4, X5, X6, X7, and Y represents the hidden variable. The path coefficient value (ɣ) is a normalized regression coefficient value that represents the magnitude of an endogenous (independent) variable's effect on the variable extraneous (the dependent variable). The value of the route coefficient is represented by a line linking two variables (1, 2, 3, 4, 5, 6, 7). The coefficient of determination (R2) represents the proportion of endogenous variables that may be explained by exogenous variables (Kusuma et al., 2021). In SmartPls, the value of the coefficient of determination is denoted by the number in the blue circle (R2Y). The correlation coefficient (λ) value in SmartPls indicates the size of the association between the latent variable and its constituent indicators. This relationship is represented graphically by a line connecting the latent variable and its indicators (Purwanto, 2021).

2. Path Diagrams to Structural Equations Conversion

Setelah After constructing a theoretical model that is subsequently translated into a path diagram, all constructs with lines and arrows connecting them to endogenous constructs are examined (Hair Jr et al., 2020):

- Specification of the measurement model (Measurement Model); the researcher specifies which variables measure which construct and creates a set of matrices illustrating the hypothesized association between constructs or variables in the measurement model's equation (Rehman Khan & Yu, 2021). The following equation represents the measurement model for one of the structures in Figure 2:

X1 = λ1. X1.1+ λ2. X1.2+ λ3. X1.3+ λ4. X1.4+ λ5. X1.5….
X2 = λ6. X2.1+ λ7. X2.2+ λ8. X2.3….
X3 = λ9 X3.1+ λ10. X3.2….
X4 = λ11. X4.1+ λ12. X4.2….
X5 = λ13. X5.1+ λ14. X5.2+ λ15. X5.3….
X6 = λ16. X6.1+ λ17. X6.2+ λ18. X6.3….
X7 = λ19. X7.1+ λ20. X7.2….
Y = λ21. Y1+ λ22. Y2+ λ23. Y3+ λ24. Y4….

- Elements of Structural Equations. Structural equations are used to express relationships of causality between constructs. Structural equations are constructed using the following principles. In the illustration of Figure 2. Y = 1 is the structural equation, X1 plus 2, X2 plus 3, X3 plus 4, X4 plus 5, X5 plus 6, X6 plus 7, and X7 plus 3, Where Y is the Purchase, X1 is the Product, X2 is the Price, X3 is the Place/Location (Place), X4 is the Promotion, X5 is the People, X6 is the Physical Evidence, and X7 is the Process.

3. Evaluation of the outer model's outcomes entails the following:

- Convergent Validity is determined by the correlation between the item/component score and the construct score, as indicated by the standardized loading factor, which quantifies the amount of the correlation between each measurement item (indicator) and its construct. Individual reflexive measures are deemed to be high if they have a correlation of greater than 0.7 with the concept being measured, however Chin, as reported by (Amora, 2021) considers an outer loading value of between 0.5 and 0.6 to be sufficient.
- Discriminant Validity is a concept that refers to a measurement model with reflexive indications that is evaluated by cross loading measurements with constructs. If the correlation between the construct and the measurement item is stronger than the correlation between the other constructs, then the construct's block size is superior

to the other blocks. Meanwhile, another technique for determining discriminant validity is to compare the value of the squareroot of the Average Variance Extracted (AVE) (Al-Skaf et al., 2021).

- Composite Reliability is a metric used to quantify a construct that is visible in the view of latent variable coefficients. There are two methods for evaluating composite reliability: internal consistency and Cronbach's alpha. If the result obtained is more than 0.70, the construct has a high degree of reliability (Ebrahimi et al., 2021; Mardianto, 2021; Maulina, 2019).
- Cronbach's Alpha is a reliability test used to validate composite reliability results. A variable is considered dependable if its Cronbach's alpha value is greater than 0.7. The test described above is a reflecting indication test on the exterior model. Numerous tests were conducted on formative indicators (Daham & Abdelkader, 2021; Russo & Stol, 2021).

4. Evaluation of the inner model's results, which include the following:

- The Path Coefficient Test is used to determine the magnitude of the independent variable's effect or influence on the dependent variable. While the coefficient determination (R-Square) is used to quantify the influence of other variables on endogenous variables. Chin stated that R2 values of 0.67 or greater for endogenous latent variables in the structural model suggested that the influence of variable was classified as good. Meanwhile, if the result is between 0.33 and 0.676, it falls into the medium group; if the result is between 0.19 and 0.33, it falls into the weak category.
- Model Goodness Test. The Q-Square value is used to determine the model's fit. In regression analysis, the Q-Square value has the same meaning as the coefficient determination (R-Square). The correlation coefficient indicates the degree of similarity between the independent and dependent variables and ranges from 0 to 1. If (R) is close to 1, it is said to have a close relationship; conversely, if (R) is far from 1, it is said to have a distant relationship. The coefficient of determination has a value between 0 and 1. A number close to one indicates that the independent variables contain practically all of the information necessary to predict the fluctuation of the dependent variable (Kusuma et al., 2018).
- Hypothesis testing. The t-statistics and probability values indicate whether the hypothesis was tested. To test the hypothesis using statistical statistics, the t-statistic value employed in this study is 1.990 for alpha 5%. The following hypotheses were tested: Ho: The marketing mix (product, price, location, promotion, people, physical evidence, and process) has no discernible effect on consumer decisions (Y).
  H1: The marketing mix (product, price, location, promotion, people, physical evidence, and process) has a large impact on consumer behavior (Y).
  The following criteria are used to accept or reject the hypothesis: H1 is accepted when the t-statistic is greater than 1.990. or a probability p value of less than 0.05.

RESULTS AND DISCUSSION

Outer Model of Organic Vegetable Purchase in Modern Market

After evaluating the measurement model for 24 indicator items, it was

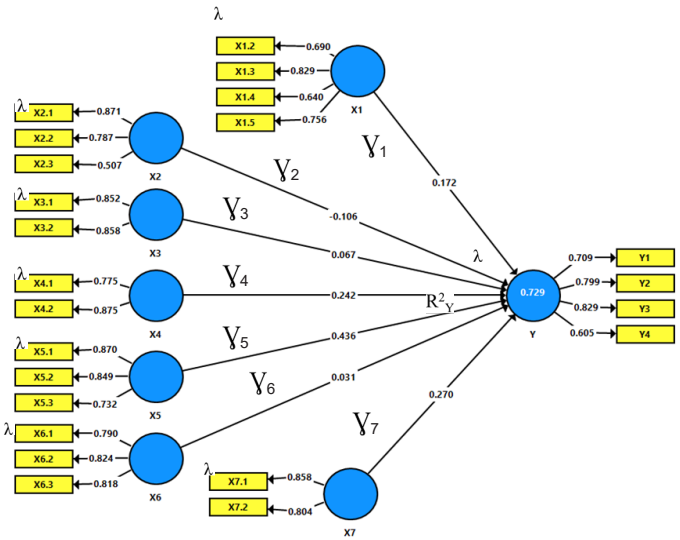

Fig. 1. The Path Diagram is a theoretical model for the purchase of organic vegetables.

determined that 23 items had a loading factor more than 0.5 and could therefore be deemed legitimate. Because indicator X1.1 does not match the test conditions, it must be discarded or removed from the model. Because item X1.1 has a loading factor less than 0.5, a new diagram is constructed, as illustrated in Figure 1.

Convert Path Diagram to Equation

a. Outer Model equation (Measurement Model):
- X1 = 0.690X1.2 + 0.829X1.3 + 0.640X1.4 + 0.756X1.5.
- X2 = 0.871X2.1 + 0.787X2.2 + 0.507X2.3.
- X3 = 0.852X3.1 + 0.858X3.2.
- X4 = 0.775X4.1 + 0,875X4.2
- X5 = 0.870X5.1 + 0.849X5.2 + 0.732X5.3
- X6 = 0.790X6.1 + 0.824X6.2 + 0.818X6.3.
- X7 = 0.858X7.1 + 0.804X7.2.
- Y = 0.709Y1 + 0.799Y2 + 0.859Y3 + 0.605Y4.

b. Inner Model equation (Structural model):
The following equation represents the structural model of purchasing organic vegetables at a modern market in Malang:
Y= 0.172product – 0.106price + 0.067 place +0.242promotion + 0.436people + 0.031physical evidence+ 0.270 process

Evaluation of the Outer and Inner Models of Organic Vegetable Purchase

The exogenous variables in this study are the product (four indicators), the price (three indicators), the location (two indices), the promotion (two indicators), the people (three indicators), the physical evidence (three indicators), and the process (2 indicators). The buying decision is the endogenous variable (4 indicators). All indicators are legitimate since they have convergent and discriminant validity greater than 0.5. All variables are trustworthy, as measured by a composite reliability score greater than 0.7 (Rehman Khan & Yu, 2021). The highest route coefficient is determined by the influence of people (X5) on purchase decisions (Y), whilst the R-Square value is used to determine the model's feasibility in this study. The coefficient of determination is 0.729, indicating that this research model has a good or strong goodness of fit.

The Marketing Mix's Effect on Organic Vegetable Purchases

The structural equation model (SEM) analysis of purchase decisions using SmartPLS revealed that product variables (t = 2.645, p 0.05), promotion (t = 2.960,

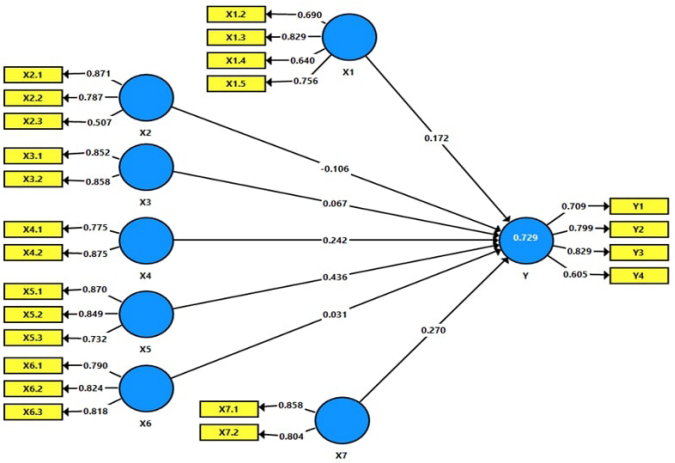

Fig. 2. Outer Model.

p 0.05), people (t = 4.052, p 0.05), and process (t = 3.087, p 0.05) all have a positive and significant effect on purchasing decisions. While price has a negative and insignificant effect on purchase decisions (t = 1.360, p > 0.05), location (t = 0.749, p > 0.05) and physical evidence (t = 0.265, p > 0.05) have a positive and substantial effect on purchasing decisions. To obtain a description of the model used in this study, the following SEM outputs from the data processing findings in Figure 3.

The outcomes of this study reveal that product, promotion, people, and process variables all have significant and beneficial effects on the purchase of organic vegetables in Malang's modern markets. This is also demonstrated by the majority of respondents who agree that organic vegetable accessible in the modern market are fresh, of good quality, varied in color and size, and packaged attractively. Melovic et al. (2020) established that the product is a factor that customers value and that it serves as a basis for decision-making. Similarly, Mansur et al. (2020) asserted that product variables have a favorable and significant effect on purchase decisions.

Promotion has a significant impact on the procurement of organic vegetables at Malang's modern market. This is also consistent with Kotler's (2009) thesis that promotion methods can be utilized to help consumers recognize products and influence their purchasing decisions. This considerable promotion is consistent with Issock et al. (2021) and Hair et al. (2020) research findings indicating the promotion variable has a favorable and significant impact on purchasing decisions. Generally, modern markets offer lower rates on individual product items. This is perceived to pique customer curiosity and may persuade people to purchase organic vegetables in today's market. Additionally, store popularity is the most significant indication of the promotion variable. This implies that shoppers feel secure and rely on the store's reliability while shopping for organic vegetables in today's market.

Additionally, the people have a high significant influence on the buying of organic vegetables at current Malang landmarks. According to field observations, modern market staff always wear neat uniforms, are quick to serve, and provide services in a friendly and polite manner. This is seen by the frequency with which respondents' responses tend to rate agree. This

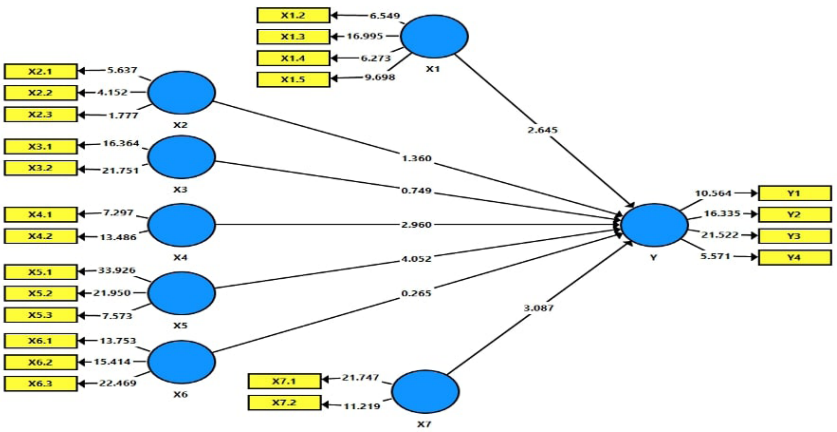

Fig. 3. Inner Model.

Table 2. Output Bootstrapping results.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	t_{table}	P_{values}	Decision
X1-> Y	0.172	0.165	0.065	2.645	1.990	0.008*	H_1 accepted
X2 -> Y	0.106	-0.082	0.078	1.360	1.990	0.174	H_1 denied
X3 -> Y	0.067	0.074	0.089	0.749	1.990	0.454	H_1 denied
X4 -> Y	0.242	0.231	0.082	2.960	1.990	0.003*	H_1 accepted
X5 -> Y	0.436	0.433	0.108	4.052	1.990	0.000*	H_1 accepted
X6 -> Y	0.031	0.034	0.118	0.265	1.990	0.791	H_1 denied
X7 -> Y	0.270	0.263	0.087	3.087	1.990	0.002*	H_1 accepted

Source: Author's computations, 2021
**=high significant (alpha 0.01)*

favorable impression will have an effect on how one perceives. In the current economy, consumers will ultimately make purchase decisions about organic vegetables. As defined by Hurriyati (2005), people are players who influence how services are presented to consumers or buyers. This study confirms the findings of Issack et al. (2021), who found that the people variable has a favorable and significant effect on purchasing decisions. This study confirms the findings of Hair et al. (2020), who found that the people variable had a favorable and substantial effect on purchasing decisions.

The process has a high significant favorable impact on the buying of organic vegetables at Malang's modern market. When purchasing a consumer goods, the consumer considers not only the price but also the time aspect. Consumers comments indicated that many agree that the service is quick, and the payment process is fast and follows proper health protocols. Melovic et al. (2020) asserted that whether the procedure is visible to consumers or occurs behind the consumer's back, it undoubtedly has an effect on his perception of a product or service given.

This study discovered that the variables of price, location, and physical evidence have no effect on the purchase of organic vegetable at Malang's modern market. Organic vegetable products are regarded luxury items due to their higher price tag than conventional vegetables. According to the respondents' characteristics, the majority of consumers who purchase at modern marketplaces earn an average of Rp. 2,000,000-3,000,000/month. Consumer income is regarded as being in the middle to upper range, implying that consumers will continue to purchase organic vegetables regardless of the price. The high proportion of respondents aged 35–40 years demonstrates that purchasers of organic vegetables in Malang City's modern market are of productive age; young managers are dynamic, and so lack the time to buy at traditional markets. In other words, the cost of organic vegetables is insignificant in comparison to the value of health. This study corroborates the findings of Adawiyah et al. (2021), who concluded that price had a negative and insignificant effect on purchase decisions. In terms of location, based on actual field conditions, the parking lot is still insufficient because the majority of current market consumers buy in their own private cars, forcing vehicles to park in inappropriate locations such as on roads. This will generate traffic congestion and make it more difficult for consumers to shop for organic vegetables in modern markets. Physical evidence indicates that the placement of vegetables and decorations or patterns are still less than optimal in convincing people to purchase organic vegetables in the modern market. Additionally, respondents believe they have not included organic veggies because they are typically mixed up with hydroponic or other vegetables. This study corroborates with Le's (2021) findings that place and physical evidence have a positive and insignificant effect on the purchasing of organic vegetables.

CONCLUSION

Seven marketing mix variables were examined in relation to the purchasing of organic vegetables at four modern marketplaces in Malang City, East Java, Indonesia. The research data were derived from primary sources and gathered through direct cnversations with consumers shopping for organic vegetables. The sample was determined by accidently sampling up to 80 consumers. SEM-PLS is used to purchase organic vegetables. The findings indicated that four marketing mix variables, namely product, promotion, people, and process, had a highly significant and positive effect on the purchase of organic vegetables, whereas price, location, and physical evidence had no effect on the purchase of organic vegetables in Malang City's modern market.

Suggestions include the following: contemporary markets should enhance their pricing techniques to enable people with lower middle incomes to purchase organic vegetables. Second, the current market is projected to place a higher premium on the location variable, as it is discovered that consumers park their automobiles in an untidy manner, obstructing inter-consumer movement. This can be remedied by expanding the parking area's capacity. Thirdly, modern marketplaces should improve and pay more attention to physical evidence variables, as many consumers continue to be confused about the sorts of organic vegetables that are still mixed in with other vegetables. This can be avoided by designating distinct locations and instructions for different sorts of organic vegetables, making them easier to recognize and locate.

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IDENTIFICATION OF INTERNAL PARASITES OF MEAT-TYPE RABBITS (*Oryctolagus cuniculus* L.) THROUGH FECALYSIS IN A STATE COLLEGE IN BULACAN, PHILIPPINES

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Abstract — Meat-type rabbits are relatively new compared to other livestock raised for meat in the Philippines. In this regard, the occurrence of parasites is not yet well-documented among rabbit farms in the country. This study determined the presence and identity of gastrointestinal parasites of rabbits farmed inside a state college through floatation and sedimentation procedures of fecal analysis. Floatation technique separates the eggs from fecal debris by floating them on a variety of solutions, whereas sedimentation technique allows heavier parasite eggs to sink to the bottom of the solution. Both procedures were conducted on 53 rabbits of varying ages. Eggs of intestinal coccidia were found on all rabbits, having a prevalence of 100%. Eggs of hepatic coccidia (*Eimeria stiedae*), and tapeworm (*Taenia* spp.) were found at 15% and 7.5% occurrence, respectively, among all the rabbits. *E. stiedae* and *Taenia* spp. were found only in young rabbits aged two months old and below, at an prevalence of 66.67% and 33.33%, respectively, for this age group. The parasites were seen using the floatation technique, whereas only coccidia were seen in sedimentation technique. Results revealed that mixed infection of intestinal coccidia with hepatic coccidia, and intestinal coccidia with tapeworm, occurred in young rabbits only. The rabbits did not show clinical signs related to the parasites discovered, owing to the low amount of parasitic load, and to the low pathogenicity of the parasites. Implications for rabbit farm hygiene and sanitation, and for rabbit health management were discussed for rabbit producers in the country.

Keywords **— Bulacan, fecalysis, meat-type rabbit, rabbit parasites**

INTRODUCTION

A parasite is a smaller organism that lives on or in, and at the expense of a larger organism called the host (Bowman, 2009). Meat-type rabbits are relatively new compared to other livestock raised for meat in the Philippines. In this regard, the occurrence of parasites is not yet well-documented among rabbit farms in the country. For internal parasites, parasitic worms and protozoa are the two major classifications. Parasitic worms (helminths) are either roundworms (nematodes), tapeworms (cestodes), or flukes (trematodes). On the other hand, protozoa, such as coccidian, are microscopic unicellular organisms with specialized organelles (Gosling, 2005).

In order to detect the presence of parasites, the procedure for live animals is fecal sample analysis or simply fecalysis. Fecalysis can be done through various processes. Kaufman (1996) enumerated the techniques and specific procedures in the diagnosis of parasitic infections of domestic animals, including floatation and sedimentation methods.

Among the parasites that can be detected from fecalysis are coccidia, which are protozoa that invade either the mucosa of the intestine, colon, cecum, or the epithelium of various ducts (Harcourt-Brown, 2002). Fourteen species have been described in the domestic rabbit, only one of these inhabit bile ducts (*Eimeria stiedae*) and causes hepatic coccidiosis, while the rest are found in the small and large intestines (Harcourt-Brown, 2002). Among the intestinal coccidia, the most common are *E. magna, E. perferans*, and *E. media*, which seldom cause significant disease but are readily seen in fecal samples, while *E. intestinalis* and *E. flavescens* seldom occur but are pathogenic (McNitt et al, 2013).

Speight (2019) reported that some of the most common internal parasites in rabbits. These are tapeworms (*Taenia serialis, T. pisiformis*), and coccidian protozoa (*E. stiedae*, other *Eimeria* spp.) Cousquer (2008), on the other hand, asserts that the only roundworm to occur in domestic rabbits is the oxyurid worm *Passalurus ambiguous*, which is sometimes referred to as a “pinworm”. Aside from *Eimeria* spp., Cosquer (2008) also adds that rabbits can have *Toxoplasma gondii* and *Ecephalitozoon cuniculi*.

This study determined the presence of these mentioned parasites from the Rabbit Production Project of Bulacan Agricultural State College (BASC), San Ildefonso, Bulacan, Philippines. Results of this study were used as additional data for IEC materials on rabbit pest and disease management.

The general objective of this study is to determine the occurrence of internal parasites in rabbits at BASC, San Ildefonso, Bulacan, Philippines. Specifically, it aimed: a. To detect the presence of infection involving gastro-intestinal parasites in rabbits through flotation and sedimentation techniques of fecalysis; and, b. To identify the internal parasites detected through microscopic examination of the eggs detected in the samples.

MATERIALS AND METHODS

Research Design

This research was a non-experimental observational study, using the cross-sectional or prevalence study design. According to Pfeiffer (2009), this type of study is used to obtain baseline information about a population, taking a random sample of animals from a population at one point in time, or at one point in the life of each animal. Each animal is examined for the presence of disease and their status with regard to risk factors.

Experimental Animals

The studied rabbits were of New Zealand White breed, and were housed in

galvanized wire cages and fresh water was automatically available at all times. These rabbits were fed with a commercial standard rabbit diet without any anti-parasitic or anti-coccidian drugs prior to sampling. Feeding with grasses is done in the project in addition with the pellets when grasses are abundant; this was not done during the study which was conducted from January to March 2021. Within the period of collection, a total of 53 rabbits were sampled from the total population of 212. Stratified random sampling was done according to age (2 months and below, 3 months, 4 months, and 5 months and above), taking 25% from each age group as samples. Each of the 53 rabbits was only sampled once.

The health program in the animal project includes ivermectin injection to rabbits that will be used as breeders when they reach 4 months of age, and as maintenance to breeders every 6 months. Ivermectin is a broad-spectrum antiparasiticide which is indicated both for internal and external parasites. The sampled animals were only those that have not received any ivermectin injection in the past five months. Antibiotics and other anti-parasiticide are not routinely given since the project is advocating natural farming system like other rabbit farms in the country.

Data Collection (Fecalysis Procedures)

Fresh fecal samples were obtained as immediately excreted using screens just below the cages. For detection of helminth and coccidian infections, simple flotation and sedimentation techniques were performed. These methods detect different types of parasite eggs according to their weight and specific gravity.

Simple Floatation Method

The study followed the simple floatation method, as described by Sirois (2011) using sugar flotation solution. About 2-5 g of feces was placed on a small plastic cup, added with 30 mL sugar solution, mixed thoroughly, strained with a metal strainer and poured into a test tube. The test tube is filled to form a convex dome (meniscus), then covered with a cover slip, and allowed to stand for 20 minutes. The cover slip was placed on a glass slide with the fluid side down, and examined using the LPO and HPO (100X and 400X magnifications).

When feces are emulsified in liquids of high specific gravity and either centrifuged or allowed to stand, the worm eggs and many protozoan cysts float to the top while the heavy coarse debris settles to the bottom. The top film can then be removed and examined. Nematode and cestode eggs float in a liquid with a specific gravity of 1.1-1.2. Trematode eggs, which are much heavier, require a specific gravity of 1.3-1.35.

Sedimentation Method

The standard sedimentation method according to Sirois (2011) was used. The fecal sample was mixed with water, strained into a test tube, and allowed to remain undisturbed for at least 20 minutes. The supernatant is poured off, and drops from the upper, middle and lower portions of the sediment are examined microscopically using the LPO and HPO.

Identification of Parasite Eggs

Slides with observed parasite eggs were further scrutinized through microscopic examination under high power objective. Reference books on parasitology served as guide in the identification of parasite eggs through the pictures and description of the oocysts. The veterinarians who were part of the study team identified the parasites.

RESULTS AND DISCUSSION

In this study, three types of parasites were observed from the animals: intestinal coccidia (*Eimeria* spp.), hepatic coccidia (*Eimeria stiedae*) and a tapeworm (*Taenia* sp.). All these parasites were seen using the floatation technique, whereas only the coccidia were seen in sedimentation

technique. Egg per gram counting was not done. The observed eggs were few, with only three to five eggs seen in a whole microscopic slide for most of the samples. The study focused on the identification of the parasite eggs.

Intestinal Coccidia

Table 1 shows that intestinal coccidia belonging to genus *Eimeria* were observed from all the animals. *Eimeria* contain four oocysts, each with four sporozoites, and are identified based on morphology and knowledge of the host animal (Taylor et al., 2016).

Table 1. Frequency and Ocurrence of Intestinal *Eimeria* spp. according to age of rabbits.

Age of Rabbit	Population (n)	F	Occurence
2 months and below	12	12	100%
3 months	18	18	100%
4 months	6	6	100%
5 months and above	17	17	100%
Total (N)	53	53	100%

The present study shows that 100% of the studied animals, regardless of age, were positive to intestinal coccidia (*Eimeria* spp.). This reported prevalence is higher than the prevalence (73.9%) documented by Hadi (2021) in his study of infected local rabbits in Baghdad, Iraq. Another study conducted by Elshahawy and Elgoniemy (2018) stated that 49% prevalence of several species of protozoa (*Eimeria* spp. and *Cryptosporidium* oocysts) were found in domestic rabbits in Egypt.

Although positive with intestinal coccidiosis via fecalysis, all the rabbits in this study looked healthy and vigorous. As McNitt et al. (2013) pointed out, intestinal coccidia are more of a nuisance than anything else, because they are seldom pathogenic. The intestinal coccidia in this study may have been acquired from the source of breeder rabbits, although water and forages are also plausible, in addition to the fact that the animals sampled were those not yet given any anti-parasitic medication.

Coccidiosis is one of common diseases in rabbits which is caused by protozoan parasites (Hadi, 2021). More than a dozen *Eimeria* spp. are documented from the intestine of rabbits. Intestinal coccidia are common in wild and domestic rabbits worldwide (Baker, 2007). *Eimeria magna* and *Eimeria irresidua* are the two most pathogenic coccidial species that affect the intestine of rabbits. The observed coccidia in the experimental animals were the less pathogenic species of *E. intestinalis, E. exigua and E. piriformis* (Figure 1). The small intestinal is their predilection site (Taylor et al., 2016).

Eimeria are parasites of epithelial cells. They enter the mucosa of the intestine, colon and cecum and the epithelium of different ducts. Infected rabbits void oocysts that need oxygen and a period of a several days to become infective, and ingestion of the oocyst discharges sporozoites into the duodenum after the oocyst has been destroyed down by digestive enzymes (Harcourt-Brown, 2002). The sporozoites invade cells and cause tissue damage as they complete their complex life cycle ultimately to release oocysts into the lumen of the gut (Harcourt-Brown, 2002; Varga, 2002). Despite of the subclinical form or no evident clinical signs observed in rabbits with intestinal *Eimeria* spp., when these animals become sick or stressed, the parasite may result to lower weight, diarrhea, and reduction of food absorbance and digestion, which finally result in a decline in profitability of rabbit production (Szkucik et al., 2014). Varga (2002) reported that Sulpha drugs medication in the feeds or drinking water can be used to treat coccidiosis in groups of rabbits, but Lukefahr (2010) added that they must not be used on a preventative basis.

The implication of the results of present study in the Philippines rabbit industry is that intestinal coccidiosis may be prevalent in rabbit farms, since majority are backyard users and do not also give regular deworming and anticoccidial medication. Even if considered mainly as non-pathogenic, the prevalence of infestation necessitates the formulation of a strategic prevention and control program against intestinal coccidiosis, which foremost includes proper floor design of cages and sanitation. According to Lukefahr (2010), to break the parasites' life cycle, the hard feces of rabbits should always fall through the floor of the hutch or cage. Control of rabbit coccidiosis involves daily cleaning of cages and hutches, provision of clean feeding troughs, and rearing on wire floors (Taylor et al., 2016).

Hepatic Coccidia

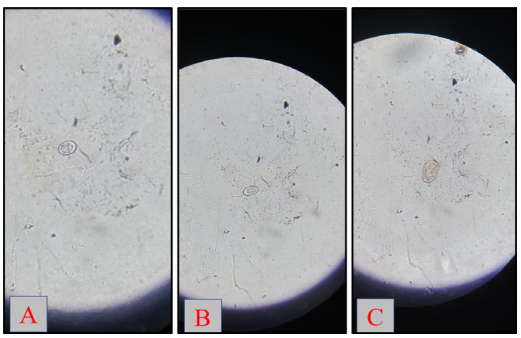

Fig. 1. Intestinal *Eimeria* spp.: (A) *Eimeria exigua*, (B) *Eimeria intestinalis,* and *Eimeria piriformis* oocyst under HPO.

Table 2 shows the prevalence of hepatic coccidia, wherein only 15% of the 53 total animals sampled for fecalysis had positive results, and these were those rabbits aging two months and below, for a prevalence of 66.67% in this age group.

These results were lower than the prevalence of 17.5% documented by Hadi (2021) in his study of infected local rabbits in Baghdad, Iraq. Another study conducted by Kornaś et al. (2015) showed that 2.9% prevalence of *E. stiedae* were found in the rabbit farms in Poland. The 15% prevalence of *E. stiedae* may be connected with stress related with weaning time. Nevertheless, the source of water and grasses may have served as the main factors in infecting the colony of rabbits, and since the rabbits have not received any anti-parasitic treatment.

Table 2. Frequency and Occurrence of *Eimeria stiedae* according to age of rabbits.

Age of Rabbit	Population (n)	F	Occurence
2 months and below	12	8	66.67%
3 months	18	0	0%
4 months	6	0	0%
5 months and above	17	0	0%
Total (N)	53	8	15%

Hepatic coccidiosis is a severe disease of rabbits caused by the species-specific *Eimeria steidae*. Its oocysts are elongated ovoid or ellipsoidal, and measure 28 µ to 42 µ by 16 µ to 25 µ with a 6-µ to 10-µ micropyle (Figure 2). The wall is smooth and colorless to red-orange (Baker, 2007). According to Varga (2002), sporulation of the oocysts is important for infectivity and requires at least two days outside the host. Oocysts are exceptionally resistant and can remain viable in soil, on vegetation, and fomites for long periods of time. As reported by of Xie et al. (2021), following the ingestion of sporulated oocysts, the sporozoites are released and mainly attack the liver and bile duct epithelial cells, where the merogony phase occurs. Merozoites reproduce within and exit from epithelial cells to repeat the process of development through the trophozoite and merogonous stages, and then the life cycle enters the gametogony phase, which produces a new generation of oocysts that are passed out in the feces.

In the external environment, oocyst sporulation (sporogony phase) occurs and results in the development of a new generation of infective oocysts for reinfection. Clinical signs are variable and subclinical disease is common. Younger rabbits are common to be infected severely, characterized by diarrhea, lethargy, anorexia, abdominal enlargement due to icterus, and hepatomegaly. The hepatomegaly can comprise up to 20% of the body weight. Mortality can occur in young rabbits with very severe disease. Mature rabbits are resistant (Baker, 2007).

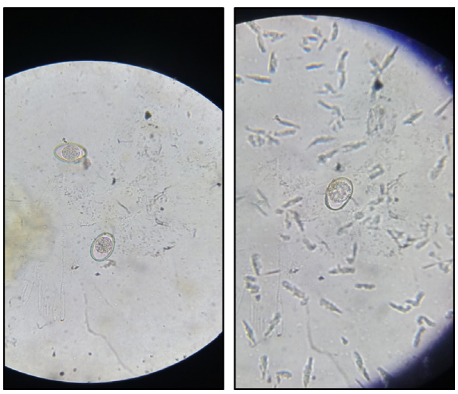

Fig. 2. *Eimeria stiedae* in 2 months old rabbit under HPO.

The condition can be treated with sulpha drugs via feed but may not be ingested in proper amounts by rabbits that are inappetent (Varga, 2002). Toltrazuril in the drinking water is highly effective in reducing oocyst output of both intestinal and hepatic *Eimeria* species. Other drugs reported to be effective include monensin, salinomycin, maduramycin, difluoromethylornithine, toltrazuril, methyl benzoquate and clopidol in combination, and narasin (Baker, 2007).

The implication of the results of present study in the Philippine rabbit industry is that hepatic coccidiosis may be prevalent in newly-weaned rabbits which are the susceptible age group, taking into consideration also the fact that majority of raisers do not also give regular deworming and anticoccidial medication. This is not much of a problem for rabbits that will be grown until three to four months or until slaughter age only. However, infected rabbits that look healthy may be used as breeders, and they can contaminate the surroundings if there is no proper sanitation in the farm. Heavily-infected breeders are also prone to suffer the severe signs of hepatic coccidiosis.

Tapeworm (*Taenia* sp.)

Table 3 shows the prevalence of intestinal worms (helminths), specifically cestodes (tapeworms) belonging to *Taenia* sp., wherein only 7.55% of the 53 total rabbits sampled for fecalysis had positive results, and these were also those rabbits aging two months and below, for a prevalence of 33.33% in this age group.

Table 3. Frequency and Occurrence of *Taenia* sp. according to age of rabbits.

Age of Rabbit	Population (n)	F	Occurence
2 months and below	12	4	33.33%
3 months	18	0	0%
4 months	6	0	0%
5 months and above	17	0	0%
Total (N)	53	4	7.55%

The prevalence results for helminths (*Taenia* sp.) is lower than the reported study of Hadi (2021) which recorded 38.75% infection rate in the domesticated rabbit in Baghdad, Iraq. Another study conducted by Szkucik et al. (2014) recorded 4.74% prevalence of *Taenia* spp. infection were found in slaughtered rabbits in Poland. Possible sources of infection were forages from surroundings contaminated by feces of infected dogs.

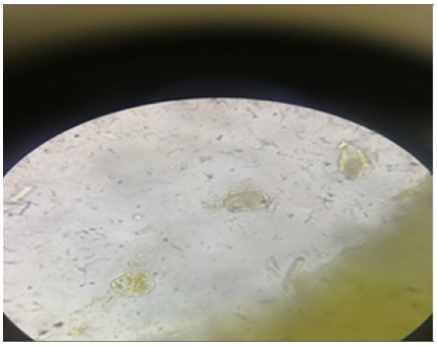

Fig. 3. *Taenia* spp. egg in 2 months old rabbit under HPO.

Rabbits are intermediate hosts of *Taenia* sp. throughout the world. Gravid proglottids passed from the definitive host, dogs, contain infective eggs (Baker, 2007). It may be problematic if rabbits are allowed to graze in contaminated pastures, and can be prevented by limiting access to dogs and cats (Keeble et al., 2016). Nabil (2020) stated that the ingested egg (Figure 3) hatches, and the hexacanth embryo enters the wall of the intestine and travels to its organ of choice via the portal veins, then grows and differentiates on capsules to form the second larval stage which consists of a fluid-filled bladder with a scolex called a cysticercus or as *Cysticercus pisiformis*. Baker (2007) also added that naturally occurring infections are rarely clinically evident. Metacestode movement in the liver can cause focal granulomatous inflammation and fibrosis. Severe infections thru experimental inoculation, can end in severe hepatitis with chronic wasting or death. There is no practical treatment for tapeworm (*Taenia* sp.) in rabbits (Lukefahr, 2010).

The implication of this present study is that tapeworm infection may be present in many local rabbit farms, since most local rabbit raisers provide forages as one of the main feed sources for rabbits, and these may come from contaminated environments. Thus, they have to be informed about thorough washing of fresh grasses before air-drying and giving them to their rabbits, and making sure to get forages from clean environments only. Insect control, such as preventing flies in the rabbit housing can also help since parasitic eggs can also be transmitted mechanically by flies from the source to the feeds (rabbit pellets or forages).

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the study determined the presence and identity of intestinal and hepatic coccidia, and tapeworms, in rabbits farmed inside Bulacan Agricultural State College through flotation and sedimentation procedures. Results revealed that intestinal coccidia occurred in rabbits of all ages, but mixed infection of intestinal coccidia with hepatic coccidia, and intestinal coccidia with tapeworm, occurred in young rabbits only. All the rabbits did not show clinical signs related to the parasites discovered, owing to the low amount of parasitic load, and to the low pathogenicity of the parasites. Implications for rabbit farm hygiene and sanitation, and for rabbit health management were discussed for rabbit producers in the country.

Recommendations of the study for rabbit farmers, as contained in the IEC materials generated by the study, include cleanliness and sanitation in the farm, proper design of cage flooring (wire flooring), clean source of water and feeds, insect control, and guided administration of antiparasitic agents. Other studies on rabbit pests and diseases are needed to help in the promotion of rabbit production in the country, and to mitigate unwanted disease outbreaks in the future.

Further studies on the identification of parasites, including necropsy and histopathologic examination of intestines, liver, and other internal organs are recommended to determine other parasites that may be present, and the corresponding pathogenesis in infected in rabbits in the Philippines.

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THE POTENTIAL OF INTEGRATED RICE-DUCK FARMING IN COMMUNITIES ALONG THE BICOL RIVER BASIN, PHILIPPINES

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Abstract— Bicol is one of the most vulnerable regions in the Philippines due to its geographic location. Climate risks that lead to low rice productivity are intensified by large bodies of water such as the Bicol River Basin, covering three provinces and 43 municipalities in the region. The present study aims to assess the effects of integrated rice-duck farming (IRDF) in six farm sites from three municipalities (Baao, Canaman and Minalabac) in Camarines Sur situated along the BRB. Using Student's t-test, IRDF demonstrated significant results in Taban, Minalabac in terms of number of grains, number of tillers, number of panicles and the weight of grains in grams ($p<0.05$) compared to conventional farming. In contrast, no yield was recovered in San Fransisco, Baao where persistent flooding was observed during the cropping season. Post-harvest soil analysis demonstrated notable variation in phosphorus concentrations (highest in DCDR at 24.72 ppm and lowest in Mangayawan at 6.94 ppm) among other parameters. Water quality analysis revealed strong distinction in the amounts of PO_4, at 36.34 ppm in Taban against 1.21 ppm in Sta. Eulalia, Baao. IRDF is an effective faming methodology when optimum conditions are present in farm communities. Nonetheless, IRDF is a promising strategy that can be instigated in policy frameworks to ameliorate rice productivity in climate-risk exposed farmlands.

Keywords **— Bicol River Basin, climate risk, conventional farming, integrated rice-duck farming, physico-chemical analysis**

INTRODUCTION

Rice is one of the most important grain crops in the Philippines. It is a major food component of every Filipino (Macalad et al., 2019). According to the works of Barroga et al. (2007), 90% of the country's population consider rice as the major staple food. This information is supported by the country's vast land area of cultivate potential, making rice industry accountable for 0.7% of the country's gross domestic product (GDP) in 2018 (Lacambra et al., 2020). According to the report of Sebastian et al. (2000) in the Food and Agricultural Organization (FAO), 11.5 million Filipinos are dependent on rice farming as their primary source of income. However, in the third quarter of 2021, agriculture, forestry and fishery (AFF) has been reported to contract a -1.7 growth rate in the gross national income and gross domestic product (GDP) (Philippine Statistics Authority, 2021). With this, the farming industry in the Philippines is challenged to promote efficient production and stable source of income to rice farmers.

To address the goal for viable, productive and profitable farming and avert gaps in rice yield, researchers and farmers, together with concerned government agencies have established good practice options (GPO). However, the choice of the best individual farming technique varies in every farmland. The integration of the best component technologies should (i) guarantee timely cropping that shall result to productive yield, (ii) maximize the use of resources and farming inputs, (iii) provide immediate profit investment as evidenced by economic benefits, and (iv) minimize the effects as environmental hazard (Alam and Starr, 2013).

One of these farming practices that has been developed over the years is the integrated rice-duck farming (IRDF), an innovative farming process where ducks feed on the farm insects and weeds in paddies and fertilize rice plants. The methodology has reached many Southeast Asian countries such as Malaysia, Vietnam, Indonesia and the Philippines. A number of studies have reported the beneficial effects of the rice-duck system when associated to farming. In the Philippines, particularly in Bukidnon, Barroga and associates (2007) highlighted that IRDF effectuated to 36.58% rise in technical efficiency in crop yield. In Bicol Region, FAO (2013) reported preliminary data on the effects of IRDF in Buhi, Guinobatan and Gubat and mentioned that farmers' income escalated as much as 30% compared with the earnings from the conventional farming.

Bicol Region with its geographic location is considered as highly vulnerable to natural disasters such as typhoons, floods, and volcanic eruptions. These natural phenomena usually lead to discernible devastations with major effects on agriculture industry. The risks in the region are intensified by major land and water bodies such as volcanoes (Mayon, Isarog, Malinao, etc.) and the large river, Bicol River Basin (BRB), respectively. This amass river has a total land area if 317, 103 ha and range into the provinces of Albay, Camarines Sur and Camarines Norte and 43 local government units (LGU) which are situated within the BRB (DENR, 2015). Because of the presence of the BRB, flooding has become the most pervasive hydrologic hazards that threatens the entire Bicol plain. The projected flooded area in BRB is 42, 124 ha and is expected to increase to 50, 402 ha or 16% of the BRB. This results to significant loss in agricultural productivity, specially to irrigated rice lands. In the last quarter of 2020 amidst the COVID-19 pandemic, the regional agriculture was ravaged by a series of strong typhoons that hit the provinces and subsequently affected the impoverished locals of the region. Department of Agriculture (DA) has estimated a total loss of 968 million pesos that has affected 40, 519 farmers in the area. (Philippine News Agency, 2020). This

phenomenon is believed to be a contributor to the decline in the GDP share of agriculture for that year. With this, the present study generally aims to determine the influence of IRDF to representative farmlands in Baao, Canaman and Minalabac along the vulnerable communities in Camarines Sur. Specifically, it aims to compare traditional farming techniques against IRDF in terms of its effect on productivity using number of grains; number of tillers; number of panicles and weight of grains in grams. Further, it aims to assess the post-harvest physicochemical characteristics of the farm's irrigation and determine the nutrient status of the soil using standardized protocols.

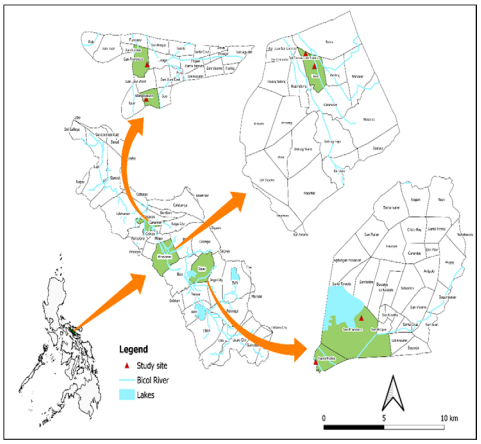

Fig. 1. Bicol River Territorial Map.

MATERIALS AND METHODS

Study Site

The experimentation was conducted in six study sites from three vulnerable municipalities in the province of Camarines Sur (Laureta and de la Vega, 2020). These sites are located along the Bicol River, exposing the populace's agricultural operations to natural disasters. These sites are: Sta. Eulalia, Baao (13.4329°, 123.3152°), San Francisco, Baao (13.4505°, 123.3350°), San Francisco, Canaman (13.6448°, 123.1141°), Mangayawan, Canaman (13.6225°, 123.1220°), Del Carmen-Del Rosario, Minalabac (13.5655°, 123.1907°) and Taban, Minalabac (13.5544°, 123.1996°). Figure 1, annual average rainfall in Camarines Sur is 2,565 mm with an estimated mean temperature of 27.0 °C, and lastly with relative humidity of 25.8% (Philippine Statistics Authority, 2019). The research was carried out in July to December 2019. The rice variety used in the experiment was Green Super Rice 11 (GSR11).

The trials were conducted solely in the fields of farmer cooperators from each study sites. Each farmer cooperator allotted approximately 0.50 ha, which was then equally divided into two parts: the rice duck system which served as experimental setup, and the farmers' conventional or traditional method of rice planting which was treated as the control. Farmlands set up were divided by a demarcated area and were protected with fences. In the traditional portion of the land, conventional farming techniques were practiced such as usual application of insecticides, pesticides and herbicides. As opposed with this set-up, no application was added in the experimental plots to directly observe the effectiveness of the ducks in the production system. Additionally, the rice-duck plots did not receive fertilizer in any form. In the traditional rice plots, complete (PNK;14-14-14) fertilizers and urea were applied, as usual practice of the local farmers.

Rice-duck farming set-up

For the IRDF set-up, the methods described by Hossain et al. (2005) were adapted with modifications. Ten days after transplantation, 20-day-old ducklings were allowed to freely navigate in the farm (150/plot). At the initial stage, the animals were kept in the plots for 2-4 hours a day. When the ducks become familiar to the environment, they were released in the plots in extended hours. Possible predators were prevented by establishing mesh nets within respective designated plots. As ducks reached four months old, they were detached from the

rice fields to prevent matured ducks from overgrazing the plots at the flowering stage. Each of the demonstration trial was treated as a replication. At the harvest period, data on growth, yield-contributing characteristics such as number of grains, number of tillers, number of panicles and the weight of grains in grams and yields of the crops were recorded.

Post-harvest Water and Soil Analysis

A representative water sample of 500 ml from irrigation systems was collected and stored in a properly rinsed polyethylene bottle. Floating debris and any other contaminants were avoided while collecting the sample. Also, 500g of soils were randomly sampled from 10 different spots of the plot at 1 m depth. Soils were allowed to air-dry for approximately one week. After appropriate labelling of site and date of collection, analyses were performed at the Department of Agriculture 5 Regional Soils Laboratory.

Determination of Nitrogen (N)

Soil organic is oxidized with potassium dichromate in concentrated sulfuric acid. The green color of dichromate is measured. The calculation of amount of organic carbon is based on the oxidation, under the same conditions of organic standards like sucrose, dextrose and the disodium salts of ethylinediaminetetracetic acid. Soil sample at 0.5 g was placed into a 250 ml of erlenmeyer flask. Potassium dichromate in 2 ml was added to the solutions. After, 5 ml of H_2SO_4 were added and cooled down. 20 ml of DH_2O was further added. The mixture was allowed to stand over night to allow soil particles to settle completely. Absorbance was measured at 627 nm.

Determination of Phosphorus (P)
Standard Preparation

Sodium bicarbonate ($NaHCO_3$) was used as extracting solution and was prepared by dissociating 42g of sodium bicarbonate in distilled water (DH_2O) to a volume of 1000 ml. The pH was adjusted to 8.5 with 50% sodium hydroxide (NaOH). Fifty percent (50%) sodium hydroxide was prepared by dissolving 50g of NaOH in a 100 ml DH_2O. Acid molybdate stock solution was also prepared by mixing dissolved 6 g of ammonium molybdate in 25 ml of DH_2O and 0.1455g of potassium anyimonyl tartrate in 5 ml DH_2O. Reagent B was prepared by dissolving 2.639g of ascorbic acid to 500 ml of Acid molybdate stock solution. The stock standard phosphorus solution was set by adding 0.2197g of potassium dihydrogen phosphate (KH_2PO_4) in about 25 ml of DH2O. This was diluted to a final volume of 1000 ml with extracting solution. Concentration of working standard ranged from 0.2-5.0 mg/l P. Calibration standard was prepared by pipetting a 5 ml aliquot of each of the working standards. Standards were allowed to develop color and the absorbance was read at 882 nm. R^2= 0.9990.

Sample preparation

Soil sample weighing 2g was placed in a 100 ml polyethylene bottle and duplicated. Briefly, 40 ml of extracting solution was added. The bottle was safely covered and shaken at 200 rpm or more for 30 minutes. Blank sample was also prepared. The extract was filtered into a 125 ml of erlenmeyer flask. This was added with 15 ml DH_2O and 5 ml of Reagent B. The flask was agitated for thorough mixing. The reaction was incubated for 10 minutes and the absorbance was read spectrophotometrically at 882 nm.

Determination of Potassium (K)

The exchangeable base is extracted by leaching the soil with ammonium acetate buffered at pH 7.0. The exchangeable bases are directly determined in the ammonium acetate (NH_4OAc) extract by atomic absorption spectrophotometry. Briefly, NH_4OAc solution was prepared by dissolving 7708 g of NH_4OAc in 1000 ml distilled water. pH was adjusted to 7.0 with acetic acid. Leaching tubes were prepared. Two grams of soil was placed into the tube and leached by adding 10 ml aliquots of

ammonium acetate at 20-minutes interval. Leachate was collected in the 50 ml flask and made up to the mark with ammonium acetate leaching solution. Potassium (K) was computed using the formula:

Exch K (cmol/kg soil) = (a-b) (0.0639) x DF x MCF

Where; DF- dilution factor; MCF- moisture content factor

Data Analysis

Statistical analysis was performed using Microsoft Excel and verified using SPSS v20.0. Student's T-Test was used to analyze the significance between the two treatments in each parameter ($p<0.05$).

RESULTS AND DISCUSSION

The comparison of the rice yield characteristics between the two experimental set- ups is presented in Fig. 2. Indistinct relationship among the parameters with varying significance is noted in every location site. Using the data in the number of grains, significant effect was noted in the traditional farming practice in Sta. Eulalia, Baao, and DCDR, Minalabac (Fig. 2A). However, increased number of grains was observed in the IRDF set-up in Taban, Minalabac. The rice's tiller number was also measured. Higher results were noted in conventional farming set-ups in Mangayawan, Canaman and DCDR, Minalabac, but tiller number has significantly risen in the IRDF arrangement in Taban (Fig. 2B). The result in the number of panicles further supports in beneficial effects of IRDF in Taban which recorded the highest number of panicles (Fig. 2C). Congruently, positive response in the weight of IRDF rice grains were observed from samples in Taban. Samples from other experimental sites showed denser grains from the traditional farming (Fig. 2D).

Soils from the different experimental sites were collected after integrated rice-duck farming. The status of the soil nutrient (Table 1) demonstrated that among the six

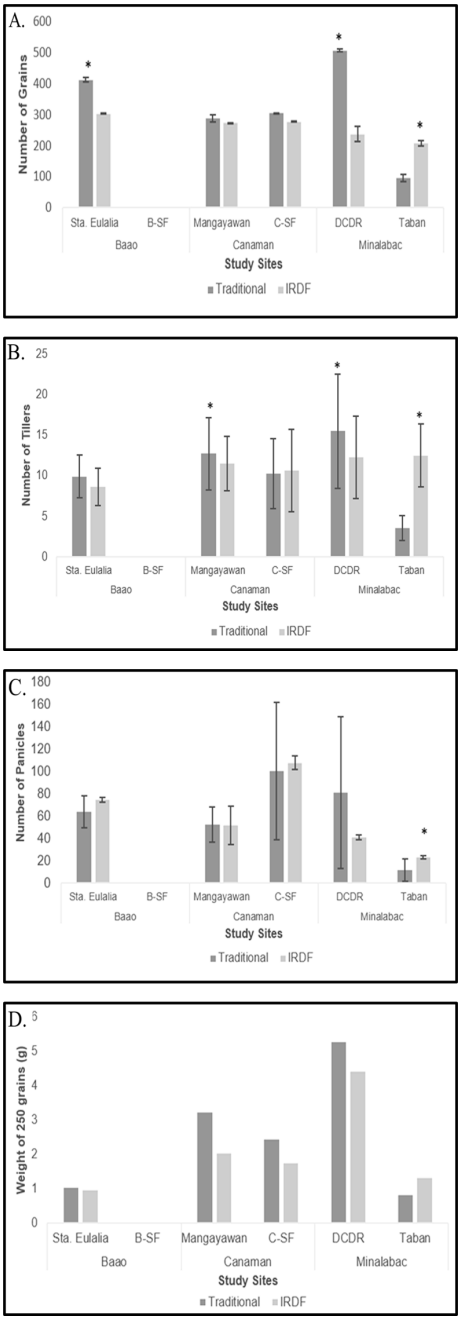

Fig. 2. Comparison of rice yield characteristics of traditional and integrated rice duck farming (IRDF). number of grains (A), number of tillers (B), number of panicles (C) and weight of 250 grains (D). SF-San Francisco, DCDR-Del Carmen Del Rosario. Values are expressed as Mean ± SD. n=12. *Significant at $p<0.05$ Level using Student's t-test.

sampling sites (excluding San Francisco, Baao where no data were generated), sampling site in Mangayawan, Canaman showed the most varying difference in two important parameters, least amounts of phosphorus (6.94 ppm) and incongruently the highest electrical conductivity (EC at 2.540 mS/cm) which basically measures the soluble salts in the soil samples essential to the proliferation status of a cell population.

Overall, soil samples from various study sites recorded a homogenous result of medium nitrogen (N) % with ranges from 3.84-4.13 organic matter (OM). Variations in the phosphorus (P) level were noted. Magayawan has low P level at 6.94. Medium levels of P were noted in Sta Eulalia, Baao, SF, Canaman and DCDR, Minalabac at ranges 14.06-15.86 while high levels of P were illustrated by soils samples collected from Taban, Minalabac. For potassium (K) quantification, all soil samples fall under the “deficient” category with less than 0.2 meq/100g soil.

For post-harvest soil analysis, the electrical conductivity was measured. This is reflective of salt concentrations, defined as dissolved organic solutes and are commonly calcium, magnesium, sodium, chloride, sulfate and bicarbonate (Center for Agriculture, Food and the Environment, 2016). It was established that soluble salts above which fall above the normal range may cause to a number of crop issues root injury, leaf chlorosis, marginal burn and sometimes wilting. This is attributable to low yield productivity in areas with high EC levels such as Mangayawan. In this site, the most acidic soil at 5.36 mS/cm was observed, followed by soils sampled from DCDR. The rest of soil samples illustrated slightly acidic status of pH ranging from 5.61 to 5.97 mS/cm.

The presence of N, P and K in fertilizers are important for an optimum productive crop (Stellacci et al., 2013; Montavani et al., 2017). When these nutrients are at excessive doses, NPK balance effects to soil-related harms such as acidification, loss of organic matter, deterioration of the structure, and reductions in biological activity and fertility (Moe et al., 2019). The modern rice varieties engineered today demand standard nutrients that allow an optimal production. However, this brings threat as the same varieties drain the soil with important nutrients at faster phase

Table 1. Nutrient profile of the soils from IRDF plot.

		Nutrient element				
	Location Site	**N (%OM)**	**P (ppm)**	**K (meq/100g)**	**pH (1:1H_2O)**	**EC (mS/cm)**
Baao	Sta. Eulalia	4.06	14.06	0.14	5.61	0.199
	SF	-	-	-	-	-
Canaman	Mangayawan	3.84	6.94	0.16	5.36	2.56
	SF	4.13	15.86	0.10	5.97	0.08
Minalabac	DCDR	3.90	24.72	0.12	5.55	0.19
	Taban	4.06	14.06	0.14	5.61	0.19

SF-San Francisco, DCDR-Del Carmen Del Rosario

than the usual grain varieties (Singh and Singh, 2017). With this, there is a challenge to maximize the yields of crops cultured in degraded soil. Efforts required to mitigate such soil types is unsustainable on the global scale (Moe et al., 2019). Added impediment in the optimal rice yield are water irrigation systems with high concentrations of salt intrusion which can be facilitated by arrays of multifactor such as but not limited to human activities and climate change.

The most critical factor in the management of salt-affected soils is the irrigation quality of water being used (Tak et al., 2012). This is observed to positively influence crop yield and physical conditions. Therefore, well-strategized establishment of irrigation water quality is instrumental to understand management changes that can be employed for long term productivity. To date, salt content in irrigation waters is easily tested. Values are estimated in terms of EC and is the basic parameter in assessing the quality and suitability of irrigation waters.

Generally, all irrigation waters from sampling sites recorded an EC within the ranges of 0.403-0.557 mS/cm (Table 2). These are considered suitable to cropping except in some frequent conditions in very sensitive crops and highly clayey soils of poor permeability. According to Visconti and Paz (2016), EC of less than 0.75 mS/cm are ideal for cropping activities. Unexpectedly, high concentrations of salt are not detected in irrigation waters of Mangayawan, currently reported to be salt intruded area. This discordance may be explained with the large absorptions by the soil in the farming sites. According to the works of Tak and colleagues (2012), pH levels from 6.5 to 8.4 are normal for irrigation water. The above data suggests that all water systems are suitable for rice farming.

NO_3-N is also quantified in the study. It can be observed that DCDR showed an elevated concentration of nitrogen at 4.33 ppm and least levels were seen at equal amount of 1.44 ppm in Sta. Eulalia, SF, Canaman and Taban (Table 2). Nitrate-nitrogen (NO_3-N) is an important N source because it is abundant in wastewaters and irrigation waters across the globe. It is well understood that nitrogen is an essential crop nutrient that enables plant growth. Usually, the source of N is the natural soil and its supplementation in fertilizers. Nonetheless, the N found in the farm water sources has the same outcome to that of the applied fertilizer. Thus, N levels within these sources should also be considered because excessive nitrogen could cause issues like plant growth overstimulation, delayed maturity or poor quality. To address

Table 2. Physicochemical characteristics of irrigation waters analyzed.

Location Site		pH	EC (mS/cm)	PO_4-P (ppm)	NO_3-N (ppm)
Baao	Sta. Eulalia	6.75	0.403	1.21	1.44
	SF	-	-	-	-
Canaman	Mangayawan	6.69	0.545	27.36	2.16
	SF	6.51	0.557	32.26	1.44
Minalabac	DCDR	6.34	0.198	12.65	4.33
	Taban	6.88	0.215	36.34	1.44

SF-San Francisco, DCDR-Del Carmen Del Rosario

such concerns, ideal fertilizer and effective irrigation management are key players. Also, it is noteworthy that the need of crops differs in every maturation stage. According to a report, high nitrogen levels can provide positive effects during initial growth stages but may cause detrimental outcomes when overexposed during the later flowering and fruiting stages (Tak et al., 2010). This would mean that farm water with elevated N level can be used early in the cropping season but this should be controlled as the nitrogen needs deescalates as it matures. Also, in whichever rice variety, nitrate should be credited toward the fertilizer rate especially when the concentration exceeds 10 ppm NO_3-N or 45 ppm NO_3-. It can be deduced that all farming sites have optimal source of NO_3-N levels and conform with the required standard concentrations.

Integrated rice-duck farming (IRDF) is a potential farming technology that can be adapted for a sustainable agriculture. Aside from beneficial effects in the amelioration of crop yields, Xu and associates (2017) highlighted that the organic farming methodology significantly decreased the CH_4 emission and increased the N_2O emission. However, IRDF suitability to vulnerable communities along BRB is a challenge to be won by the farmers. Attention must be extended to the ducks such as herding them into rice paddies in the daytime and keeping them back before night time. Elaborated work confirm that regular feeds and the fencing instalment take an initial additional capital (Suh, 2014). Also, in salt intruded paddy fields, ducks must be monitored in their time of exposure because this condition may affect the duck health and behavior.

CONCLUSIONS

IRDF is a prospective farming methodology in tropical countries like the Philippines, with promising effect not just in the sustainable production of rice yields but also in mitigating the threats of biocides' long-term adverse health effects and more so, global warming. In this study, IRDF was investigated to improve various rice yield characteristics such as number of grains, number of tillers, number of panicles and the weight of grains in grams, supporting the notion that it can be employed in rural farmlands with close proximity to BRB. This study suggests that IRDF can be economically profitable even in flood-persistent areas because practical poultry products from ducks are favored by consumers, and thus can be an alternative source of livelihood in such areas. Taken together, more researches must be carried out to characterize other physicochemical parameters that can display pivotal effect on farming development. Future studies on the economic viability of IRDF is also warranted.

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CURRENT GOOD MANUFACTURING PRACTICES COMPLIANCE AND MICROBIAL EVALUATION OF SMOKED FISH FROM SELECTED ENTERPRISES IN NAGA CITY AND PASACAO, CAMARINES SUR, PHILIPPINES

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Abstract — Compliance to Good Manufacturing Practices (GMP) requirements and microbial quality of smoked fish from selected enterprises in Naga City and Pasacao, Camarines Sur, Philippines was evaluated. Seven enterprises were identified and were profiled as to processing techniques which were shown to be different among enterprises. Assessment to GMP compliance revealed that enterprises have very low conformity to organization, personnel, equipment and utensils, and hygiene and sanitation requirements. Three enterprises with more than 20 years existence, annual production of 10,000 kg to 30,000 kg and wider scope of distribution were chosen as source of smoked fish to be focused of microbial evaluation. Total plate count of the product revealed that only one of the enterprises produces smoked fish that is not beyond the standard limit 5X105 CFU/g. Detection for coliform revealed that values were low having values ranging from <50 CFU/g to <100 CFU/g however, smoked fish was found to be positive for contamination and presence of *Escherichia coli*, results showed counts ranging from <10 CFU/g to <20 CFU/g which is beyond the limits set by Philippine National Standards.

Keywords **— Smoked fish, enterprise, good manufacturing practices compliance, microbial quality**

INTRODUCTION

Smoked fish is an important diet as a protein source for developing countries due to its relevant cheapness and longer shelf life than other protein source. Smoked fish and other traditional products of fish such as salted, dried or fermented products produced by small scale family establishments are common in the Philippines (FAO, 1990). According to Bureau of Fisheries and Aquatic Resources smoking as a means to preserve fish is not as prevalent as drying but is seen as an important industry in Camarines Sur. In fact, the Department of Trade and Industry of the province provides assistance and trainings that aims to improve quality of produced smoked fish.

Smoking method lessen chances of possible spoilage by microorganisms and enzymatic reaction (Kobajashi et al. 2012) but smoked fish can still be contaminated with pathogenic microorganisms, due to the following factors namely; improper smoking conditions, distribution and improper storage (Agu et al., 2013, Akinwumi & Adegbehingbe, 2015) resulting to the products' limited shelf life. In fact, several studies set in Africa reported by Olaleye & Abegunde in 2015, Gbolagade et al. in 2012, and Akinwumi & Adegbehingbe in 2005 showed instances of detection in alarming levels of pathogenic microorganisms such as coliforms, *Escherichia coli, Salmonella* and *Staphylococcus aureus* in smoked fish products.

In the Philippines however, only few studies about evaluation of its quality especially in terms of microbiology are published. Information is scarce especially of smoked fish in Camarines Sur.

This study is in consonance to the increasing public interest and concern over food safety, as well as commercial pressure to improve food quality and shelf-life (Bell et al., 2005). It is aimed to evaluate the degree of compliance of smoked fish enterprises to the different requirements of good manufacturing practices. More importantly, this may address scarcity of information about microbial quality of smoked fish in Camarines Sur, Philippines.

MATERIALS AND METHODS

This study included interview of smoked fish producers as to profile practices, techniques and knowledge in handling smoked fish. Smoked fish samples were obtained from identified smoked fish enterprises in the Province of Camarines Sur. The study was carried out in two phases: survey and experimental.

Conduct of survey

Modified survey questionnaire designed by Kyangwa & Odongkara (2005) which gathered information on the processors' knowledge and handling practices of smoked fish and survey questionnaire utilized by Canini et al. (2013) to investigate on the characteristics of site and personal hygiene of identified respondents were used. Likewise GMP checklist (AO no. 153 s. 2004) intended to assess compliance of facilities to lay standards was also used. Focus of the interview was referred facilities by Bureau of Fisheries and Aquatic Resources and Department of Trade and Industry which were located in Brgy. Abella and Brgy. Sangay in Naga City and Brgy. San Cirillo in Pasacao, Camarines Sur.

After interview and initial assessment of identified enterprises, top three enterprises were selected based on the length in the fish smoking industry, average amount of processed smoked fish per year and the scope of distribution.

Sample collection

Sampling was done from February to March 2017, with a frequency of once a week during the same day of smoked fish production. Collection of samples was done every production schedule of the enterprises which were Tuesdays or Wednesdays. Five

samples of 250 grams each were obtained from each enterprise. Gathered samples were packed on original packaging used in the enterprises where smoked fish are wrapped on newspaper before packed on plastic bags. Evaluation of sample was done on the same day samples were acquired; prior to evaluation, samples were stored in freezer with temperature ranging from -4 to -10°C.

Microbial Analyses

Methods for microbial analyses of smoked fish sample used are procedures described in Bacteriological Analytical Manual (BAM), Association of Analytical Chemists (AOAC, 15th and 17th edition) and Food Microbiology and Laboratory Practices (Bell et al., 2005). Smoked fish samples were subjected to total plate count, coliform and *Escherichia coli* enumeration using Hygiena-MicroSnap rapid detection device.

Aerobic Plate Count

Twenty five grams of smoked fish sample was added with 225 mL distilled water and was blended for 2 minutes, resulting to 10-1 dilution. Prepared solution was regarded as the homogenate.

Using sterile micro pippetor, dilutions was prepared out of the homogenate. One mL of the homogenate was added to 9 mL of diluent to make dilutions; 10-3, 10-4 and 10-5 were plated out.

Detection and measurement of RLU (Relative Lights Unit)

Before transfer of enriched sample, detection device was allowed to equilibrate to room temperature before used. To bring the extractant liquid to the bottom of the tube, tube was flicked downward forcefully once. Then, aseptically, enriched sample from the enrichment device was transferred to the detection device by inserting swab to transfer sample up to the filling level indicated on the detection device. It was noted that filling was up to the fill line only as over filling may result to inconsistent and increased reading. The same as the enrichment device, the snap valve of the detection device must be bent and broken for activation. After activation, tube was shaken to mix liquids and right after was inserted to luminometer to initiate reading; displayed results were recorded as RLU.

Coliform and *E. coli* Homogenization of sample

Sample was homogenized through the same process described for APC.

Enrichment of sample

One (1) mL of aliqout from dilutions 10-1 was transferred to the enrichment device for coliform and *E. coli*. The same procedures and techniques described for MicroSnap Total Detection Device were employed.

Detection and Measurement of RLU

After transfer of enriched sample and activation of detection device, incubation at 37ºC for 10 minutes followed. After incubation, detection device was inserted to the luminometer to initiate reading; displayed results were recorded as RLU and were transformed to equivalent CFU/g using the table provided by the manufacturer.

RESULTS AND DISCUSSION

Selection of enterprises

Based on the information given by Bureau of Fisheries and Aquatic Resources and Department of Trade and Industry, a total of seven enterprises were assessed and visited for this study; four of which located in Pasacao and three from Naga City. Based on the given criteria (existence in the industry, scope of distribution, average production per year); two facilities in Pasacao and one in Naga City were chosen as respondents for this study.

Based on the data presented on Table 1, it showed that Enterprise 1, 4 located in Pasacao and Enterprises 5, situated in Naga City are the top three facilities to meet

Table 1. Summary of information gathered from the enterprises visited.

Enterprise	Existence (years)	Scope of Distribution	Average annual production kg/yr.
Pasacao			
Enterprise 1	+25	Partido, Pili, Ocampo (there are direct buyers)	36,000
Enterprise 2	1	Pili, Tinambac, Calabana	10, 080
Enterprise 3	15	Pasacao, Calabanga	36,000
Enterprise 4	+20	Pili, Naga, Calabanga	36,000
Naga City			
Enterprise 5	+55	Naga, Iriga, Buhi, Nabua, Naga (supplies some restaurants such as Graceland)	13,440
Enterprise 6	10	Francia (Naga)	6,720
Enterprise 7	17	Naga	13,440

the criteria given and thereby were chosen as respondents for the research where samples of smoked fish was acquired.

Compliance to GMP requirements

In order to evaluate the present condition and state of visited enterprises, GMP checklist developed by Zamudio et al. (2013) was adopted. Results gathered were correlated to the results obtained during microbial analyses. Enterprises were assessed based on the sections stated in the GMP requirements which include; organization, premises, equipment and utensils, sanitation and hygiene, and warehousing and distribution.

Organization

All of the enterprise has adequate number of personnel that compensate labor requirement probably because these are family establishments that involves all family members to the operations. However, no organizational structure with determined responsibilities is available; most of the time head of the family is the one who functions as quality assurance or production manager. Because of this, roles or functions of personnel are not specified thereby responsibilities are performed less effectively. All enterprises do not have available written documents containing standard procedures for processing, production and cleaning. These documents are needed to check and validate if procedures employed in every production are standard for operations. Production records are of importance in implementing process controls and traceability of error in case of production rejects. Lack of these documents results to variation in day to day operations which consequently leads to inconsistent product quality and specifications.

Premises

All enterprises failed to conform on the sections specified for requirements in premises. Plant design and size is one of key factors in attaining sanitary operations. Walls, ceilings, and floors must be made of concrete with no impervious finish so as to allow easy cleaning and limit harborage of undesirable microorganisms. Lighting and ventilation must be adequate enough for comfort of workers and personnel, and likewise to avoid contamination of food (FDA, 2004).

During evaluation, problems in conformity to these requirements were evident on occasions where products were directly laid on floor because of insufficient space that may possibly result to cross contamination and deterioration of smoked fish quality. Anihouvi et al. (2019) related high microbial load of smoked fish to exposure in unhygienic environment.

There are facilities that smoke fish in open air although majority have enclosed or protected smoking facility (71.42%) that is more ideal than the open air smoking facility which is more susceptible to contamination. Likewise, it was observed that all enterprises are near residential houses since these facilities are family establishments with close proximity to the owner's house and still others the owner's house agreeing to the report made by FAO (1990). Moreover, a number of enterprises were located near highly contaminated areas such as toilet, drainage, dust bin and pig pen which poses contamination of food products as these areas are harbored with physical, chemical and microbial contaminants (Canini et al., 2013).

Equipment and Utensils

Smoked fish enterprises usually use baskets during the boiling procedure and weaved baskets made of bamboo slits called kaing during the smoking process. Buildup of grime, food debris and dirt were observed on the equipment and utensils which were evident during visit in the enterprises. Bamboo or wood has uneven surface which is difficult to clean hence become an ideal growing ground for microorganisms which in turn can be introduced to the smoked fish. Equipment and utensils have direct contact to food products, making them a primary source of contamination (Olaleye & Abegunde, 2015). Thus, a requirement that utensils and equipment should made of stainless steels as these are corrosion resistant and so as to permit easy cleaning and sanitation. Likewise, correct washing and sanitation is also important to remove food debris, filth and minimize microbial contamination. Non conformity to these articles results to smoked fish that is likely to be contaminated with microorganisms cross contaminated from the equipment.

Personnel Hygiene

Personnel working in direct contact with food and those involved in processing shall be free from illness or communicable diseases such as cough, lesions, and boils which are source of microbial contamination. It was found that personnel in the enterprises do not have current medical records because these are small scale fish processors where majority of workers are family members. Although, personnel are free from obvious communicable disease that shows the awareness on the importance of having healthy personnel to work in the plant.

Likewise, it is also important that personnel conform to hygienic practices to protect food from contamination. Majority of enterprises have personnel conforming to hygienic practices though only few have formal training regarding sanitation and hygiene. According to FDA (2004) personnel must have knowledge about the importance of sanitation and hygiene to establish production of safe and clean food.

Personnel were found to be aware on the basic hygienic practices to be applied when working, all wash hands at least three times a day, some were using clean clothes and had finger nails cut. Jay et al. in 2008 reported that bacterial pathogens may be transmitted from humans to food and that poor personal hygiene may facilitate transmission. Hence, hand washing is one of the most critical hygienic practices as enteric pathogens can survive on the hands for three hours or longer. However, no enterprise practices the use of hairnets in the site which can add more points to food safety and some females involved in processing has nail polish.

Sanitation

Sanitary facilities to support hygienic operations must also be present. Hand washing and toilet facilities are readily accessible for use. However, there are enterprises which have toilet facilities near the plant which poses the risk of food to be contaminated with fecal matter or other human excretions. Akinwumi & Adegbehingbe (2015), Uduchukwo et al. (2016) reported that the quality of smoked fish is dependent on factors including site and personnel hygiene.

Production and Process control

Written handling and manufacturing procedures employed by the enterprises from receiving of raw materials, through processing and during the storage of finished products are not present. According to FDA, it should be ensured that production processes do not contribute to the contamination of food products making process control important. It should be noted however, that all enterprises are small scale food processors that do not have quality control officers to inspect and function as process and production control. Operations are carried out from knowledge passed on from family generations thus conformity to standards is not evaluated.

Warehousing and Distribution

All enterprises are practicing the first in-first out (FIFO) system. However, storage facilities of finished products are not secured from rodents, insects or other pests. Finished products are handled on the same area for processing thus products are exposed to spillage, dirt and garbage. The exposure of finished products may result to physical, microbial and chemical contamination that may pose health risks to consumer.

In general, all enterprises visited were found to have little conformance to requirements of Good Manufacturing Practices. This result is found to be in consonance to the report that small scale fish processors or entrepreneurs in the Philippines are often non-compliant to set standards especially that of concerning hygiene and sanitation (FAO, 1990). It was also reported that only fish processing facilities that are for export conforms to the standard set by authorities (FAO, 1990) but it should be noted that smoked fish produced by these small scale processors are those accessible for majority of buyers thus its quality and microbial safety must be checked.

Characteristics of Operation and Site Hygiene

Site hygiene

Akinwumi & Adegbehingbe (2015), Uduchukwo et al. (2016) reported that the quality of smoked fish is dependent on factors including site and personnel hygiene; the quality of raw materials used; the preparation employed for the raw materials; and the handling techniques used before, during and after processing. Thus, hygiene and sanitation in addition to handling and processing techniques have direct implications on the quality of smoked fish.

Processing Techniques

Based on the hot smoking procedure stated on the PNS/FDA 26 (2010), questions to assess processing techniques carried out by the enterprises were developed. Washing of raw materials before processing significantly lowers the microbial load of materials, 42.85% of enterprises evaluated were found to wash raw fish 2-3 times before salting or brining. However, 2 out of 7 facilities do not wash and directly proceed to processing. With these numbers, four uses tap water while one uses well pump water.

In addition, ratio of fish to salt during soaking in brine solution and duration varies from enterprise. All enterprises do not monitor and has no standard time for soaking. Two enterprises soak for 30 minutes while the rest soaks until raw fish

becomes firm. Brine soaking does not just add to the salty taste of the smoked fish this also results osmotic pressure that draws out water from the fish and act as an additional preservation method (Oğuzhan & Angiş, 2012).

The same observation were made for the boiling of smoked fish in brine solution; in all the enterprises boiling temperature and duration is not monitored though some enterprise set indices and parameters to know if boiling is enough. Likewise, smoking temperature and duration is not monitored; during interview it was revealed that the smoking duration depends on the size of fish and amount of smoke. Others use the appearance of fish to indicate if smoked fish is already cooked. Only one of the assessed enterprises does not use artificial colorant but 85.71% apply artificial colorant at levels that are not regulated.

As reported by Adeyeye (2018), Andhikawati & Pratiwi (2021) and Hagos (2021), there are varying methods to produce smoked fish and that these methods has effects on the sensory and microbial quality of the finished product.

Results of Microbial Evaluation

Aerobic Plate Count

Figure 1 shows the microbial load in log10 cfu/g of smoked fish for every week of sampling. Enterprise 1 was consistent into producing smoked fish that is of conformity to standard limit. Microbial load of Enterprise 4 was higher and was revealed that out of 5 sampling week, 4 had values that exceeded limit. Similarly, Enterprise 5, found to have the highest count was consistent in producing smoked fish beyond the standard limit.

The varying counts among the enterprises can be attributed to the differences in smoking techniques, variation in sanitation and hygienic practice (Gbolagade et al., 2012, Olaleye & Abegunde, 2013, Agu et al., 2013) that has direct impact on the quality of fish.

Similarly, the difference in the microbial load among the smoked fish in each enterprise can be possibly attributed to absence of standard process control and process monitoring. Although different fish species were subjected to microbial analyses; Akinwumi & Adegbehingbe (2015) claimed that microbial flora associated with fish could be from the environment from which it is harvested and not specific to a particular species making initial microbial load of raw fish also a factor.

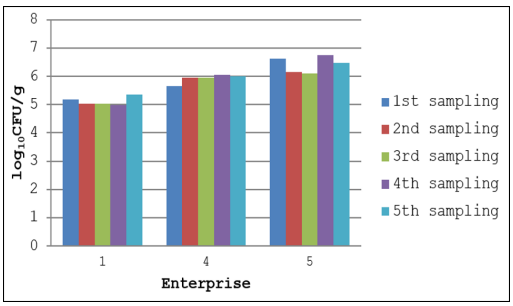

Fig. 1. Total plate count of smoked fish for every week of microbial evaluation.

In addition, Ibrahim et al. (2014) reported that microorganisms detected in smoked fish may be introduced from water used for washing, utensils and wrapping materials and the exposure of products or raw materials to high temperature and unhygienic condition.

Coliform and *Escherichia coli*

Coliforms are enumerated and detected in food products in microbial analyses as this microorganism is a general sanitary indicator of a food processing environment and it is also considered as a significant standard of hygiene and sanitation (FDA, 2013). Dutta et al. (2018), Akinwumi & Adegbehingbe (2015) and Olaleye & Abegunde. (2015) detected the presence of coliform in smoked fish and reported that the presence of this microorganism is an important public health concern. Coliforms

are easily killed by heat, thus are ideal when testing for post-processing contamination of cooked fish and fishery products (Jay et al., 2008).

Smoked fish samples from different facilities were evaluated as to the presence of coliform and it was revealed that all were detected to have presence of coliform. Table 2 shows the coliform RLU count of the smoked fish samples.

Results showed that the coliform count from the enterprises range from 4-12 Relative Light Units or <20-<100 CFU/g; on average, smoked fish from Enterprise 1 was found to have the lowest coliform RLU that is 5 RLUor <50 CFU/g while Enterprise 5 was found to have the highest count having mean of 9 RLU or less than 100 CFU/g. The difference in the level of detected microorganisms between enterprises can be attributed to varying factors such as differences of pre and post-smoking processes among enterprises (Agu et al., 2013), smoking and processing techniques and the hygiene and sanitation conditions among others (Akinwumi & Adegbehingbe, 2015). However, if these results are correlated to the information gathered about the enterprises. Enterprise 1 and 4 has lower coliform count possibly due to shorter holding time for the fresh fish as it is near the fish source in Pasacao Fish Port compared to that of Enterprise 5 in Naga City which utilized frozen or fresh fish. Although, it was expected that Enterprise 5 will have the lowest count because it has conformity to GMP requirement regarding the use of stainless steel equipment and utensils.

On average, coliform counts of the samples indicates lower microbial load compared to the previous studies conducted about the microbiology of smoked fish (See Table 2). This may be attributed to the difference of sampling time, related studies focused on the microbial analyses at markets while this study focused on newly processed product from the enterprises. This coincides to the report of Agu et al. in 2013 that post processing contamination significantly affect the coliform count of smoked fish. Olaleye & Abegunde (2015) claimed that low counts for coliform may be attributed to conformance of food handlers to basic sanitary rules.

Escherichia coli

Escherichia coli is an enteric bacteria that is used as an index for fecal contamination and unsanitary processing of food products (FDA, 2013). Detection of this microorganism is important as its presence pose health risk and causes gastro intestinal illness.It is shown in Table 3 that smoked fish samples were detected to be positive with *E. coli*. Values were ranging from 0 RLU to 7 RLU equivalent to <10 to <50 CFU/g having values that were beyond the limit set by PNS/FDA 26 which was 11. Among the facilities, Enterprise 1 was the lowest; followed by Enterprise 4 and lastly Enterprise 5 that has the highest count.

Table 2. Coliform in estimated CFU/g of the smoked fish.

Enterprise	Sampling schedule and microbial load (Estimated cfu/g)				
	1	2	3	4	5
1	<50	<50	<50	<50	<50
4	<20	<20	<50	<50	<100
5	<50	<50	<100	<100	<100

Table 3. *E.coli* count estimated CFU/g of smoked fish.

Enterprise	Sampling schedule and microbial load (Estimated cfu/g)				
	1	2	3	4	5
Enterprise 1	<10	<10	<10	<10	<10
Enterprise 4	<10	<10	<20	<10	<10
Enterprise 5	<20	<20	<20	<20	<20

It can be seen that smoked fish sample form Enterprise 1 was consistent to having less than 10 CFU/g of *E. coli* and thus conforms to the standard value set by PNS/FDA 26 (2010) for smoked fish. All throughout the sampling collection, this enterprise produced smoked tamban (sardine species) a relatively small variety of fish thus it is concluded that *E. coli* count is directly proportional and affected by the fish size. In addition, there are limited sources of contamination in this enterprise; though it is near the owner's house, processing facility is physically separated from it.

Enterprise 4 produces the same variety of smoked fish but has higher *E. coli* count with 1 occasion out of 5 sampling instance exceeding limits, during the information gathering it was found out that a pig pen is located at the back of the facility that is of proximate distance from the processing area. The same personnel working in the processing area may be the same personnel working in the pen that causes cross contamination. In addition, proximity of the area where contaminants be, can justify these results. The facility is not physically separated from the owners' house and is surrounded by residential houses.

However, it can also be that the water source from which the raw fish was acquired has positive number of *E. coli.* According to FDA in 2011, harvest areas for some shellfishes are examined for safety of *E. coli,* this method however is not done for fishes thus the possibility that even before processing the microorganism is already present. According to Alikunhi et al. (2017) all fish and sea food are susceptible to contamination originating from the marine environment. This is further aggravated by the practice of not de-gutting or eviscerating fish for smoking.

CONCLUSION

Based on the data given by Department of Trade and Industry and Bureau of Fisheries and Aquqtic Resources, there are seven established smoking enterprises in Naga City and Pasacao, Camarines Sur, Philippines.

Smoked fish enterprises in Naga City and Pasacao, Camarines Sur, Philippines have been long existent, distribution of produced smoked fish are mainly in the province. It was revealed that annual production ranges from 6,720 kg-36,000 kg. Facilities were found to be family establishments that belong to the small scale fish processors that have low conformity to the GMP requirements. Likewise different processing techniques were employed by each facility that has consequent effect to smoked fish quality.

Only smoked fish from one of the enterprises was found to conform to the standard for total plate count limit; although coliform count was found to be significantly lower than the values reported from recent related studies conducted. However, all smoked fish evaluated were found to be positive in *E. coli*. Samples from Enterprise 5 were revealed to exceed standard limit for *E. coli.*

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SMALL-SCALE AQUACULTURE: LESSONS FROM THE FIELD

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Abstract — There are several issues, concerns, situations, and dilemma that are often omitted because the focus and emphasis of program implementation, sometimes for very valid reasons, is on the technological aspects. As a result of this, many initiatives, especially those that are aimed at benefiting smallholders, are not able to meet the expectations of the results – outputs, outcomes and impacts – mostly as the emphasis on social as well as economic dimensions are lacking. Any technology cannot be owned and accepted by farmers if they are not designed with the social dimensions in mind. This paper that deals with issues as well as the possible approaches and solutions, carries the experiences of the author working as a development professional in some South-east Asian and South Asian countries including in the Philippines, Lao PDR, Viet Nam, Bangladesh and India. Some of these perspectives also reflect point of views and experiences of other professionals in the field.

***Keywords* — Aquaculture, livelihoods, small-scale, social dimensions, women**

INTRODUCTION

It has been observed that most aquaculture and fisheries projects and programs are run by very competent fisheries and aquaculture specialists and organizations. However, though in most such programs, there is a provision for 'social scientist' but unfortunately they do not have much of a say on how things should be run. While having emphasis on technical dimensions is an essentially apt approach, it misses out on the understanding of community members – the primary stakeholders to such initiatives – if the social dimensions are not considered seriously. As a result very often extremely well-structured, well-designed, and well-meaning interventions fail as the social dimensions of the program are either not taken into account during the designing and implementation of the program or have a mismatch on how it is structured. The technical solutions of most small-scale aquaculture systems are in place and the focus should be emphatically matched with the social dimensions of the program to achieve direct and positive impacts. This paper typically represents "smallholders" which is defined in India as those owning less than 2.0 ha of farmland. In India, for example, they comprise 78 percent of the country's farmers, but own only 33 percent of the total cultivated land; they nonetheless produce 41 percent of the country's food-grains.

Aquaculture and Livelihoods

While aquaculture, for many farmers can be a main source of livelihood or primary livelihood, for many it is a secondary or tertiary source of livelihood. On several instances, aquaculture projects and programs, attempt to 'impose' aquaculture as the primary livelihood for the household and attempt to 'graduate' the farmer into considering this as the primary source of livelihood. It may, however, not be the best thing to do as it has serious implications on their primary livelihoods and the way it is carried out by them. These kinds of forced changes may have several negative implications on their lives and livelihoods.

In order to introduce aquaculture to subsistence farmers, it is necessary to understand how the role of aquaculture impacts other livelihood activities. The understanding of the 'space' they have or can have for aquaculture, will be the key to a successful intervention.

Increasing Farmers' Income

In recent times there has been a lot of emphasis on increasing farmers' incomes. However, many a times it is misconstrued as increasing 'farming incomes'. Most small-scale farmers do what they can best do with the given limitations of resources – infrastructure, land, water bodies, input supplies, etc. – and in some ways have reached a point of saturation. Hence even if they have a little more of resources, they will not be able to add much to their incomes.

So while on one hand improving efficiencies will lead to improved production (both quality and quantity), they need to be encouraged to additionally explore possibilities of off-farm and non-farm enterprises either individually or in collectives. While the 'farming' itself has reached a point of saturation, the additional and complementary sources of livelihoods (off-farm and non-farm) not only provide an additional opportunity but also allow other members of the family to be engaged meaningfully (Nasar et al., 2018).

Partnerships

In most instances, 'partnership' is seen as 'partnering with donor or funding agencies' and not with like-minded organizations that can complement rather than compete for the cause. There are several organizations that are, for example, working around health or watershed management or agriculture programs that can become a very effective partner.

Partnering with local government agencies and local NGOs is a proper strategy in order to phase out smoothly. This also takes care of institutional capacity building and enables the community to work closely with the government or other major stakeholders. Complimenting each other in a holistic manner will be important to accelerate livelihood growth (Al Ruqishi et al, 2020).

Convergence

There are several wonderful government and other initiatives and programs such as watershed management, agriculture, horticulture programs and the likes that have demonstrated a fairly visible impact over a long run. Different states in india, for example, have different sets of policies and program for the fishery sector. The central government has published a Report on Convergence Initiatives in India (Ministry of Rural Development) and states that the convergence of different programs like: Watershed Programs, National Agriculture Development Program (Rashtriya Krishi Vikas Yojana), National Horticulture Mission, Scheme of Artificial Recharge of Ground Water through dug well, BRGF (Backward Regions Grant Funds), with MGNREGA (Mahatma Gandhi National Rural Employment. Guarantee Act) will enable better planning and effective investments in rural areas. This convergence will bring in synergies between different government programs/schemes in terms of planning, process and implementation. This will also facilitate sustainable development. (Report on Convergence Initiatives in India - An Overview; 2013).

Convergence of such programs to include aquaculture and fisheries initiatives is not only possible but also extremely practical. Also lots of learning can be drawn from different state policies like that of the Madhya Pradesh State fishery policy in India that protect farmers during drought and also gives special consideration to women.

Common Property Resources (CPRs) and Individual Ponds

While most of the laws are meant to address the needs of the stakeholders on CPRs, there is very little understanding and clarity about the support and contributions that can be received or made for smallholder individual ponds.

Proper documentation of issues, concerns and needs of smallholder individual pond owners should be encouraged in order to influence policies conducive to their practices. Also, it must be noted that common properties need a strong institutional base that require sustained facilitation and different set of protocols as compared to private water bodies.

Community mobilization

In a large percentage of cases for small-scale aquaculture and fisheries projects, the focus is on individual households across the value chain. As a result of this there are scanty examples of fisheries collectives unlike in the agriculture sector. Small and marginal farmers constitute a majority in Indian agriculture but are integrated through traditional value networks which lack supportive environment with institutional and infrastructural system, inadequate resources and effective coordination within the value networks (Singh et. al., 2018). Given the success of Farmer Producer Organizations (FPOs) in India, the country aims for an additional ten thousand FPOs and several agencies, both government and private, are contributing to the cause. Encouraged by this, there have been some evolution around Fisheries FPOs but a lot more needs to be done.

Considerable groundwork on community organizing has to be done before introducing an aquaculture project to communities which do not have any previous experience in aquaculture. The government will need to take a cue from the Agriculture sector and promote fisher collectives as well.

Informal Collectives

Grouping large number of households for one large cage, reservoir or pond system, for example, has its negative impact (such as conflict etc.). Similarly single-system single-household methods also do not always work because of the lack of confidence with technical aspects on the part of the farmer in addition to the required investments. This also includes the issues pertaining to inaccessible input and output prices and markets.

One relatively good strategy would be to have 'small affinity groups' (three to four households) working together. The process of grouping 'birds of the same feather' has to be carefully done. In any case, it will be important to have informal collectives first before they graduate into more formal and larger structures.

Information, Education and Communication (IEC) Material

Reliance on extension materials of the usual descriptive type is unfounded in communities with low literacy. In such instances, hands-on training and demonstration are more successful. With the emerging scenario, digital learning space is going to play a key role.

Extension materials should be user-friendly with lots of self- explanatory sketches and diagrams. Video documentation to which the farmer are seen to be most responsive, is a good training material. The farmer trainer should be trained to use such simple materials for echo-training, etc. With the changing times, digital learning is and will play an important role in educating the farmers both technically as well as on social issues.

Role of Women

Women involvement especially in fish culture is not guaranteed although many women participate. The reasons for this could range from the roles that is assigned to women at the household level to the distance of ponds from the household. Since women are engaged with multiple roles both at the household and at the community, they have little time left for accommodating additional responsibilities. Women play a critical role in every link of the value chain in small-scale fisheries, although their best-known roles are in processing and marketing of fish and other fishery products. This perception of the highly gender-segregated division of labour (men fishing / women processing) has shaped the generalized approach in supporting development initiatives for small-scale fisheries (Lentisco & Lee, 2015)

Fish-ponds and / or culture systems close to the house have been observed to enable women's involvement. This will also enable other members of the household to contribute in fish culture across the value chain – all the way from feeding, up keeping of ponds, watching out for disease outbursts, harvesting, cleaning, shelving and eventually selling.

Planning and Management

While the projects plan according to their preferences of logistics and other criteria, it oftentimes fail to address the needs of farmers related to their timings that they are mostly available. When a training, for example, is planned in seasons when the farmer and other members of the household are busy with other livelihood activities, it misses out on the expected attendance and attention of farmers.

Training courses must follow the relevant seasons of fish spawning and grow out. The rice planting season is critical to farmers and their involvement is limited during this period - do not plan farmer activities during the preparation and planting season.

Pond Management

Pond management is critical and crucial for all aquaculture systems but particularly so with small ponds. As stated earlier, better pond management will result into a robust ecosystem, thus providing an able

environment for fish growth.

There are plenty of reference materials that are simple and easy to use and can be found online. Several agencies provide short trainings and insights into pond management. There is a plethora of information materials available on YouTube, for example, that will come very handy to train farmers. However, the best way is learning by doing but the key to it is sufficiently good plankton growth (greenish tinge of the water) and sufficient oxygenation.

Disaster Management

Aquaculture and fisheries face the brunt of most disasters – mostly floods and typhoons. As a result of this, on one hand the projects suffer a serious setback but on the other, it is the resource poor community member who gets into a no-return situations.

Proper planning and foresight needs to be considered in relation to typhoon and other natural disasters. This entails proper location of ponds, cages and other systems that are less affected by typhoons. Short-cycle systems with fingerlings in place of fry stage will ensure harvesting before a predictable flood season.

Integrated Agri-Aqua (IAA)

It is not uncommon to have farmers indulge with several farming initiatives such as agriculture and aquaculture in a combined way. There are several examples of this such as rice-fish culture, duck-fish culture, etc. Several farmers, for example, are engaged with ornamental fish breeding and culture which not only fetches a comparatively higher price but can also be done in relatively smaller water bodies. The fish yield from the IAA ponds was 60% higher compared to non-IAA ponds because of a more frequent use of on-farm resources and better management. The net income from IAA ponds was 175% higher compared to non-IAA ponds, due to reduced costs and higher yields. (Mulokozi, 2021).

Farm diversification is a risk aversions strategy for smallholders. If one component fails, the other can provide the critical support for survival. The different components interact in a symbiotic and synergetic manner, enhancing overall production, optimizing resource use and thus providing for the subsistence needs of the household. Trees provide shade for crops and livestock while producing fruit; livestock manure is used as a fertilizer and crop by-products are fed to animals. Integration of aquaculture into smallholder farming system improves food and economic security. This also serves as a platform for additional income and engagement of other family members. With the emerging focus and success of Farmer Producer Organizations (FPOs) and other form of agriculture collectives, it is possible to educate and convince them to use their water bodies for integrated agri-aqua systems.

Monoculture vs Polyculture

In many cases, fish farmers prefer single species culture for many reasons but primarily because they have gathered experience over the years with a single species throughout the value chain including marketing. In the Philippines, for example, the most preferred species is Tilapia because of its established success in other parts of the country and its market value. Similar trends are being seen in India primarily because it is demand driven. Culture of carps such as Rohu and Catla in the Bhimavaram region of Andhra Pradesh, is a good example of this. In the case of Bhimavaram though, the produce is essentially commercial and may not necessarily cater to the needs of small-holders.

Polyculture for small-holders can serve as a risk aversion strategy and the diversity also helps to maximize natural food in the ecosystem. Ideally larger ponds should be stocked with different varieties of carps although local market preference is also for smaller species. Markets in states where fish is a major consumer item, such as West

Bengal, Odisha, Assam, etc. also prefer smaller species on their table. This also encourages in situ conservation of species in addition to providing value in micro-nutrient supply which otherwise larger species lack.

Demonstration

In many instances, farmers fail to adapt a practice as it is unknown to them. If a new technology or practice such a cage culture or pen culture or for that matter, rice-fish culture is introduced, farmers would like to see a working example of these before deciding if they want to take it up.

A working example (of systems - ponds, cages, etc.) in their village is necessary for them to believe that a new system/ method of production is possible. Setting up demonstration systems is therefore a good way not only to create awareness but also for the farmers to see it as something doable.

Farmer Trainers

It is very difficult logistically and financially to train a very large number of farmers in one go. At times it is also not possible to have ideal field sites for demonstrations etc. Even if the trainings are conducted, there is no manpower to hand hold or follow up and support the farmers in the field.

Farmer to Farmer (F2F) extension approach in agriculture is a systematically utilization of community leadership and informal communication between farmers. As a generic term we use it as 'farmer trainer', even though it goes by different names e.g. lead farmer, farmer-promoter, and community knowledge worker. This approach helps in building effective, farmer-centred extension systems and empowering farmers as change agents for improving livelihoods in their communities (Meena et al, 2016).

Echo-training with farmers themselves as the lead resource persons is a good strategy. It enables farmers to have a sense of ownership on the process also and not on the culture systems alone. This also enables better use of limited extension staff resources as some of these farmer trainers (also known as 'farmer friends') can be used as extension agents and technical staff.

Seed Availability

While many projects ensure production of quality seeds, there are very few examples of community owned and managed hatcheries. As a result of this, the producer has to be completely dependent on either government owned or private hatcheries. On one hand there are very few collectives and on the other, even lesser community owned and managed hatcheries.

Fish fingerling availability and distribution is a major constraint in geographically isolated areas. Therefore farmer-based fingerling production is critical for expansion of aquaculture especially in geographically isolated areas.

Seed Production and Beyond

Most of the hatcheries operate in a location where they can supply seeds to a very large geographical area. Many a times because of the distance that has to be covered for transportation of fish seed and fry, there is a very large percentage of mortality. This discourages the farmers to invest time, money and effort. Entrepreneurs who can produce quality seeds and grow out seeds to fry to fingerlings stages should be encouraged.

Community owned and managed seed production systems will go a long way. Nursing of fingerlings to a larger size separately in nursery systems will overcome many production related problems - transportation stress, short grow out season in rainfed ponds, predation, water quality stress at stocking, etc.

Feed Availability from Local Resources

One of the major costs in fish farming

is the feed. Relatively high prices for commercial feed favor large, vertically integrated fish farms whereas small-scale farms are becoming increasingly vulnerable to rising feed costs and the highly competitive market. Since the volumes produced by small-holders and small ponds cannot compete with commercial enterprises, the margins of profit are abysmally risky.

If the right pond management methods are brought into use, it will also enhance plankton production leading to natural food availability in the ponds. While this may suffice for extensive systems, additional formulated feed may be required for semi-intensive and intensive systems. Encouraging micro- and small feed making enterprises that process locally available resources like crop and livestock byproducts has potential for ensuring the supply of low cost feed without compromising its quality and also generating local employment. This will lead to better profit margins thus encouraging small-holders to invest time, money and effort.

Poaching

Theft of stock is a primary concern of farmers and deters investment and inputs to the system. This is another reason why ponds and cages nearer to the houses or within the community area are well fed and productive. Ponds in rice-paddies away from home do not encourage proper investments.

Some of the approaches to overcome this problem range from forming 'affinity groups' (of 4 to 6 pond or cage owners in the same vicinity), to taking turns to guard the system to outsource guarding to private individuals – most of which cannot be done by individual farmers.

Value Chain

There are several opportunities in the value chain that ranges from farm to fork which have not been tapped effectively. There are several interventions, for example, hatcheries, transportation of seeds, input and output supply and prevention of post-harvest losses that can be a point of intervention for NGOs that work around fisheries and aquaculture or in partnership with such organization.

Earlier value chain studies were concentrated on tradition approach. In this approach, the focus was mainly to economic dimension. The social, behavioural and institutional dimensions were focused separately without any interconnectedness. While, new approach is a holistic and integrated approach with inter connection of all the dimensions together (Social, economics, behavioural and institutional dimensions). (Jeyanthi and Chandrasekar, 2017).

NGOs and local organizations can possibly identify one or more links in the value chain and play the role of a key stakeholder thus adding value to what the smallholders are engaged with. Hence, it is time to move ahead from traditional fishery cooperatives to Farmer Producer Organization system for developing entire value chain rather than just fish production.

Prevention of Post-Harvest Losses

There is very little authentic data on the percentage of post-harvest losses incurred by both commercial and smallholder farmers. However, there is enough anecdotal evidence and some authentic data to prove that the percentage of losses is high and that it is a major concern.

Huge losses occur along the fish value chain, both in terms of quantity and quality due to discards at sea, improper handling, storage & icing, lack of cold chain facilities and delay in transportation. Reducing harvest and post-harvest fish loss will enable money saving for the primary producer, enable the sector to feed more and ease the pressure on water, land and climate. The fish landing sites are numerous and remote in interior parts of the country

sometimes inaccessible. Delay in transport, non-availability of ice for proper storage brings down the price of freshwater fishes in the markets which is an economic loss for the primary producer (Geethalakshmi, 2020).

It is possible to use local materials backed up with some indigenous knowledge and practices to prevent or reduce post-harvest losses by increasing the shelf-life of the harvested fish especially for smallholder farmers. This will also take care of the quality of the fish that will be made available to the consumers.

Credit and Financial Assistance

One of the bottle necks in small-scale aquaculture and fisheries is that it requires relatively larger investments. In many cases the farmer does not have easy access to credit. Subsidies and state intervention are essential for the sustenance of small-scale fisheries across the world and are also necessary to promote sustainable practices. In a study where semi-structured interviews with small-scale fishers from four fishing villages in two main coastal districts in India show that although a large share of the sampled population (90%) is aware of the existence of subsidies only 42% have availed of them. Results pointed to technical, political and social factors that inhibit small-scale fishers from relying on state welfare measures as a security against vulnerabilities. (John et al., 2014).

As to credit, farmers wish to have money to improve their systems but are unwilling to borrow at commercial rates. The transition from subsistence fish production to income generating activity is gradual, time taking and varies among farmers. While borrowing at commercial rates may not work out well, it is possible that well-established collectives such as SHGs may lend to groups or for that matter, approach lending agencies such as banks as collectives rather than individual farmers.

CONCLUSIONS

There are several examples across the globe where projects have performed well as long as there has been sufficiently robust inputs – technical, infrastructural and social – but have failed to sustain the program due to lack of ownership from the communities. Involving the community members is essential not only during the implementation of the program but also during the conceptualization. Such consultations go a long way to have the right blend of implementation and ownership. While designing projects and programs that are aimed at benefiting small-holders, the above mentioned issues, concerns and dilemma should be considered. This will not only enable better implementation of programs and maximize available resources and opportunities but will also receive a better buy-in from the primary stakeholders – the smallholders.

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FIRST REPORT OF *Thielaviopsis ethacetica* CAUSING NECK BENDING/ INCLINATION OF THE UPPER REGION OF OIL PALMS IN NIGERIA

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Abstract — Plant diseases are among the major challenges faced by the oil palm cultivation in Nigeria. The major plantation diseases of the oil palm include Fusarium wilt (*F. oxysporum fsp. elaeidis*), dry basal rot (*Ceratocystis paradoxa*), *Ganoderma* trunk and recently neck bending/inclination of the upper region of the palm noticed in some Southern and Western States of Nigeria. Pathological and molecular investigation into the etiology of the disease was found to be caused by *Thielaviopsis ethacetica*. Depending on the disease severity on the oil palm, the symptoms include gradual inclination of the palm, yellowing of fronds, drying of the leaves of the palm from the base, production of a fermented fruit odor, and finally the collapse and death of the palm. *T. ethacetica* was consistently isolated from the diseased oil palms; produced numerous spores of two types (microconidia and macroconidia) and were further characterized using spores sizes, morphology and sexual compatibility test. The aggressive nature of *T. ethacetica* on the oil palm was confirmed by the sexual compatibility test resulting in the presence of sexual spores in the tissues of the severely affected palms while asexual spores were present in tissues of the mildly affected palms. The outcome of this study confirmed *T. ethacetica* to be the causal agent of neck bending/inclination of the upper region of the oil palm in Nigeria.

Keywords **— Neck bending/inclination of upper region, Nigeria, oil palm, *Thielaviopsis ethacetica***

INTRODUCTION

The oil palm in the wild appear to be free from serious pests and diseases not until after the World War II when effort was been made to make it a plantation crop (Hartley, 1988). Some of the major plantation diseases of the adult palm in oil palm plantations include the Fusarium wilt (*F. oxysporum fsp elaeidis*), dry basal rot (*Cerastocystis paradoxa*) and the Ganoderma trunk rot. National survey carried out in Nigeria between 1947 and 1984 showed that the incidence rate of the Fusarium wilt (*F. oxysporum fsp elaeidis*) disease ranged between 0.03 to 47% and can destroy up to 47% of field palms (Oritsejafor,1989). Effort towards management of the Fusarium wilt disease of the oil palm was screening of oil palm progenies against different species of *F. oxysporum fsp. elaeidis* to obtain tolerant palms.

The *Ganoderma* truck rot and the dry basal rot diseases caused by *Ganoderma* and *Thielaviopsis* spp. respectively have been effectively managed using good agronomic practices and chemical base fungicides. These diseases have been under control since their outbreaks. However, there was a sudden outbreak of the *Thielaviopsis* spp. disease in some oil palm plantations in the year 2019 resulting in a rare disease symptom (inclination of the upper region of the palm) in the oil palm. Survey studies showed that the source of the oil palms was not indigenous. The outbreak of the disease was first recorded in Southern part of Nigeria in a commercial oil palm plantation of 11,000 hectares, affecting oil palms between the ages of 2-3 years and later in some other plantations in Western part of Nigeria. The disease has a characteristics symptom of neck bending/ inclination of the upper portion of the oil palm (Esiegbuya, 2019). The disease is observed to be common in oil palms between the ages of 2-3years, with incidence rate of between 65%-75% in affected plantations. The severity of the disease on the palm results in complete death of the palm within a month of symptom manifestation. Asymptomatic palms sometimes later suffer from fruits abortion during its bearing stage thereby brings about huge loss to the farmers.

Neck bending disease or inclination of the upper portion of palms has been previously reported in date palms Mirzaee et al. (2014); Abdullah et al. (2009). According to Abdullah et al. (2009) *T. paradoxa* and *T. punctulata* isolated from the soil of date palm plantations were responsible for the disease during the process of transplanting offshoot of the palm to the field. Suleman et al. (2001) also implicated the pathogens *C. paradoxa* and *C. radicicola* colonizing the date palm that are under stress also resulting in neck bending and eventual death of the palms.

Due to the huge economic importance of the oil palm and this being the first report of this disease symptom with the oil palm in Nigeria, and also the ability of the pathogen to cause dry basal and fruit abortion at later stages of the oil palm development necessitated the need to carry out a study on the etiology of the pathogen on the oil palm with the aim of providing a management strategy for the disease.

MATERIALS AND METHODS

Study locations

The outbreak of the neck bending/ inclination of the upper region of the palm was reported in several plantations in Nigeria, however, the two study locations used in the study was selected based on plantation size and availability of weather data.

Plantation A, where the outbreak of the disease was first observed is a private-owned plantation of 11,000 ha situtated in Edo State, Benin City, Southwestern Nigeria, is bounded approximately by latitudes 6.08° and 6.30°N and longitudes 5.01° and 5.27°E. The climate of the region

is characterized by a double maximal year-round rainfall pattern with a mean monthly rainfall of about 2000mm which peaks between May and October and a mean monthly temperature of 27°C.

Plantation B where the incidence of the disease was not recorded is an agricultural research institute located in Edo State, Southern Nigeria in the heart of the oil palm belt region. It is on latitude 060 0331N and longitude 050 37 1E and on altitude 149.4m. The region is characterized with high rainfall and temperature. Rainfall is over 2066mm per annum, and temperature of 30 – 33°C.

Other plantations where the outbreak of the disease was recorded but with no weather station were in Egbedore, Ondo and Ikole Ekiti, Ekiti States of Nigeria.

Soil Water Deficit

The water deficit was determined according to the methods of Chaillard et al. (1983); Corley (1996) and Roslan and Haniff (2004) cited in Bakoumé et al. (2013). Evapotranspiration (ETc) of oil palm in the month was considered to be 150 mm/month in a month with less than 10 days of rain and 120 mm/month for 10 days and above of rain. Soil water deficit was calculated by the difference between the monthly rainfall (ER) values and ETc.

Collection and Isolation of Fungal Strains

Ten samples each were collected in 2019 from roots, stems, meristem, bud tissue (under the meristem), spear leaves, leaflets from old leaves, petiole bases of young leaves, inflorescences, fruit peduncles and soils near oil palms (*E. guineensis*) affected by the neck bending/ inclination disease. After tissue collection, the samples were washed with water, surface sterilization was performed by the immersion of the previously washed plant tissue in hypochlorite (1%) for 1 min, then in ethanol (70%) for 1 min which was then rinsed with water.

Isolates from soil samples were obtained by serial dilution (10-1, 10 -2 and 10-3) with sterilized distilled water; 0.1 ml of each dilution was plated on potato dextrose agar (PDA) and incubated at 250C. Where fungal growth was detected, subsequent 0.1ml spore dilutions were transferred into water agar (20g Difco agar, 1L distilled water) plates and incubated at 25°C until isolations of single culture was obtained.

Morphological Identification of the Different Isolates of *Thielaviopsis* spp. Isolated from the Soil and Inner Tissues of the Oil Palm

Preliminary identification of each of the isolated fungus was done using its cultural and microscopic features according to methods described by Borges et al. (2019). The preliminary identified isolates using cultural and microscopic features were also sent to Commonwealth Mycological Institute (CMI), Surrey, England, UK for identification.

a. Pathogenicity testing of fungal isolates

The thirty isolates of *Thielaviopsis* spp. obtained were individually inoculated onto approximately 6-month- old oil palm *E. guineensis* (highly susceptible species) seedlings of ten replicates each which were at the 6-10 true-leaf stage, by inoculating with an agar plug (5mm in diameter) containing mycelium of *Thielaviopsis* spp. at the base and upper stem of the palm. Prior to inoculation, the base and upper stem of the palms were surface sterilized with 75% ethanol and mechanical injury was created with a surfaced-sterilized 3mm cork borer. The control consisting of ten oil palm seedlings were similarly treated except that they were inoculated with agar plug without fungal growth. The inoculated plants were kept in a humid chamber and environmental conditions such as rainfall, humidity and sunlight were measured. To satisfy Koch postulates, inoculated points in the oil palm seedlings showing disease infection

resulting from the effect of *Thielaviopsis* spp. was inoculated on freshly prepared PDA on triplicates plates and growth was recorded.

b. Sexual compatibility test

The sexual compatibility test was carried using the methods described by Borges et al (2019). Monosporic strains were cultivated in PDA with sterilized oil palm frond fragments. The isolates were placed in Petri dishes, 3cm apart in between the sterilized oil palm frond, and incubated for 2 to 4 weeks in the dark at 25°C. Thereafter, the dual culture plates were examined for the presence of sexual fruiting bodies (Mbenoum et al. 2014).

RESULTS AND DISCUSSION

Symptomatology and Soil Water Deficit in the Study Locations

Field observation of the symptoms of the neck bending/inclination of the upper portion of the oil palm disease of the oil palm begins with a characteristic symptom of gradual inclination of the palm (Figure 1), yellowing of fronds, drying of the leaves of the palm from the base (Figure 2) and finally the collapse and death of the palm during the dry season (Figure 3). Transverse section of the base of affected oil palm seedling was characterized with production of a fermented odor (Figure 4).

Fig. 1 Fig. 2 Fig. 3 Fig. 4

Fig. 1. Gradual inclination of the upper region of the palm.
Fig. 2. Yellowing of the fronds.
Fig. 3. Final collapsed of the oil palm.
Fig. 4. Transverse section of the trunk of the palm characterized with the production of a fermented fruit odor.

The outbreak of the disease was first noticed in the February 2019 with young palms between the ages of 2 and 3 years. The affected young palms in the affected plantation were cultivated in both loamy and laterite soils followed with good agronomic practices recommended for oil palm cultivation. The high incidence of the disease among the young palms resulted in the gradual collapsing and death of the young palms within a month of symptom manifestation. Transverse of affected trunk palm was characterized by a fermented fruit odor.

The soil water deficit in the year 2018 (Figure 5) in the plantation where the incidence of the disease was first recorded has to a total of 575.2mm soil water deficit accruing for a period of six months while in 2019 it was 451.9mm for six months. The

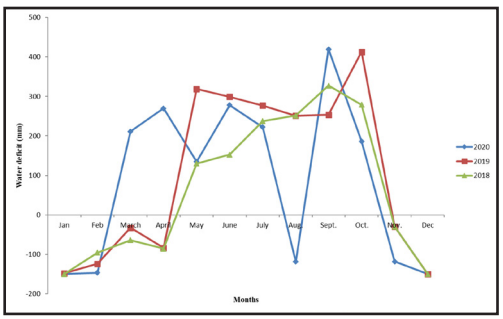

Fig. 5. Soil water deficit for locations were the neck bending disease/inclination of the upper region of palm was recorded.

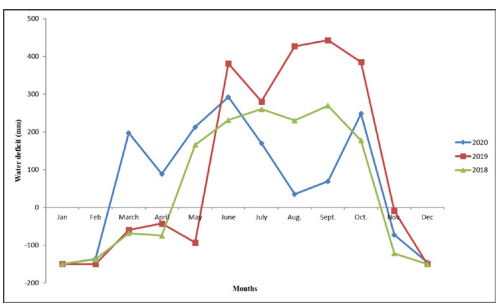

Fig. 6. Soil water deficit for station were the neck bending disease/inclination of the upper region of palm was not recorded.

year 2018 has a total rainfall of 1703.5mm while the year 2019 has a value of 2,145mm.

In the plantation where the outbreak of the disease was not recorded, the total soil water deficit was for the year 2018 (Figure 6) was 703.2mm for a period of six months and 655.6mm for 2019 for also a period of six months. The total amount of rainfall for 2018 and 2019 was 1530.8mm and 2312.1mm respectively.

Morphological and Microscopic Description of Fungi Associated with the different Portions of the Diseased Oil Palm Tissues and Soil Samples

a. *Cultural and microscopic characteristics of the isolates*

Colonies initially presented white coloration, turning dark after four days of growth (Figure 7). Primary conidia were hyaline, unicellular and cylindrical while the secondary conidia were brown, unicellular, became darker with age. Aleuroconidia were unicellular, dark brown, had rough cell wall (Figure 8). There was no sexual compatibility between the isolates.

Figure 7. Culture plate of *T. ethacetica* on PDA.

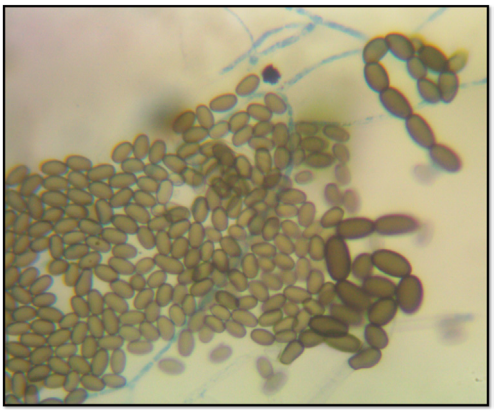

Figure 8. *T. ethacetica*: Secondary conidia in clusters (yellow arrow), Aleuroconidia in chains (black arrow), Primary conidia in chain (red arrow).

b. *Molecular identification and confirmation of the pathogen by CMI*

Molecular identification of the pathogen using the CMI identification protocol revealed the presence of *Thielaviopsis* spp. where there were similar matches to sequences of *T. euricoi* and *T. ethacetica* (and synonyms of these species). The three isolates sent for confirmation based on their virulence on the oil palm were assigned CMI No. E0000764001, E0000764002 and E0000764003, respectively.

1. Pathogenicity testing

a. *Pathogenicity testing of the isolates unto the base of the palm and definition*

The results of the pathogenicity test using the different isolates of *Thielaviopsis* spp. unto the base of the palm resulted in the formation of a pathogenic lesion around the point of inoculation within seven days after which, no visible symptom was observed.

b. *Pathogenicity testing of the isolates unto the inner tissues of the palm and definition*

Pathogenicity trials of *Thielaviopsis* spp. into the inner tissues of the palm also revealed a group of the isolates based on the virulence level that showed gradual invasion of the spear leaves of the palm by the pathogen resulting in the necrosis of tissues around the point of inoculation, abnormal spreading of the palm fronds and finally fracture and collapse of the spear leaves at the point of inoculation. Transverse section of the oil palm stem showed brownish coloration of the inner tissues of the palm and gradual yellowing and abnormal spreading and inclination of the fronds.

c. Pathogenicity levels defined

Pathogenicity data were obtained from a total of 30 fungal isolates collected over one-year period. During the pathogenicity testing, symptoms of the disease were evident within a week after inoculation. All isolates caused black necrotic lesions at the point of inoculation, and in some cases, leaf chlorosis. The symptom caused by individual isolates of *Thielaviopsis* spp. differs on the oil palm based on the stage of disease severity. The isolates were classified into three groups or levels according to their pathogenicity on the *E. guineensis*, oil palm seedlings. The control plants remained healthy during the evaluation period while the *Thielaviopsis* spp. strains showed high pathogenic variation between isolates.

Pathogenicity level –The first group consisted of 28 isolates, which caused stem lesions after which no further symptom developed. The isolates in this group were morphologically black on PDA, producing two types of spores (microconidia and macrocondia). The microconidia are secondary conidia in chains while the macroconidia (Aleuroconidia) is a large oblong, thick-walled, brown-black spore borne in chains. This group contains the largest number of *Thielaviopsis* spp. The second and third group also consisted of one isolate each which causes abnormal spreading/inclination of the palm fronds and collapse of the spear leaves at the point of inoculation. The isolates in each group were morphologically similar to those in group one. *T. ethacetica* has not been previously identified to be associated with the oil palm in Nigeria. Mbenoum et al. (2015) believed the pathogen to have its origin from Cameroun. This is due to the high genetic diversity of the four groups of the pathogen in the country with two of the genetic groups of the isolates native to the oil palm and the other two from cacao and pineapple (Mbenoum et al., 2015). Cameroun is among the oil palm producing nations with a production rate of 210, 000 tons of crude palm oil in 2010 (Ngom, 2011) and shares its border with Nigeria. There is possibility of seed and seedling transmission between countries during oil palm plantation establishment. This could be interpreted as the likely source of introduction of the pathogen into Nigeria.

Thielaviopsis paradoxa previously reported to be associated with oil palm in Nigeria causes various diseases such as the dry basal rot (Robertson 1962; Wingfield et al., 1993) and black seed rot (Omamor, 1985). *Thielaviopsis paradoxa* has been previously known as *Spororischima paradoxum* de Seynes, *Chalara paradoxa* de Seynes, *Ceratocystis paradoxa* de Seynes (teleomorph phase of the fungus) Dade, 1928; Mbenoum et al. (2014). Due to the complexity in the identification of the fungus, de Beer et al. (2014) proposed the genus *Thielaviopsis* which accommodates fungi that are typified by *T. paradoxa* sensu stricto. Molecular studies have highlighted increasing species diversity within this genus, distinguishing between discrete homothallic (*T. cerberus*) and heterothallic (*T. paradoxas*.str., *T. musarum* and *T. ethacetica* and *T .euricoi* which were previously treated as *T. paradoxa*)

(Mbenoum et al. 2014; Mbenoum et al. 2015).

There is the possibility of previous misidentification of the genus associated with the oil palm especially in the absence of molecular markers as suggested by Mbenoum et al. (2015) or probably the case of plant pathogens that have been introduced into a new region along with their host resulting in the emergence of devastating new disease (Anderson et al., 2004; Brasier 2008 cited in Mbenoum et al., 2015), as observed in this study. The devastating effect of *T. ethacetica* on the oil palm can result in 65% loss of the palms if adequate measures are not taken in time.

The absence of information in literatures on the devastating effect of *T. ethacetica* on the oil palm in Nigeria led to the interpretation that the findings from this study is the first report on the pathologic effect of *T. ethacetica* on the oil palm in Nigeria.

Studies have confirmed that *T. ethacetica* is different from *T. paradoxa* due to the absence of the synnemata morphological marker. Meanwhile the similarity between the two fungal isolates was inferred by the morphology of the perithecium and the presence of digitate ornamentation at the base of the perithecium (Mbenoum et al. 2014; Melo et al. 2016). Morphological analysis of *Thielaviopsis* spp. complicates taxonomic studies since the same strain produces different types of conidia at different developmental stages (Borges et al., 2019). Apart from describing the taxonomic status of *T. ethacetica*, these authors (Mbenoum et al. 2014; Mbenoumet al. 2015 and Borges et al., 2019) did not attempt to describe the disease impact of *T. ethacetica* on the oil palm thus, probably indicating its endophytic relationship with oil palm.

Thielaviopsis spp. has also been previously identified as an endophytic pathogen affecting susceptible host genotypes under stress (Alvarez et al., 2012). There is the possibility that the exotic oil palms being imported into Nigeria were host to *T. ethacetica*, thus felled to the pathogenic effect of *T. ethacetica* as a result of environmental changes. The second possibility might be that the exotic palms imported into Nigeria were unable to withstand the pathogenic effect of the soil borne *T. ethacetica* in Nigeria.

The amount of rainfall recorded in this study was within the range stated by Hartley (1988) but the soil water deficit in the two study locations was higher in the study location with no record of the disease than the study location where the outbreak was recorded indicating that the soil water deficit has a minimal role on the outbreak of the disease. However, low soil water deficit has been reported to be associated with some physiological disorder in palms (Sime and Darby, 2011). Soil water deficit is however depended on soil water holding capacity (Caliman and Southworth 1998). Olivin (1968) and Van der Vosen (1969) stated that the annual average soil water deficit that is optimal, suitable and favorable and unfavorable for the oil palm is ≤150mm, ≤250mm, ≤400mm and ≥ 400mm, respectively.

Several authors have shown that the isolates of the *Thielaviopsis* spp. varied in aggressiveness on different hosts, such as eucalypts, coffee, gmelina, taro and edible fig (Baker et al., 2003; Marin et al. 2003; Zauza et al. 2004; Guimarães et al. 2010; Harrington et al. 2011). The varied level of aggressiveness was attributed to the genetic variability observed in the genus (Harrington et al., 2000; 2011; Baker et al., 2003; Oliveira et al., 2015) thus constituting a limiting factor in screening for crop resistance and greater use of fungicides for its control (McDonald and Linde 2002). Different level of aggressiveness of *T. ethacetica* was also noticed in this study among the thirty isolates causing the inclination of the upper

region of oil palm. The aggressive nature of *T. ethacetica* was attributed to presence of sexual spores in the tissues of the severely affected palms while asexual spores were present in tissues of mildly affected palms. Mbenoum et al. (2015) described *T. ethaceitica* as a heterothallic fungus that requires two compatible partners (MAT 1-1 and MAT 1-2) to produce sexual spores.

The interaction between *T. ethacetica* and the host tissue in this study gave rise to the damage layers and release of a fermented fruit odour which confirmed the invasion of the host by the pathogen through its spores. Kuo et al. 1969; Tokeshi and Rago 2005;Raid, 2009 cited in Borges et al. (2019) confirmed that during tissue colonization by *T. paradoxa* host plant tissues release an odor characteristic of pineapple essence, which is due to the release of ethyl acetate, the toxin responsible for inhibiting buds and roots. Joli (1961) also noted that the micro and macroconidia lie freely in the soil and/ or in buried plant tissues and macroconidia play major role in long term survival of the pathogen in the soil. This study showed that the microconidia was mainly present in the colonized tissues thus indicating its role in the pathogenicity of the fungi.

CONCLUSION

There is an indication that the isolation of *T. ethacetica* associated with the oil palms was from exotic palms imported into the country. This called for proper quarantine measures in order to control the transmission of plant pathogens within borders of the country. However, further molecular studies and pest risk analyses are needed to confirm the origin of the *T. ethacetica* isolated from the oil palm. The devastating effect of *T. ethacetica* on the oil palm also emphasized the need for effective management of the disease.

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DEVELOPMENT AND EVALUATION OF RICE – BASED CHIPS USING LOCALLY AVAILABLE LEGUMES

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Abstract — The effect of the different locally sourced legumes as protein source in rice-based chips was investigated in this study. Extruded snacks was produced from rice and locally sourced legumes namely mung bean (*Vigna radiata L.*), pigeon pea (*Cajanus cajan)* and chickpea (*Cicer arietinum*) in 70:30 (rice:legume) ratio. The physicochemical properties were evaluated and results revealed that the three treatments had expansion ratios of 2.35 to 2.61, moisture content ranged from 3.38 to 5.08%, and water activity of 0.43 to 0.57. The protein content of the three treatments contained 10.02, 10.33 and 11.66 of protein for rice-based chips, respectively. Based on the sensory evaluation and texture profile analysis, the use of chickpea for rice-based chips showed significant difference among the other legumes and was the most acceptable treatment in terms of color and general acceptability. The microbial load of the three treatments had a colony count of 2.9-4.21 CFU/g aerobic plate count and have no growth for yeast and molds. The results of the nutritional facts computation for 100g dried chips based on the Food Standards Australia New Zealand (FSANZ) for the Treatments 1, 2, and 3 were the following: energy kcal of 1650, 1580, and 2050, carbohydrate of 84.2, 80.0, and 104.0, protein content of 9.4, 11.9, and 11.0, a total fat of 0.7, 0.7, and 1.7, and a saturated fat of 0.1, 0.1, and 0.2, respectively.

Keywords **— Extruded snacks, local legumes, natural rice-based chips, Philippines**

INTRODUCTION

Rice *(Oryza sativa)* is a staple food crop and one of the most important foods in the Philippines. It is also consumed in the form of noodles, puffed rice, fermented sweet rice, and snack foods made by extrusion cooking. However, rice protein, like other cereal proteins, is not an ideally balanced protein (Patrick, 1971). Combination of rice and legumes or pulses such as "rice and bean" are eaten by many people. This is a favorable dietary trend because the legumes are relatively rich in protein which in turn is relatively rich in lysine. Legumes are low-cost and high-quality protein that can supplement or substitute the daily protein requirement, which is usually obtained from expensive animal and marine sources.

The Food and Nutrition Research Institute (FNRI) has developed Rice-Mongo crunchies as one of the protein-rich food products that could address the nutritional problems of the country. The development of this nutrient-rich foods particularly snack foods that resemble the chips and crunchies sold at commercial outlets is also prepared at the Complementary Food Processing Facility located at the Central Bicol State University of Agriculture (CBSUA), Philippines.

The desire for sustainable protein sources has brought a new focus on legumes. Legumes are food resources that is a good source of complex carbohydrates, proteins, and dietary fiber. The protein content of legume grains range from 17 g/100 g to 40 g/100 g and approximately equal to the protein content of meat which is 18 to 25 g/100 g (de Almeida Costa et al., 2006).

The pigeon pea (*Cajanus cajan*) and chickpea (*Cicer arietinum*) are also common legumes that is grown in the Philippines. These locally grown legumes constitute as an important source of dietary proteins and many other nutritional values (Martin, 2018). The protein content of pigeon pea varieties ranged from 23 to 26% (Fasoyiro et. al, 2010), and chickpea varieties contained 22 to 24% of protein (Rachwa-Rosiak et al, 2015). The protein content of both the pigeon pea and chickpea are comparable with those of the other legumes such as the mung bean. However, the utilization of these legumes as an alternative source of protein has not been undertaken for producing rice based-chips.

Therefore, this study was conducted to develop and evaluate the properties of rice-based chips using different kinds of local legumes.

MATERIALS AND METHODS

Materials

Rice, mungbean and chickpea were purchased at Naga City Peoples Mall in Naga City, Camarines Sur. Brown colored pigeon pea seeds was purchased from Mariano Marcos Memorial State University, Ilocos Norte. All the raw materials were processed at the Complementary Food Processing Facility, CBSUA, San Jose, Pili, Camarines Sur. The legumes were ground separately to produce flour using an industrial grinder and then sieved to remove dirt and its outer layer.

Processing of Rice-Based Chips

The formulation for the different treatments of rice-based chips was patterned from the FNRI wherein the rice-legume ratio is 70:30 which means that for every seven cups of rice flour, three cups of the legume flour is added. Three legumes were used as treatments for the development of rice-based chips: T1 (rice-mung bean), T2 (rice-pigeon pea) and T3 (rice-chickpea) combinations. Rice-based chips was prepared by mixing rice flour and legume flour following the 70:30 ratio. Water was then added and the mixture were mixed for 10 minutes using a mechanical mixer. The mixture was placed on a tray evenly flattened with a 5cm thickness and

then steamed for 30 minutes at 100°C. The product was cooled down and then extruded. The extruded mixture was pre-dried in a mechanical drier for 30 minutes at 65°C. The pre-dried product was cut into small pieces approximately 8-10 cm long and dried again in the mechanical drier for 2 hours at 65°C. The dried product was deep-fried in oil for 2-3 seconds at 280°C and then cooled down for packing.

Examination of Physicochemical Properties

The expansion ratio (ER) of extruded samples were examined by using a micrometer to measure the diameter of a cylindrical sample. Ten measurements were taken and then averaged. The Moisture Analyzer (Model No. LSC-60) was used to test the moisture present in the sample. Five (5) grams of the sample was dried at 1050C and weighed until the weight is constant and results for % moisture content is recorded. The water activity (aw) of the sample was measured using the ROTRONIC aw which includes the bench-top unit HygroLab C1, the handheld device HP23-AW-A and the software HW4-P-QUICK-Vx for its quick capability.

Fat extraction method was conducted to measure the percentage of lipid in the initial sample can then be calculated. In this method, the sample was pulverized into small particles and placed in a porous cellulose thimble. The thimble was placed in an extraction chamber, which is suspended above a flask containing the solvent and below a condenser. The flask is heated and the solvent evaporates and moves up into the condenser where it is converted into a liquid that trickles into the extraction chamber containing the sample. At the end of the extraction process, which lasted for 16 hours, the flask containing the solvent and lipid was removed. The solvent in the flask is then evaporated by boiling. Once the boiling point of the solvent is reached, the solvent evaporates and the mass of the remaining lipid is measured. The percentage of lipid in the initial sample is calculated. Whereas the Protein analysis of each treatment was tested in the Department of Science and Technology-Regional Standards and Testing Laboratory. The crude protein content was determined using the methods described in Association of Official Analytical Chemists (AOAC, 2006) TM-Ch-004 with reference to AOAC 978.04A, 19th Ed.

Sensory Evaluation

Rice-based chips was evaluated by ten (10) trained panelists using the sensorial attributes such as color, aroma, flavor, crunchiness, hardness and general acceptability of the product using the descriptive score sheet. The general acceptability was evaluated to determine the most acceptable among the three (3) treatments. Each panelist was provided with three (3) different samples randomly together with the score sheet.

Coded sample was presented to each of the panelists using ranking test. The gathered results were decoded and analyzed through the analysis of variance test (ANOVA) to determine the acceptability of the product.

Textural Profile Analysis

The different treatments were evaluated by fifteen (15) untrained panelists according to each Textural attributes such as Crispiness, Hardness, Brittleness and Fracturability. Each panelists was provided with three (3) different samples randomly arranged together with the score sheet. The panelists underwent a brief orientation for the evaluation of the texture of the product through mastication. The panelists draw line across the 7cm line scale with the code number of the sample which corresponds to the scale of evaluation. The sample score card was shown in appendices.

Statistical Analyses

All measurements were done in triplicate. Analysis of variance (ANOVA) and least significant difference were done

using the Statistical Analysis System (SAS Institute, Carry, NC) while differences between treatments were determined using Duncan's multiple range test.

Microbial Analysis

The aerobic plate count was carried out using Standard Plate Count Agar AOAC (1996). Initial product sample homogenates were prepared in sterile diluents in ratios of 1:10. One ml from the sample was aseptically diluted in series up to a dilution of 10-3 using sterilized pipette. The diluents were pour plated in triplicates then the liquefied media around 35ºC was poured and mixed thoroughly with the sample by mixing the contents by moving the plates gently in clockwise and counter clockwise direction for three times. When the agar solidified the plates were inverted and wrapped using cleaned surface of bond paper. Incubation was done at 25ºC for 48 h. After the incubation period, the number of visible colonies grown on each dilution plates were counted and recorded. The corresponding average CFU/g of the sample was computed using the formula below:

$$N = \frac{\Sigma C}{[(1\ x\ n_1) + (0.1\ x\ n_2)\ x\ (d)]}$$

Where:
N = Number colonies per gram of product
ΣC = Sum of all colonies in all plates counted
n_1 = Number of plates in first dilution counted
n_2 = Number of plates in second dilution counted
d = Dilution from which the first counts were obtained

were determined. The procedure on homogenization of the samples was the same as with the procedure of aerobic plate count analysis except that the 3M Petrifilm was used for the enumeration of yeast and mold (AOAC Official Method 2014.05) and the incubation period was 5 days.

Nutritional Fact Computation

Nutritional Facts could help consumers to follow a healthy diet and make healthy food choices. The Nutrition Facts of the samples were computed including the serving size, number of serving and the amount of various nutrients contained in the product. It was calculated using the Nutritional Panel Calculator (NPC) under the Food Standards Australia New Zealand (FSANZ). It is a governmental body responsible for developing standards for food available in Australia and New Zealand. The NPC assist in obtaining average nutrient quantities for nutrition labelling (FSANZ Explanatory Note, 2011).

RESULTS AND DISCUSSION

Moisture Content Determination

Results show that the moisture content of the three treatments ranged from 10.33 to 12.02% dry basis. Among the different composite flours, the highest moisture content was observed in mung bean flour whereas pigeon pea flour has the lowest moisture content. However, after the drying and frying process results revealed that the rice-based chips containing the highest moisture content was with the chick pea flour having a moisture content of 5.08 and 4.62 for dried chips and fried chips, respectively. Moisture content of the composite flours has higher moisture content than on the dried chips and fried chips. The drying and frying processes using high temperatures will cause lower water content of rice-based chips due to the evaporation of water (Setyaningsih, 2019). These also provides the desired crispiness of the chips.

Table 1. Moisture Content of flours, dried chips and fried chips.

Treatment	Moisture Content (%)		
	Flour	Dried Chips	Fried Chips
Rice	12.2	-	-
T1 (Mung bean)	11.05	4.62	3.48
T2 (Pigeon pea)	10.33	4.25	3.38
T3 (Chickpea)	10.52	5.08	4.62

Water Activity

The analysis for the determination of water activity content for rice-based chips showed that the rice-mung bean combination has the highest water activity having the amount of 0.57, whereas rice-pigeon pea and rice-chickpea combination has a water activity of 0.43 and 0.48, respectively. More recently, it has been shown that water content has an effect on the crispness of the product. The lower water content, the crunchier the product will be. A study conducted showed that the water activity of rice crispies is 0.56, whereas extruded cereals range from 0.64 to 0.68, and extruded snacks ranges from 0.708 to 0.762, (Sauvageot and Blond, 2007).

Expansion Ratio

The expansion process of the pellets by frying can be divided into three phases. In the first phase, moisture loss occurs at the periphery of pellets into the oil, and the pellet becomes plastic in texture. In the next phase, moisture inside the pellets turns to steam by the heat. And finally, as the vapor quickly evaporates, the pellets expand for the expansion, the product should be thoroughly cooked and be elastic enough to have gas-retaining ability for air cells. The results for the expansion ratio of the rice-based chips revealed that the rice-pigeon pea has the highest expansion ratio of 2.61 mm, whereas the rice-chickpea has 2.49 mm expansion ration and the rice-mung bean combination had the lowest expansion ration of 2.35 mm. The lower particle size of the different legume flour likely attributed the expansion ratios of the product. It is said that a lower particle size can result in more gelatinization and increased cooking of the starch due to the increased surface area to volume ratio of the particles (Martin, 2020).

Chemical Composition of the Natural Rice-Based Chips

The result shown in Table 2 revealed that the extracted fat in the different treatment of rice-based chips ranged from 17.3 to 20%. Rice-pigeon pea combination has the highest fat extracted among the treatments. Extruded snack foods such as chips are fried after extrusion. The oil content of this extruded snack ranged from 20 to 35% as compared to a commercial product that has only 21% oil.

The protein content of the rice-based chips ranged from 10.02 to 11.66%. Rice-mung bean has the highest protein content among the treatments. The amount of the legume flour influences the protein content of the rice-based chips because the legumes have a high protein level (Sumardiono et. al, 2022). Extrusion process improves protein digestibility via denaturation, which exposes enzyme-access sites. Denatured proteins, incorporated in a snack food formula, are considered to be less functional and contribute little or nothing to the expansion process that occurs during extrusion. The variation in the fat and protein content of the rice-based product can be attributed to the differences in the genetics, varieties, and growth environments of the legumes used (Du et al., 2014)

Table 2. Fat and protein content of rice-based chips.

	T1 (Mungbean)	T2 (Pigeon Pea)	T3 (Chickpea)
Fat (%)	18.39	18.65	18.17
Protein (%)	11.66	10.02	10.33

Sensory Evaluation

The results for sensory evaluation were summarized in Table 3. Three Treatments were subjected to sensory evaluation to determine the specific characteristic of the rice-based chips through attribute test by ten (15) selected trained panelist who assessed the different sensory attributes in terms of Color, Aroma, Texture (crunchiness), Texture (hardness) and the General acceptability.

Table 3. Mean scores of the different attributes of Rice-based Chips.

Attributes	T1 (Mungbean)	T2 (Pigeon Pea)	T3 (Chickpea)
Color	2.8[a] Brown	4.07[c] Dark Brown	3.0[b] Cream
Aroma	3.07 Moderately Pronounced	3.33 Moderately Pronounced	3.1 Moderately Pronounced
Flavor	3.47 Moderately Perceptible	3.80 Moderately Perceptible	3.5 Moderately Perceptible
Texture (Crunchiness)	4.27 Crunchy	3.87 Crunchy	4.1 Crunchy
Texture (Hardness)	3.40 Hard	3.07 Hard	3.5 Hard
General Acceptability	7.27[b] Like Very Much	6.53[a] Like Moderately	7.6[b] Like Very Much

Mean scores with different letters are significantly different at 5% level of significance under Table 3.

The result shows that the color of the treatments is significantly different from each other. This is because of the different colors of legumes seed coat used and the effect of color during the frying process that darken the color due to high temperature of frying oil. The aroma of the different treatments showed no significant difference. The aroma of the legumes on the different treatments did not affect the aroma of the rice-based chips. This is because the chips undergo frying process in which this process lessens the aroma of legumes after frying. The flavor of the legumes used for rice-based chips were rated as moderately perceptible and shows no significant difference among treatments due to the weak flavor of legumes which is based from the total legume content of 18.75% of its total formulation on the rice-based chips. Crunchiness of the rice-based chips was also evaluated and results revealed that all the treatments were rated as crunchy which showed no significant difference among treatments. The texture of the rice-based chips in terms of hardness showed that all treatment was not significantly different and rated as hard. It was related to the texture profile that are near ranged and through its low moisture content that harden the rice-based chips.

The general acceptability of the rice-based chips has a mean score ranging from 6.54 to 7.6 among treatments and showed significant difference. The rice-chickpea combination for rice-based chips has the highest mean value of 7.6 characterized as like very much, whereas rice-pigeon pea has the lowest mean score of 6.53 characterized as like moderately. Although the rice-chickpea combination was not always rated as the most preferred treatment in terms of sensory attributes, however the general acceptability revealed that rice-chickpea was the most acceptable treatment.

Texture Profile Analysis

Mean score results for the texture profile analysis of the rice-based chips as shown in Table 4. Results revealed that rice-chickpea has the highest mean score in terms of hardness, crispiness, and brittleness, while rice-mung bean has the highest mean score in terms of fracturability.

From a sensory perspective, Figure 1 shows the relationship among the textural attributes of each treatment. It is well documented that water affects the crispness of the rice-based chips. Water is essential since it gives an effect to the appearance, texture and taste of the food. The crispiness

of the rice-based chips was supported by the low water content and the drying and frying process (Setyaningsih et. al, 2019).

Table 4. Mean score of texture profile analysis.

Treatments	Hardness	Crispiness	Brittleness	Fracturability
T1 (Mungbean)	2.73	3.53	2.13	2.93
T2 (Pigeon pea)	2.40	4	2.33	2.80
T3 (Chickpea)	3.0	4.2	3.2	2.5

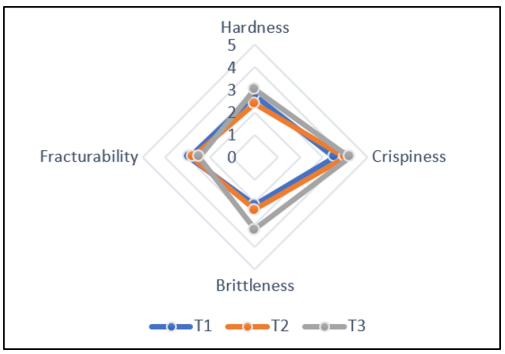

Fig. 1. Texture Profile Analysis of Rice-based chips.

Microbial Analysis

The results for the microbial analysis of rice-based chips in terms of Aerobic Plate Count and Yeast and Molds Count showed that all treatment confirms to the microbial standards for Rice-based Chips.

The aerobic plate count of all treatments reported to have 2.9 to 4.21 CFU/g. Based from the results, it was observed that there was a minimal microbial growth in the product this is because the rice-based chips undergo high temperature processing such as drying and frying. Results passed the FDA Revised Guidelines for The Assessment of Microbiological Quality of Processed Foods with the standard of 103. On the other hand, the result for the yeast and molds count was reported to be <1. This is in conformity for the microbiological quality standards set for snack foods as stipulated under FDA Circular 2013-010 otherwise known as the Revised Guidelines for the Assessment of Microbiological Quality of Processed Foods where yeast and mold count should not exceed at 10. The same was observed by Uzoaga and Kanu (2020) on the yeast and mold count of extruded and baked samples made from sweet potato, cassava, and plantain fortified with Moringa oleifera powder. Yeast and molds are generally more resistant to dry conditions (e.g., low water activity) than other microorganisms. However, the high temperature used for drying and frying as well as the extrusion processes and the conduct of microbial analysis immediately after processing resulted in the very low microbial count of the product.

Nutrition Facts Computation

Nutritional facts were also calculated per 30g serving of the most preferred formulation using the Nutritional Panel Calculator. Based on the result shown in Table 5, computed results were comparable to the energy recommendations which was based on the Recommended Energy and Nutrient Intake (2003). The formulated product was a good source of energy and can supply the nutrient requirements needed for the diet.

Table 5. Computed Nutritional Composition of Rice-Based Chips.

Nutrition Information	T1 (Mungbean)	T2 (Pigeon pea)	T3 (Chickpea)
Serving size (g)	100	100	100
Energy (kcal)	1650	1580	2050
Protein (g)	9.4	11.9	11.0
Fat, total - saturated	0.7 0.1	0.7 0.1	1.7 0.2
Carbohydrate -sugars	84.2 0.4	80.0 0.2	104.0 0.6
Sodium	6	9	137

In terms of protein and fat, the rice-based chips have higher value present since legumes used are good sources of protein and may contain more lipids and essential fatty acid.

CONCLUSION

The results of the study lead to the following conclusion that rice-based chips were processed in combination with different legumes such as mung bean, pigeon pea and chickpea using the formulation 70% rice flour and 30% legume flour. The physico-chemical properties such as moisture, water activity, expansion ratio, fat and protein of the rice-based chips with different legumes were determined and it was found that rice with mung bean, pigeon pea and chickpea combination had a moisture content of 3.48, 3.38 and 4.62; a_w of 0.43, 0.48 and 0.57; expansion ratio of 2.35, 2.61 and 2.49; fat of 18.39, 18.65 and 18.17; protein of 11.66, 10.02 and 10.33, respectively.

It can be concluded that the most acceptable rice-based chips in terms of the sensory analysis using descriptive test is the use of chickpea on the development of rice-based chips which gained the highest mean value of 7.6 characterized as like very much. Microbial analysis for the three treatments were conducted and it was found out that treatments had colony count of 2.9 to 4.21 CFU/g aerobic plate count and have no growth for yeast and molds.

The computed nutritional content of the rice-based chips using different legumes was computed FSANZ Nutrition Facts Calculator. The samples had the following computed nutrition facts: energy kcal of 1650, 1580, and 2050, carbohydrate of 84.2, 80.0, and 104.0, protein of 9.4, 11.9, and 11.0 total fat of 0.7, 0.7, and 1.7, saturated fat of 0.1, 0.1, and 0.2 for Mung bean (T1), Pigeon pea (T2), and Chickpea (T3), respectively.

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A JOURNEY IN SEARCH OF *Tetragonula biroi* (Friese 1898) PROPOLIS

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Abstract — This paper looks into the mapping of *Tetragonula biroi* in the different islands of the Phlippines exploring into the propolis sources, the derivatives from different sources and exudates, harvesting and processing of propolis, and other research gaps involving the *T. biroi* species across regions. The dominant vegetation and host trees were scrutinized for the possible exudates utilized and processed by the bees. These are tabulated and charted with images from the Meliponaries, Bee Farms and Eco-Parks visited in many different islands of the Philippines regions. The resultant propolis and cerumen textures and consistency were compared for value-added product derivative considerations. The considerations include possibilities for use in aromatherapy, cosmeceuticals, nutraceuticals and pharmaceuticals. Some recommendations on the chemical processes and procedures for product derivatives are provided herein. Harvesting and post-harvest modus operandi are suggested with references from F.A.O. literature and past experiences.

Keywords **— Cerumen textures, host trees, meliponiculture, propolis, vegetation exudates**

INTRODUCTION

Biogeography Overview

Wallacea region (shown in black). Wallace's line (2) demarks the boundary of the Asian biogeographic realm to the west and the mixed fauna of the Wallacea region to the east, Huxley's line (1) shows Huxley's extension of the Wallace line to include the Philippines (Esselsty et al., 2010), Weber's line demarks the point of faunal balance between Australian and Asiatic influence on several taxa and Lydekker's line (4) demarks the western boundary of the Australian biogeographic region (Chandra n.d.). The map is redrawn from (O'Connell, 2013).

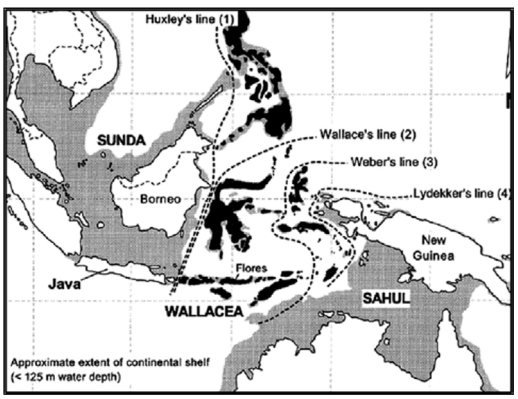


Fig. 1. Map of Wallacea Region (Shown in black).

Meliponiculture – Alternative Opportunities

Over the past decade, many losses in global apiculture call for alternatives and propolis plus pot-pollen products (Vit et al., 2018) and their derivatives. Do these questions arise; what is an alternative to Apiculture? What else besides honey? Are pollination and crop yields elements of agriculture worth considering? Are there other derivative products that can be developed? What about the Future of Agriculture incorporating Meliponiculture? What is the future of value-added beekeeping product innovation and demand? How does a farmer start or look for hives besides buying from hive hunters or ravaging nature? Hive hunters stock supply in unprepared transition areas. Termites' nests are the best bet to get from nature. The coexistence of stingless bee colonies in arboreal ants' and termites' nests in the Philippines is a phenomenon to be exploited (Jalil, 2019).

History of Agriculture Development and Migration

Delta valleys flourished with agriculture in the fertile lands. The rapid urban and industrial expansion has pushed the agriculture activities further upwards to higher ground. The overpopulation of the Urban delta regions (Personal Observations). This has led to overwhelming retardation of human amenities. Agriculture and food crop production are always necessary regardless of COVID-19 pandemic circumstances or otherwise. Highland agricultural stations with terraced plots and greenhouses for cultivation can be developed. It's a good thing that biological pollinating agents have not migrated much over the years (Eltz, 2003).

Inferences during Periodic Expeditions in Wallacea

Looking at the pollution and the mess that progress has possibly attributed to climate abnormalities, it is not surprising that the current COVID-19 pandemic hotspots are in highly urbanized populations.

Delta and valley living has been prone to floods in the past and more so in this age of climatic change. To achieve sustainable natural resources, one ultimately must migrate to highland suburbia. Cleaner remote areas in higher altitudes appear safer and more promising. Agriculture on higher ground is the way forward.

Advantages to Highland Crops

Better air quality and lower concentration of human population, hence doing away with environmental pollution. There is no soil nutrient exhaustion and less water pollution from lowland industrialization. Abundant natural pollinating agents for better crop yields.

Considering all these factors allows one to harvest quality products from Meliponiculture in agriculture settings. In Meliponiculture, the harvestable products are honey, propolis and pot-pollen.

Meliponiculture in a Nutshell - Propolis Products

In the Philippines, the most prolific species for obtaining Meliponiculture products is *Tetragonula biroi* (Ciar et al. (n.d.)). This data we gather from reports in the Handbook of Meliponiculture Vol 1 2016 (Mostoles, 2017).

Following were the objectives:

1. To observe different textures and consistency of *T. biroi* propolis across regions.
2. To ascertain the derivative products of propolis from different vegetative exudates.
3. To scrutinize the different *T.* nr. *biroi* types.
4. To infer the operating procedures in meliponiculture in the Philippines.

METHODOLOGY

Over five years of periodic expedition in the Philippines to conduct mapping of Meliponiculture activities among stingless beekeepers and their product development efforts. Information on the vegetation was provided by the beekeepers and methods of harvesting bee products were observed and recorded. The vegetation and host trees were examined for possible exudates utilized and processed by the stingless bees. ere scrutinized for the possible exudates utilized and processed by the bees. These were tabulated and charted with images from the meliponaries and Eco-Parks visited. The resultant propolis and cerumen textures and consistency were compared for value-added product derivative for possible use in aromatherapy, cosmeceuticals, nutraceuticals and pharmaceuticals.

DISCUSSION

Several varying stingless bee species exist throughout Wallacea and S.E.A., with diverse propolis and pot-pollen (Vit et al. 2018) characteristics and properties (Vit et al., 2013). The stingless bee's array has a wide selection of vegetative sources in Wallacea (Raes et al., 2014) and can adapt to varying sources in the many habitable conditons (Roubik, 2006). There is a need to arrange group discussions to exchange and share regional findings inter islands and higher altitudes.

There is a need to consolidate research on stingless bee propolis & pot-pollen across regions. Compare results of derivative products of propolis from different vegetative exudates. Organize clinical trials of the various products with relevant authorities. Need for D.N.A. sequencing and analysis of the different stingless bee types. Set standard operating procedures (S.O.P.) in meliponiculture and propolis & pot-pollen harvesting.

Propolis Textures and Consistency

The chart below shows the vegetative exudates that may influence different textures and consistency of cerumen and propolis produced in a stingless beehive.

Different bee species have varied preferences in foraging exudates for different uses in nest building material and defence and hive protective purposes (Michener 1961 & 2007). In the Sunda regions, bee species are often categorized by their dependence on specific exudates (Sakagami; 1978 & 1989; Schwarz 1937 &

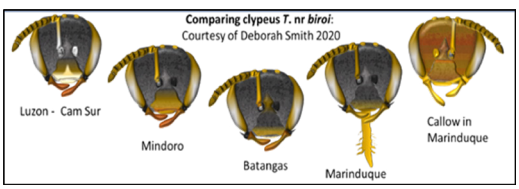
Table 1. Propolis Texture and Consistency from Phloem and Sap of Different Vegetative Sources.

Exudate	Texture Range	Consistency	Vegetative Source
Phloem	Fluff & Soft (for involucrum sheath)	gluey and gummy	Leaf shoots Flower buds
Sap	Soft & Pliable (for pots & entrance)	Sticky to tacky	Saplings Leaf petiole Sepal
Latex Milk Gum	Limber to semi-hard (at times for pillars)	moderately hard, can be cut with little effort.	Trunk branches Fruit Rind Stem Pedicel
Resin	Semi-hard to brittle (usually batumen)	Semi-dry to rough and flaky	Dipterocarps, Evergreen Resinous trees (Appannah 1998)

1939) e.g., some are dependent on resin while some are only on latex, milky sap or gum (Leonhardt, 2010 & Leonhardt et al., 2010). However, it appears that *Tetragonula biroi* can utilize a wide variety of exudates (Starr & Sakagamim, 1987).

T. nr. *biroi* variety (Smith in AAA Conf. 2020)

There are several varying near biroi specimens throughout Wallacea (Mostoles & Baja, 2017); one is the true *biroi* that Friese described from PNG (Sahul) in 1898 (Freise, H. 1898). The *T. nr. biroi* array (Baltazar, 1966; Rasmussen, 2008)) has a wide selection of vegetative sources in Wallacea and can adapt to varying sources in Sunda and Sahul (Welzen & Alahuhta, 2005).



(Illustration referenced to the AAA 2020 report on varieties of *T.* nr. *biroi* by Prof Deborah Smith). This diversity may account for the affinity and adaptability to foraging different vegetation types around the islands of the Philippines.

Observations of Dominant Vegetation in the Philippine Islands

During expeditions to different Islands in The Philippines, the dominant vegetation was recorded. In some instances, the host trees were examined for peculiar characteristics. There were cases where stingless bees occupied termite-infested trees (Jalil, 2019), and in certain regions, they were found to fall after a typhoon. Dipterocarps were observed in some regions like Mataas Na Kahoy in Batangas, Luzon and the Gawahon Eco-Park in Negros Occ. while Eucalyptus was favoured for their gum in some simulacra of some parks like Ilog Maria farm in Cavite and the Gawahon Eco-Park in Negros Occ. It was observed in mango plantations in Calatagan, Luzon and in Leyte, jackfruit plantations in Leyte and coconut plantations in Quezon and Sorsogon, Bicol Region. This is not highlighting monoculture crop settings, but these plantations have other forage sources for the bees. The issue is more on the dominant vegetation (Welzen & Alahuhta, 2005).

Below are some observations of vegetation provided or naturally available for stingless bees' concentration and Meliponaries for forage. Selection of unique dominant vegetation and possible high-grade derivative products from propolis were done.

UPLB Laguna	Campus	Raintree

Fig. 2. Host tree: Raintree (*Samanea saman*). Varying shapes and ornamentation but textures and consistency similar throughout.

CvSU Campus	Meliponary	Dragon Fruit

Fig. 3. CvSU, Cavite Dragon Fruit Farm -Sticky and a lot of muck left on the box surfaces.

Cavite	Indang	Los Pepes Bee Farm	Pomegranate

Fig. 4. Dominant vegetation: Pomegranate (*Pumica granatum*).

Silang	Ilog Maria	Bucari pine & Gum Tree

Fig. 5. Bucari pine & Gum tree - Resinous texture and gummy appearance.

Laguna	Alaminos	Anciado	Rambutan

Fig. 6. Dominant vegetation: Rambutan (Boonthai & Sawatthum, 2014). -Impending threats can cause Spikes.

Negros Occ	Gawahon Eco Park	Ricky Sobesta	Eucalyptus

Fig. 7. Gawahon Eco Park - Dominant vegetation - Eucalyptus Dried gummy slob.

Malitbog, Bongabong	HN Organic	Organic crops (Cinammon)

Fig 8. Organic crops (Cinammon) pulpy and pliable.

Mataas Na Kahoy	Cudia Farm	Dipterocarps *Shorea* sp.

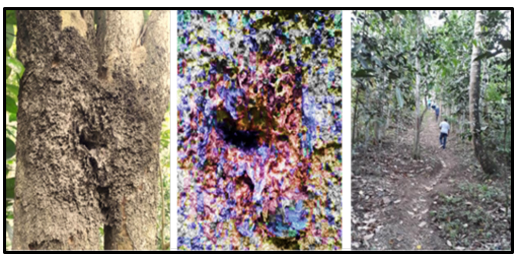


Fig. 9. *Dipterocarps Shorea sp.* Resinous texture.

Negros Occ	Gawahon Eco Park	Freddie Lozada	Lowland Dipterocarp

Fig. 10. Gawahon Eco Park - Dominant vegetation - Lowland Dipterocarp – Resinous.

Mindoro Occ	Sta Cruz	OMBKA	Cashew nut

Fig. 11. Cashew nut semi-hard and labyrinth -like.

Sorsogon	Bulusan	Balai Buhay Sa Uma	Avocado & Pili

Fig. 12. Sorsogon Avocado & Pili – Avocado sap & Pili resin “Elimi’.

East Samar	Maypangdan, Borongan City	Ruel B. Delantar	Cyathea Sp.

Figure 13. Host Tree: *Cyathea sp*. Dark and mucky cerumen.

Mindanao	Davao Oriental	Oriental Bee Farm	*Artocarpus gomezianus*

Figure 14. https://en.wikipedia.org/wiki/*Artocarpus_gomezianus.*

Care of Propolis and Post-Harvest Storage

1. Make sure boxes are completely dry - avoid damp lumber.
2. Smear internal surface with cerumen & wax, then flame to eradicate fungus spores and borer eggs.
3. Avoid Honey spills – they attract ants and cockroaches.
4. Eradicate cockroaches – they contaminate the propolis.
5. Full protective attire during harvesting – avoid Human contamination.
6. Keep harvested propolis cool and in a sealed container – avoid dissipation of aromatics

Aromatics are a major asset to cerumen produced from exudates of Resinous trees and Gum trees like Eucalyptus. One can only presume that these aromatics are the attractant for the bees in the first place. As propolis and cerumen are maintained, these aromatics makes it valuable for Aromatherapy. It is therefore imperative to keep products away from pests and contaminating vermin and bugs.

Contaminating Pests

Wax moths and cockroaches are among the common pests that may not destroy the colony but are detrimental to the quality of products obtained. Below are some cockroaches recorded in the hives during the travels.

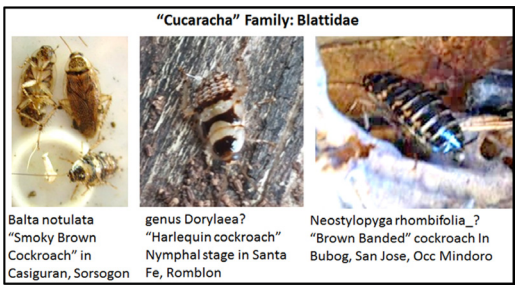


Fig. 15. Cockroaches recorded in the hives (Jalil 2018).

Types of Propolis

There are five types of propolis

1. Batumen is the hard cavity wall linings or the shell of a stingless bee nest. This part keeps intruders out.
2. Involucrum is a cerumen sheath enveloping the brood and may consist of many layers to regulate and stabilize the brood temperature and humidity.
3. Cerumen of the nest entrance tube or funnel, with resinous 'ornamental' spikes or flanges.
4. Storage pots. Also built with cerumen, they hold honey, pollen, rarely wax or resin.
5. Pillars hold all components in place and support the components as struts (Michener 1961; Roubik 1996; Jalil 2014; Jalil 2019).

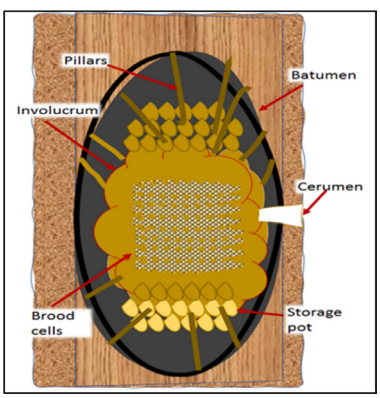


Fig. 16. Types of propolis.

CONCLUSIONS

- There is a need to consolidate research on *T. biroi* propolis across regions.
- Compare results of derivative products of propolis from different vegetative exudates.
- Organize clinical trials of the various products with relevant authorities.
- Need for D.N.A. sequencing and analysis of the different *T.* nr. *biroi* types
- Develop S.O.P. in meliponiculture of stingless bees (Cortopassi-Laurino et al, 2006) and the propolis harvesting (Krell, 1996).

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FACTORS INFLUENCING THE ADOPTION OF FARM MACHINERY: A CASE FROM BANGLADESH

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Abstract — Mechanization is vital for sustainable agriculture development of agrarian countries, not only to feed the growing population, but also to save power and resources. The main purpose of the study is to determine the innovation capacity of farmers. Innovation capacity refers to the farmers' adoption of new farm machinery. The study was conducted in Rajshahi District of Bangladesh. Sixty (60) farmers were purposively selected to participate in the study. Data was collected through structured personal. The dependent variable of this study was the innovation capacity of the farmer. The independent variables were farmer education, farm size, annual family income, organizational participation, farming experience, knowledge about farm machinery, farm machinery training, and condition of farm equipment. Appropriate scales were developed and used in order to measure the independent variables. The findings revealed that two-thirds (75 percent) of the farmers had medium innovation capacity, while 18.3 percent had low innovation capacity, and only 6.7 percent of them had high innovation capacity. Results of multiple regression analysis revealed that knowledge about farm machinery, farm machinery training, and condition of farm machinery are the influential factors for determining innovation capacity of farmers.

Keywords **— Adoption, Bangladesh, farmers, farm machinery, innovation capacity**

INTRODUCTION

Bangladesh is a small agro-based country with an area of 1, 47,610 square kilometers. The total population of the country is 158.9 million with an annual growth rate of 1.37 percent (BBS, 2017). The Bangladesh economy is vastly dependent on the agriculture industry. Agriculture represents directly and indirectly almost 15.96 percent of its Gross Domestic Product (GDP) and 80 percent of its employment opportunity (BBS, 2017). In addition to supporting the economy, agriculture is also important because of the role it plays in providing food for the people of Bangladesh. In the past, the agriculture sector was largely dependent on manual and labor-intensive practices. Increasing yields was difficult because manual labor is very time consuming. Today farm machinery that replaces labor-intensive activity is more widely available for use in Bangladesh agriculture. Adopting use of modern agricultural farm machinery provides opportunity to increase crop production while also decreasing manual labor and increasing the quality of life for the farmer. Many innovative types of machinery were discovered in the 20th century. The agricultural sector is converting from dependence on manual labor to mechanization. Mechanization is imperative in the rural development process not only in terms of feeding the population, but also for saving power and resources. Rural development requires careful mechanization through the adoption of suitable machinery for various agricultural operations. Mechanization is essential for increasing the production efficiency of rice farming in Bangladesh (Saha,2015). Cropping intensity and production of food crops has recently increased significantly due to adoption of mechanized tillage, irrigation, and spraying operations (Sarkar and Prahaladachar, 2000). Mechanical inputs currently used in Bangladesh are Shallow Tube Well (STW) and Deep Tube Well (DTW) for irrigation, power tiller and tractor, disc plough, disc harrow, weeder, sprayers, and threshers. Multiple research studies emphasize the importance of appropriate farm mechanization as an important policy and development goal in Bangladesh (Mandal, 2002; Mandal, 2014 and Zhang et al., 2014). Compared to other South Asian nations, farm machinery use has advanced considerably in Bangladesh [Justice and Biggs, 2013], particularly for land preparation, irrigation, and post-harvest activities.

There are many types of innovative farm machinery, but farmers do not adopt it as expected because they lack knowledge about the machinery and possible benefits. As a result, there is still lack of innovation capacity of the farmers. Farmers have been recognized as one of the key sources of innovation. Many studies on agricultural innovations continued to consider farmers as adopters of externally driven innovations (World Bank, 2011; Hayami and Ruttan,1985). Over time, farmers have been accepted as innovators and experimenters and not just adopters of introduced technologies. There are even claims that some of the technologies developed by the scientists were actually based on the ideas and practices originated by local farmers (Roling, 2009; Chambers et al., 1989; Rhoades, 1989). However, food production in Bangladesh is the major sector in agricultural development (Khan and Sadid, 2005). Over time, the population in Bangladesh has increased to 158 million people rapidly increasing the gap between crop production and need for food. However, the agricultural production can be increased to produce more food if farmers adopt innovative farm machinery. In turn, this will allow Bangladesh to work towards achieving the United Nations Sustainable Development Goal No. 2, eliminating hunger.

The literature indicates the capacity, boundaries, and types of activities define innovation capacity for farmers. To help

overcome the shortcomings in innovation studies and particularly in understanding the concept of the innovation capacity, this research aims to identify and analyze the innovation capacity of farmers in adoption of innovative farm machinery, identify and analyze the farmers' problems in adopting innovation or innovative farm machinery to address the acute food problem

Thus, it can be said that development of the country is only depend when the innovation capacity of farmers in adoption of farm machinery are increased in agricultural sector. On this scope the present study is anticipated to assess the capacity of the farmers in adoption of innovative farm machinery.

Objectives of the study

The purpose of this study was to determine the innovation capability of farmers in adoption of farm machinery. In achieving the general objective, the following specific objectives can be formulated:

1. To measure the status of innovation capacity of the farmers to adopt farm machinery;
2. To assess and explain the role socio-economic characteristics play in the farmers in adoption of farm machinery; and
3. To explore the factors associated with farmers' innovation capacity in adoption of farm machinery.

Theoretical Framework

During the late 1980s and early 1990s, the concept of capacity development came into surface as a prominent theme in international development, such as agricultural extension and adult education, in response to the disapproval of the reduced impacts of technical cooperation on millions of smallholder farmers in low-income nations. However, lack of state competences for economic development, human well-being and ecological justice are overall concerns for sustainable development (Clarke and Oswald, 2010; Morgan, 2006, Morgan, 1989). Similarly, the literature on competence development, particularly in post-secondary training and education, grew during the 1970s and 1980s, initially in the United States and later in Europe in response to the limitations of theory-based teaching and learning (Mulder, 2011, Mulder, 2007; Wolf, 2001 and Kerka, 1998).

The contemporary literature on learning and innovation competence development in agricultural education and extension interconnects the independently developed fields of competence-based learning and learning-based competence. While, competence-based learning philosophies came out in response to the limitations of theory-based teaching and learning that are largely supply driven. Theory and practice of learning-based competence advanced within the field of capacity development.

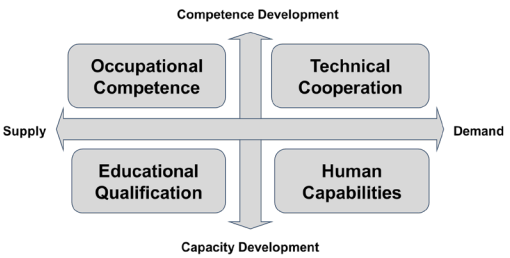

Fig. 1. Learning and Innovation competence development framework.

Capacity development, in general, involves positive changes at four ontological levels. The individual level includes changes in cognitive, affective and psychomotor domains of learning. The organizational level; network and system level; and the broader enabling environment, such as institutions, policy and governance.

For the necessity of this research, the framework as modifiedslightly by adding an extra dimension which is economic capabilities. The new modified framework is given in Figure 2.

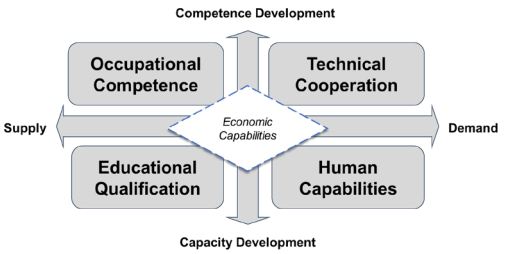

Fig. 2. Learning and Innovation competence development framework (modified).

In other words, capacity development is about transformational changes that empower individuals, leaders, groups, organizations, networks, systems and societies to put knowledge and other capitals into use (UNDP, 2009; CIDA, 2000). Thus, in the modified framework economic capabilities was added to assess innovation capacity of the respondent.

MATERIALS AND METHODS

Study Area

The study was conducted in two Sub-districts (Upazila) named Paba and Mohonpur under Rajshahi District of the northern region of Bangladesh. Two villages were purposively selected for the study in consultation with the experts, i.e., Upazila Agriculture Officers (UAO) and Upazila Rural Development Officers (URDO) of the selected sub-districts. These two villages are Haripur and Mougachi. Paba sub-district is located at 24°26.6′ North latitudes and 88°37.7′ East longitudes and Mohonpur sub-district is located at 24°33.8′ North latitudes and 88°39′ East longitudes. Moreover, these two villages have good facilities and people of these villages are familiar with the farm machinery. Figure 3 shows the study area.

Sampling, Data Collection and Analysis

An updated list of all the farmers was collected from the Upazila Agricultural Officer (UAO). About 35 percent or 60 farmers were selected as the sample

Fig. 3. Map of Rajshahi district showing Paba and Mohonpurupazila of Bangladesh.

following simple random sampling method. A structured interview schedule was developed for collecting data for assessing the status of innovation capacity in adoption of farm machinery by the respondents. An interview schedule was carefully prepared in English keeping in mind the objectives of the research and following the procedures of determining their selected characteristics and their extent of use of agricultural machinery and their innovation capacity. Appropriate scales were developed to operationalize the dependent and independent variables of the study. A draft interview schedule was pre-tested with 10 farmers from the study area that facilitated the researcher to identify faulty questions and statements in the draft schedule. On the basis of pretest results, necessary correction, alternations, additions, and modifications were done in the interview schedule, after examining the answer of the respondents.

Five dimensions were selected. Each of the dimensions had 5 statements obtained from the FGD. A four-point rating scale was used to measure the role of focus variable. Possible responses were high, medium, low and no with the corresponding scores of

3, 2, 1, and 0 respectively. The innovation capacity of the farmers was computed by adding all the scores obtained from each of the dimension of innovativeness from which respondents will be benefitted. Hence, the scale score ranged from 0 to 15 for each dimension, where 0 indicates no innovation capacity and 15 indicates high innovation capacity of the farmers for adoption of farm machinery. Ranking of the statements was done to prioritize the statements where informal education, interest towards machineries, social networking, good physical health and income were number one for each dimension respectively.

The collected data were coded, categorized, tabulated and analyzed scientifically using the Statistical Package for Social Science (SPSS) ver. 16.0 computer program. Both descriptive and inferential statistics were used to describe the data in this study. Pearson's Product Moment Coefficient of Correlation was used to identify association between the explanatory and focus variable. Besides, multiple linear regression and step-wise multiple regression were employed to identify the factors affecting the focus variable.

RESULTS AND DISCUSSION

Socioeconomic Characteristics of the Respondents

The demographic and socioeconomic characteristics of the respondents are shown in Table 1. The mean age of the respondent farmers was 39.8 with standard deviation of 8.48.

The average education score of the respondents was 6.73 which means on average, participants in the study had a secondary education.

It is clear from Figure 4 shows that half (50 percent) of the respondent farmers have secondary education followed by a quarter (26.7 percent) having primary education. While, 15 percent of them were illiterate. Education is believed to facilitate diversified information sources and assumed to be positively correlated with the extent of adoption of new farm machinery (Forsman, 2011; Szeto, 2000; Shahil et al., 2013 and Rajalahti et al., 2008).

Table 1. Socio-economic Characteristics of the Respondents.

Category	Mean	SD*
Age (year)	39.48	8.48
Education (year of schooling)	6.73	3.62
Household Size (number)	4.97	1.52
Farm Size (Hectares)	.757	0.458
Annual Income ('000' BDT*)	76.77	64.42
Organizational Participation (Possible score: 0-24)	2.23	1.44
Farming experience (No. of years)	18.53	6.89
Knowledge on farm machinery (Possible score: 0-51)	30.0	6.45
Training received on farm machinery (No. of days)	2.11	2.98
Innovativeness (Possible score: 0-27)	13.78	2.33
State of using (Possible score: 0-48)	14.75	2.76

*SD = Standard Deviation; *BDT = Bangladeshi Taka

Farm size influences both access to technology adoption and increase innovation capacity towards farm machinery (Morshed and Lashgarara, 2011; and Hall et al., 2007). Table 1 also revealed that average farm size of the respondent farmers was 0.7 ha. and average annual family income 73,000 BDT. As family income is the key factor in the process of innovation capacity and adoption of new farm machinery. It is imperative to take necessary decisions towards innovation and adoption capacity apply machinery to the farm (Wang et al., 2008).

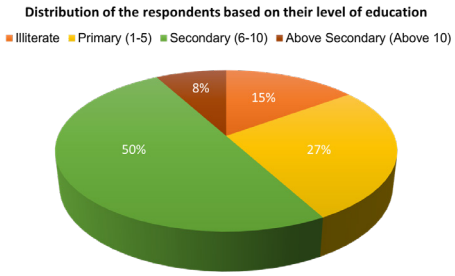

Fig. 4. Distribution of the respondents based on their level of education.

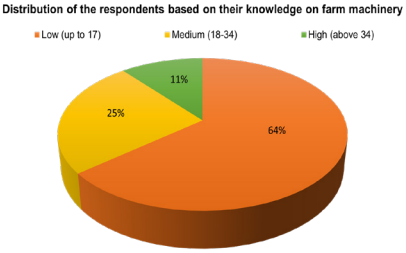

Fig. 5. Distribution of the respondents based on their knowledge on farm machinery.

It is evident from Table 1 that organizational participation score of the respondent farmers were relatively poor as the average score was only 2.2. However, they had sufficient farming experience that stimulates the farmers to take necessary actions in response of any farming problems during using of farm machinery. It is found that the average farming experience score of the respondents was 18 years with standard deviation of 6.89. It is assumed that experienced farmers can have better understanding the importance of innovation and use of farm machinery to the field and hence, are able to take immediate measures to on and off field farm activities (Nambisan et al., 1999).

The Figure 5 also revealed that more than half of the farmers (64 percent) have low knowledge on farm machinery followed by a quarter (25 percent) had medium knowledge on farm machinery and only 11 percent of them had higher knowledge on farm machinery. The mean score of knowledge on farm machinery of the respondents was 30 which indicate also poor knowledge of the farmers on farm machinery.

Farmers Innovation Capacity in Adoption of Farm Machinery

Farmers' innovation capacity is an important attributes of a farmer to adopt a new machinery to maintain his farm in an efficient and cost-effective manner. Thus, farmers' innovation capacity in adoption of farm machinery was measured and shown in Table 2.

Table 2. Distribution of the respondents based on their innovation capacity.

Respondent Categories	Respondents		Mean	SD*
	No.	%		
Low innovation capacity (0-25)	11	18.3	34.96	10.85
Medium innovation capacity (26-50)	45	75.0		
High innovation capacity (51-75)	4	6.7		

In Table 2 indicate that two-thirds (75 percent) of the respondents had medium innovation capacity followed by 18.8 percent had low innovation capacity. In the study area innovativeness and the knowledge about farm machinery is medium, so we can say that farmers adopt new machinery as earliest as possible time and they are also willing to congregate knowledge on machinery use in future. It is evident from Table 2 that the majority of the respondents farmers had low to medium level of innovation capacity for adoption of farm machinery.

Table 3. Dimensions-wise innovation capacity of the farmers. Possible score (1-15).

Dimensions of Innovation Capacity	Respondent Categories	Respondents		Mean	SD*
		No.	%		
Educational qualification	Low (0-5)	36	60.0		
	Medium (6-10)	23	38.7	5.3	2.38
	High (11-15)	1	1.0		
Occupational competence	Low (0-5)	18	30		
	Medium (6-10)	33	55	7.4	2.71
	High (11-15)	9	15		
Technical co-operation	Low (0-5)	18	30		
	Medium (6-10)	35	58.3	7.3	2.76
	High (11-15)	7	11.7		
Human capabilities	Low (0-5)	7	11.7		
	Medium (6-10)	47	78.3	8.2	2.15
	High	6	10		
Economic capabilities	Low (0-5)	22	36.7		
	Medium (6-10)	35	58.3	6.6	2.74
	High (11-15)	3	5		

Actually, five dimensions were used to assess the innovation capacity of an individual in adoption of farm machinery (Table 3). In the Table 3, the mean of dimensions represents that farmer had low educational qualification but compared to educational qualification they had good field in occupational competence, technical cooperation and also human capabilities. Economic capabilities are also higher rather than educational qualification.

Additionally, the specific statements under each of the dimension for measuring farmers' innovation capacity for adoption of farm machinery were rank ordered and shown in Table 4. On the basis of these aspects of different dimensions of innovation capacity the overall innovation capacity of an individual was measured. It is evident in Table 4 that in the case of educational qualification dimension informal education ranked 1st position, while formal and non-formal education ranked 2nd and 3rd position respectively. It means that though farmers' agricultural technical education level is poor but they are rich in informal education as they learn a lot from their surroundings. They had also a good level in formal education (Figure 4). So, they can adopt new machinery for running their farming activities. Among the occupational competence aspects farmers' interest on machineries ranked 1st position, knowledge on use of machinery and ability to modify the machinery to some extent according to his need ranked 2nd and 3rd position respectively.

It means that a farmer having willingness and fair knowledge on machinery will lead him to adopt innovative machinery. Similarly, in the case of technical cooperation, social networking of a farmer ranked 1st position while in the case of human capabilities good health stand 1st position. Farmers from the study area mentioned in the focus group discussion (FGD) sessions that "They use different farm machinery for minimizing their labor forces as well as sow and harvest

crop on time". However, in the case of economic capabilities income and access to credit of a farmer is found as crucial in line with their innovation capacity. This findings is supported by the findings of Wang and Pervaiz, 2004; Yam et al., 2011 and Santamaria et al., 2009.

Table 4. Rank order of the statements for measuring farmers' innovation capacity.

Aspects of Dimensions	Score	Rank Order
Educational qualification		
Formal education	92	2
Non-formal education	43	3
Agricultural education	35	4
Technical education	28	5
Informal education	124	1
Occupational competence		
Interest on machineries	125	1
Knowledge on use of machinery	106	2
Skill using machinery	65	4
Previous experience of using machinery	106	2
Ability to modify to some extent according to his need	69	3
Technical cooperation		
Social networking	145	1
Participation on workshop and seminar about machinery	97	2
Maintenance of farm machinery	77	4
Ability of minor troubleshooting	81	3
Access to spare parts	47	5
Human capabilities		
Good physical health	146	1
Communication exposure	116	2
Leadership capacity	70	5
Decision making ability on farming activities	105	3
Self-efficiency on farm machinery	74	4
Economic capabilities		
Income	135	1
Access to credit	98	2
Purchasing capacity of machineries	78	3
Installment scope in case of buying machineries	49	4
Scope of buying machineries	37	5

It means that a farmer having willingness and fair knowledge on machinery will lead him to adopt innovative machinery. Similarly, in the case of technical cooperation, social networking of a farmer ranked 1st position while in the case of human capabilities good health stand 1st position. Farmers from the study area mentioned in the focus group discussion (FGD) sessions that "They use different farm machinery for minimizing their labor forces as well as sow and harvest crop on time". However, in the case of economic capabilities income and access to credit of a farmer is found as crucial in line with their innovation capacity.This findings is supported by the findings of Wang and Pervaiz, 2004; Yam et al., 2011 and Santamaria et al., 2009.

Econometric Estimation of Factors Affecting Farmer's Innovation Capacity and Adoption of Farm Machinery

Multiple linear regression analysis was employed to determine the factors and their contribution in predicting the focus variable, i.e., farmer's innovation capacity and adoption of farm machinery. Table 5 presents the outputs of the analysis.

The results show that seven explanatory variables out of eleven were significant with the F value of 11.36** and adjusted R2 value of 0.659. Therefore, the results imply that about 65.9 percent of the variation in the innovation capacity in adoption of farm machinery of the farmers was explained by the combined effects of explanatory variables. The findings showed that sfive out of eleven variables (farm size, knowledge on far machinery, training received on farm machienary, innovativeness and state of using farm machinary) are the significant in explaining innovation capacity of the farmers in adoption of farm machinery. The results imply that these factors influenced the farmer's innovation capacity and adoption of farm machinery in the study area. The results exhibits that farm size had a positive

coefficient with adoption of farm machinery. Farmers who have large family need more food production and farm machinery is the most helpful to do this job. The results show that the large farm size thrusts the farmers in practicing more farm machinery. This may be because the practice of agricultural machinery requires large farm size (Wettasinha et al., 2008). A study conducted by Amlaku (2012) found that land area has positive and significant influence on innovation capacity. Knowledge on farm machinery was positive and significant for the practice of farm machinery by the farmers in the study area. The result implied that increase of farm machinery knowledge augments the adoption rate of agricultural machinery. Farmers are afraid of taking risks associated with the adoption of new machinery. Therefore, the result may be due to the fact that higher knowledge and skill of the farmers to the machinery holds less risk and they do not need to pay for high damage. Training on farm machinery also emerged as a positive and significant factor in adoption of farm machinery and innovativeness of the farmers. It may be because the farmers having training on machinery management can easily operate a farm machine (UNDP, 2009). These platforms bring them in contact with different skill with different insights. They can learn from training regarding any kind of machine problems and can fix their problems accordingly. This result is in line with Rahman (2004). Innovativeness was also found to have positive and significant relation with the innovation capacity and adoption of farm machinery by the farmers. This implies that increasing innovation and adoption facilitates the farmers' practice and adjustment to the farm machinery in the study area. According to Tidd et al. (2005) farmers exposed to adoption of farm machinery are more are more capable to increase production than others. The results also exhibited that state of using farm machinery have positive and significant relationship. It is due to use of machinery in different sector can bring more production than manual way of cultivation. This result is in line with Beinecke, 2009; Laursen and Foss, 2003; Link and Siegel, 2007, and Verde et al. 2011.

Table 5. Summary of multiple linear regression analysis.

Explanatory Variable	Stand. Coefficients (B)	Stand. Coefficients (B)	't' value	F value
Age (X_1)	-.041	-.032	-.252	
Education (X_2)	.371	.124	1.35	
Household size(X_3)	.733	.096	1.14	
Farm size (X_4)	4.347	.192	2.11*	
Annual family income (X_5)	.013	.077	.896	
Organizational participation (X_6)	.232	.032	.351	
Farming experience (X_7)	-.073	-.047	-.381	11.36**
Knowledge on farm machinery (X_8)	.385	.229	2.18*	
Training received on farm machinery (X_9)	4.223	.331	3.17*	
Innovativeness (X_{10})	1.614	.193	2.17*	
State of using farm machinery (X_{11})	1.696	.197	2.23*	
Adjusted R^2 = 0.659				

Step-wise Multiple Regression Analysis

To understand the contribution of each variable to the respondents' variation in innovation capacity and adoption of farm machinery in the study area, a step-wise multiple regression analysis was conducted. Table 6 represents the output of the analysis. The findings indicate that out of seven significant socio-economic characteristics obtained from the multiple linear regressions, three such as farm size, training and knowledge on farm machinery entered into the model. The findings also indicate these three variables together (R^2 = .659) explained 65.9 percent variation in the farmers' innovation capacity in adoption of farm machinery in the study area.

The first variable entered into the model was knowledge on farm machinery of the farmers (R^2 = .445) which had the highest contribution (44 percent) in explaining the variation in the focus variable.

Table 6. Summary of stepwise multiple regression analysis.

Model	Variables entered	Multiple R	Multiple R^2	Variation explained (%)
Constant + X_8	Knowledge on farm machinery (X_8)	.667	.445	44.5
Constant + X_8 +X_9	Training received on farm machinery (X_9)	.737	.543	9.8
Constant + X_8 +X_9 +X_8	Farm size (X_8)	.779	.607	6.4
Constant +X8 + X9 +X8 + X10	Innovativeness (X_{10})	.814	.663	5.6

This implies that with the increase of knowledge, the farmers are more likely to adopt farm machinery. The farmers with more knowledge and skill are usually more capable to adjust their farms with time and facilities (Rahman, 2004; and Courvisanos, 1996). This may be due to that educated farmer use farm machinery for their agricultural production. The second variable entered into the model was training of the farmers and it is shown that 9.8 percent variation of the focus variable was explained solely by the training of the farmers. The finding reveals that with the increase of training of the farmers, they are more likely to apply machinery to their field in the study area. This may be due to that taking risk does not affect their production although negative results may come (Barquin, 2001). However, knowledge and training on farm machinery of the farmers together (R2 = .543) had 54.0 percent contribution in the variation in innovation capacity of the farmers. The third variable entered into the model was farm size of the farmers which accounts for 6.4 percent contribution in explaining the focus variable. Farm size plays a significant role in adoption of agricultural machinery. The finding implies that with the increase in farm size, the farmers are more likely and able to use farm tools in the study area. The farmers with larger farm size use machinery for save time, money and labor (Sarker et.al, 2009). The fourth variable entered in to the model was innovativeness of the farmers. According to Courvisanos (1996) the innovative farmers have greater knowledge to understand and ability to adopt farm machinery as they have a wider exposure to different information sources. Innovativeness of the farmers helps them to indentify the farm machinery related problems and need of tools. Therefore, the finding implies the same.

CONCLUSIONS

In Bangladesh farmers innovation capacity in adoption of farm machinery are very important because the agricultural production not so well. The population is growing and the need for food is also growing. So farmers need to increase their innovation level in adoption of farm machinery. The study revealed that majority of the farmers had medium innovation capacity. Most of the farmers had small farm size and they did not have adequate money for adopting new farm machinery. As a result, medium innovation capacity was found among the farmers. The study showed that farm size, training, innovativeness and state of using farm machinery had significant contribution in explaining their innovation capacity in adoption of farm machinery. Better access to training on farm machinery along with better knowledge on farm machinery resulting in increasing innovation capacity of the farmers in adoption of farm machinery by the farmers. The study shows that among the different factors contributing to the innovation capacity in adoption of farm machinery of the farmers, knowledge on farm machinery contributed the highest bringing about the change in improving farmers' innovation capapcity. Thus, the knowledge on farm machinery

of the farmers may be considered as the most influential factors while taking policy measures for the extent of using farm machinery in the country. Other influential factors explored by the study are training received on farm machinery, farm size and innovativeness. Thus, it can be concluded that if it is possible to target the large farmers with the view of improving their knowledge and innovativeness through structured training on farm machinery may provide a big push in improving farmers' innovation capacity for adopting new farm machinery that will ultimately ensure sustainable crop production in the country. However, to let it happen an inclusive initiative is needed from concerened agencies (Department of Agricultural Extension and Bangladesh Agricultural Development Corporation) of the Ministry of Agriculture.

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ASSESSMENT OF LIVELIHOOD OPTIONS IN SUPPORT OF COMMUNITY BASED CONSERVATION IN THE SOLOMON ISLANDS

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Abstract — Community-based resource management (CBRM) where traditional and indigenous knowledge is combined with science to maintain resources has been widely used for inshore fisheries in the Pacific region. In Solomon Islands, CBRM is recognized as a strategy to enhance food security, adapt to climate change and conserve threatened species. However, even with its national recognition, rural communities are still faced with economic and social challenges while trying to manage their resources. Per se, it is vital that while communities are engaging in resource management, they should also be involved in sustainable supplementary livelihood activities that will sustain their living. With that notion, a study was conducted with the Sirubai Voko Tribal Association (SVTA) members at Pusiju village in South East Vella La Vella in Western Solomon Islands to assess what is working well for them and what is not so as to identify livelihood options that would be more appropriate to support their forest conservation initiative. The SWOT analysis protocol, pairwise ranking and the SLOPIC tools were used and six out of 11 livelihood options were considered as the most suitable for SVTA communities. From the study, we recommend that selection of livelihood options must be realistic based on what is available in the community in lieu of external sources. Thus, although the resources required for successful implementation of livelihood options may vary, the major goal is for the livelihood options considered to constantly support conservation into the future without failing.

Keywords **— Community-based organization, conservation, diagnostic analysis, Solomon Islands, supplementary livelihood options, sustainability**

INTRODUCTION

Throughout the pacific region, coastal communities are experiencing dwindling supplies of natural resources exacerbated by both direct and indirect anthropogenic effects. In Solomon Islands, population growth, changing climatic conditions and unsustainable developments such as logging, agricultural activities, and human settlements among others pose a direct threat to both terrestrial and marine resources. Coupled with the challenges of limited access to financial resources, market, political instability, global economic downturn, and the recent COVID-19 pandemic, these hurdles create a huge challenge to the health and livelihood of rural communities. According to Solomon Islands National Statistics Office and World Bank, (2017) from a survey conducted in 2012–2013, 12.7% of the country's population live below the basic needs poverty line. This however varies accordingly for each province depending on the population size and poverty rate.

Successive governments over the years have developed centralized state control or top-down coastal protection and management approaches that are merely politicized and most often do not meet the requirements of rural communities. Consequently, the rural communities often have minimal engagement and support from the central government which also contributes to a number of failed projects in the past. Many commercial fish stocks, and terrestrial flora and fauna continued to dwindle in the islands while the management policies are collecting dust on office shelves. In most Pacific Island countries, the top-down resource management efforts and livelihood related approaches are too costly both financially and in terms of scarce human resources to be of much practical value for broad-scale national application (Ram-Bidesi et al., 2011). Incompatibility of inherited government systems with the social and geographical realities of some independent Pacific island countries is also an issue (Govan et al., 2009). For Solomon Islands in particular, the diversity of cultures and remote islands increase the difficulty of developing a generic top-down approach that will be applicable for all the rural communities in the country.

A move from top-down to a locally based management approach that is more adaptive would be more suitable for rural Solomon Islands communities. While the emphasis is for the management to be driven by communities, most often communities collaborate with partner organizations and/or government representatives for technical support. This approach corroborates a study by Wheeler & Root-Bernstein (2020) which emphasized on co-management that leads to informed decision making when indigenous and traditional knowledge are combined with science in the process. Currently in the Pacific region, CBRM tends to dominate inshore fisheries management strategies. Specifically, for Solomon Islands, CBRM is recognized as a strategy that is adopted to improve food security, adapt to climate change, and conserve threatened species by facilitating rural participation and enabling local people to make their own plans for management of resources (Sukulu et al., 2016). With the recent Ecosystem Approach to Fisheries Management (EAFM), CBRM now takes a more holistic ridges to reefs approach which builds on customary land and marine tenure, traditional ecological knowledge, and existing leadership structures to maintain resources. The ridges to reefs approach recognizes that human activities occurring on the land has intense impact on streams, rivers and near shore areas. Nevertheless, even with this more holistic approach, communities are still faced with economic challenges in light of increasing population, food insecurity, higher food prices, loss of foreign currency from imports, changes of culture due to influence from inter marriage in the societies, and pressure

from destructive developments that seduce people with high incentives.

Some partner organizations advocate that communities should be incentivized with alternative livelihoods to effectively manage their resources, however the sustainability of such an approach will depend entirely on the affiliation of the partner organization to the project (Govan et al., 2009; O'Garra, 2007). Therefore, unless community driven sustainable supplementary livelihood options are in place, exploitation and dwindling of resources will continue due to limited economic activities available for communities to have an adequate lifestyle. As articulated by Blythe et al. (2014); Collins et al. (2009); Finkbeiner (2015); Hanh & Boonstra (2018); and Mills et al. (2017), sustainable livelihood options can improve living standards of rural households and empower their capability to face uncertainties. It is therefore important that while communities are actively engaged in resource management, they should also participate in sustainable supplementary livelihood activities that would help improve their wellbeing.

In this article, we present an investigation of how livelihood options are assessed in a four days' interactive workshop with Sirubai Voko Tribal Association (SVTA) communities using participatory diagnostic tools. SVTA is a community based organization (CBO) located in South East Vella La Vella in Western Solomon Islands. It is one of the few CBOs that firmly stand against unsustainable developments such as logging to effectively conserve its rainforest. To date, the rain forest has been under protection for almost a decade with no human disturbance. In the analysis process, helpful and harmful factors in the communities were identified using Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis followed by assessment of six existing livelihood options using the Supplementary Livelihood Options for Pacific Island Communities (SLOPIC) tool. We draw on this investigation to explore how supplementary livelihood options would be supported by identifying what makes a livelihood option worth undertaking or rejecting (O'Garra, 2007). This simple process can be replicated to other contemporary Pacific Island communities which are also challenged with pressures of resource degradation, climate change and with limited options to sustain their livelihoods.

MATERIALS AND METHODS

SWOT Analysis

The diagnosis exercise was conducted in January, 2021 by 42 individuals from Pusiju and Valapata communities who were selected based on their affiliation to SVTA. The respondents were separated into three groups according to men, women and youths to identify factors that are helpful and/or harmful to their communities following the SWOT analysis protocol described by (Sarsby, 2012). We conducted the SWOT analysis to assess the communities' strengths, weaknesses, opportunities and threats which is very important to help them make the most of what they have to their best advantage, and to reduce the chances of failure by guiding them to understand what is lacking, and eliminating potential hazards that may likely jeopardize their development plans. Information from the SWOT analysis was then used to develop the following action strategies: Growth strategies, internal development strategies, External development strategies, and Survival strategies. These generic strategies should be established before the two communities plan to seriously engage in supplementary livelihood activities.

Pairwise Ranking

Following the initial diagnosis above, the three groups ranked the threats from the SWOT to help facilitate development of the action strategies. Here we used the pairwise

ranking tool described by Govan et al. (2008) to compare threats in pairs to choose which is the most critical over the other. The most critical threats were identified by each group to help us match and convert the harmful factors from the SWOT into helpful factors. Thus, the pairwise ranking will help to direct where SVTA management should focus their efforts and time to prevent the threats identified from undermining their progress.

Supplementary Livelihood Options for Pacific Island Communities (SLOPIC)

A total of 11 livelihood options were identified but only six were considered for their relevance to the SVTA communities. The assessment was conducted following the protocol described by Govan et al. (2008). Basically, the SLOPIC tool is used to assess supplementary livelihood options that are appropriate and sustainable for communities. While it is seen as a guide towards success, the critical perception advocated in this tool is building on what the community have and not so much about depending on external sources. According to O'Garra (2007), most projects that are ongoing without relying on subsidies are those that have involved baseline studies and continuous monitoring all throughout. As highlighted by Govan (2011) in the SLOPIC guide, this tool is used to assist community people choose different livelihood options most of which maybe existing options and assessing these options to see how promising they are for their communities. A promising livelihood option is one that continues into the future coping with changes and disasters and without losing the things that make the livelihood possible.

Livelihood Options

The assessment for sustainability of supplementary livelihood options was conducted by analyzing for the following resources: Natural Resources, Equipment, People and skills, Market and Transport, Finances, and Support and Information (Govan et al. 2008).

RESULTS AND DISCUSSION

SWOT Analysis and Pairwise Ranking

We choose to analyze only the most critical threats based on how they are ranked using the pairwise ranking tool, and the common opportunities, weaknesses and strengths. Outlined in figure 1 are the generic strategies formulated from the diagnosis exercise.

SLOPIC Exercise

The six options identified in the SLOPIC exercise include betel nut, canteen, banana, piggery, kava and fishing. These were selected based on their suitability in terms of the availability of the resources that will make them work. We assessed to find out the resources that each livelihood option being considered will rely on to be successful. Figure 2 shows some important resources that the livelihood options being assessed will require to succeed. Most of the needs identified from the assessment are also covered under the four generic strategies shown in Figure 1.

The SWOT analysis indicated a number of helpful factors which in principle form the basis of the success of SVTA and previous community projects implemented by Pusiji and Valapata communities. Cooperation and/or oneness, good leadership, information sharing, and consultation were found among others to be the key strengths of the two communities. These could be so because every individual in Pusiju and Valapata communities are closely related through common ancestry and inheritance. A study by Ross et al. (2019) corroborated with these findings by highlighting that community participation and collaboration is an important element in supporting management and sustainability in many communities of the Asia-Pacific region.

On the contrary, community weaknesses diagnosed during the exercise include issues of weak leadership, lack of communication, lack of education, and laziness. Weak leadership in this context include certain SVTA leaders who do not get feedback to improve in contrast to those others who listen to their community members, delegate work, communicate effectively and most importantly strive for improvement. Weaknesses usually lead to poor management that often affect the demand for a desired resource and weaken the cohesiveness of a community (Singleton, 2000). Such situations may pose challenges to management in rural Solomon Islands communities, yet some of these associated weaknesses can be converted into strengths to expedite development of internal factors that will help the community to progress. As highlighted in the internal development strategies in Figure 1, when weaknesses are converted into strengths, a number of new opportunities will open up for the community to improve (Sarsby, 2012). Moreover, the communities can move forward with internal developments by capitalizing on the concept of "social capital" as proposed by Malherbe et. al. (2020). Social capital in this context basically involves the norms and networks which allow people to work together towards common goals. The key attributes of social capital are oneness/social cohesion and good leadership which for the case of SVTA are key strengths. Thus, according to Gutiérrez et al. (2011) and Jupiter et. al. (2017) these attributes coupled with effective implementation and community ownership of the process will determine success in resource management.

In rural communities, deliberation on opportunities is sometimes overrated and often raise a lot of expectations. Nevertheless, for SVTA; the most important opportunities identified during the analysis were: access to new technology, assets and information; support from the national government; capacity building in terms of human resources and infrastructure; higher education; and sport and music. These can be successfully matched with existing strengths previously highlighted to develop growth strategies that would lead to actualization and progress in the community. Essentially, progress will only happen when the community do more on what it is good at and invest on those factors that enhance its capability (Sarsby, 2012). Given the technical capacity of SVTA to lead development initiatives, it is auspicious that enthusiastic individuals especially youths in both Pusiju and Valapata communities can develop higher in various social activities. When our team visited the two communities, it was obvious that SVTA is investing more in education and sports which are crucial for their progress. Actually social activities such as sports help to promote strong cohesiveness by increasing self-esteem, community identity, and unity that can advance other developments in the community (Skinner et al., 2008).

Rating the threats identified from the SWOT analysis using a pairwise ranking tool; land dispute, high illiteracy, poor leadership, and poor management stood out as the most critical threats that SVTA management must prevent at all costs. Land is a very important natural resource that all livelihood options will depend on to actually operate (Govan, 2009). In Solomon Islands, land is a tribal inheritance however, this descent-based land ownership hindered quite a number of developments in the past when disagreements arose from unfair distribution of livelihood assets (Hviding, 1993). To prevent land dispute, SVTA must be proactive to establish cordial working relationships with sister tribes as indicated in the survival strategies in Figure 1. Correspondingly, rural communities like Pusiju and Valapata will move away from threats on poor leadership and poor management when their leaders are empowered with the appropriate capacity (Warner, 2000).

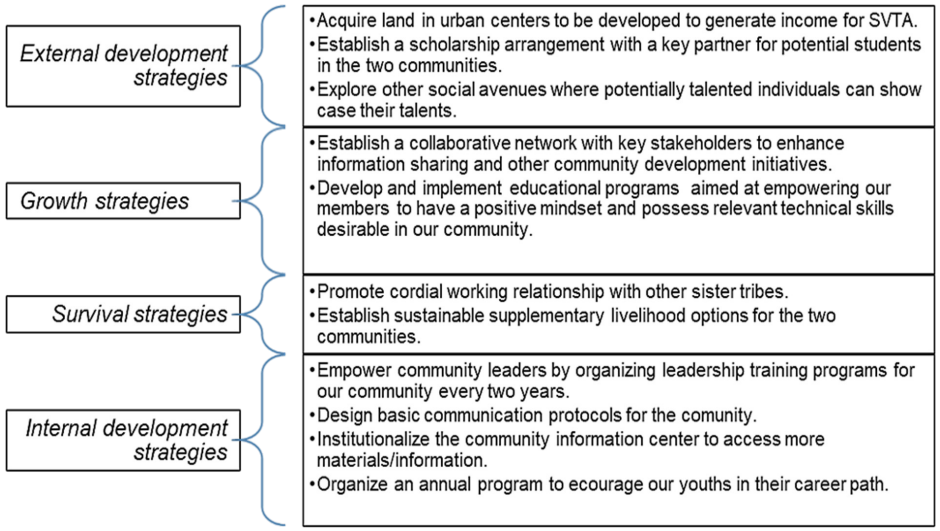

Fig. 1. Four generic strategies formulated from the diagnosis exercise.

Besides the SWOT analysis above, quite a number of requirements were identified from the assessment of livelihood options using the SLOPIC tool (Figure 2).

The most common requirements highlighted were basically; sea transport, farming/fishing equipment and tools, communication, relevant information, capacity building and establishment of a sustainable trust fund. While, the latter is paramount for the sustainability of the rest of the other requirements, yet information and capacity building are equally important to ensure technical knowledge and skill is available in the community (Warner, 2000).

Although it is important to specify the resources required for each livelihood option, the usefulness of a resource to a livelihood option also depends on the personal judgment of whoever is doing the assessment. Often respondents tend to

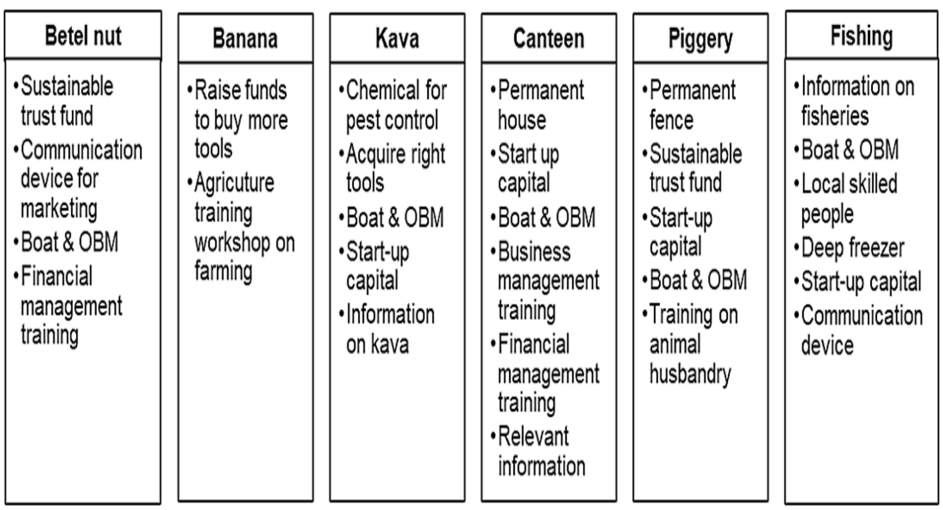

Fig. 2. Resources identified during the assessment that will make the livelihood options more successful.

predetermine the suitability of certain livelihood activities prior to assessment which may result in turning a blind eye to important resources that should be involved for the livelihood option to be feasible. Despite minor variations in the assessment process, the important prerequisite for sustainability is that communities build on what they have instead of depending entirely on external sources. Apparently, some of the requirements must be acquired elsewhere outside of the community, however, the generic strategies in figure 1 should offer a useful guide to focus only on what is more appropriate for the community. Thus, livelihood options which are community-led, and builds on community innovations will very likely to be successful.

For the case of SVTA, assessing for sustainable supplementary livelihood options is very important as they had already been bombarded twice in the past 10 years to give in to logging. With the recognition of appropriate livelihood options from this study, SVTA members can actively participate in these livelihood activities to improve their wellbeing while at the same time prevent external pressures that may lure them to destabilize their firm confidence in forest conservation. Hence in order to progress further, SVTA must capitalize on its key strengths which corroborates to Albert et al. (2010), who also emphasized that community support and leadership are key factors for success in resource management.

Specifically, from the assessment; Betel nut, Banana and Kava indisputably meet most of the required resources including natural resources, equipment, people and skills, market and transport, and support and information although they will require some reasonable funds to set-up. For Canteen, Piggery and Fishing; while most of the required resources such natural resources, people and skills and market may be available, they will require some initial capital to start and to actually operate. Even with environmental challenges cause by changing climatic conditions, banana is a very sustainable livelihood option for SVTA communities because they have two (2) types: the first one which is quickly harvested (meqora naka) is very suitable for bigger households and the other which takes longer to be harvested (qole naka) is farmed mainly for food security. Unlike banana, betel nut and kava are long term economic activities which normally take more than three years to be harvested however, comparatively, the financial benefit of kava is far better than all the other economic activities. Piggery and canteen will succeed when the requirements highlighted in figure 2 are fulfilled. Moreover, fishing is a sustainable livelihood option that can continue as part of the day to day activities of the community. Fishing is not only done for income generation, but it also contributes to food security which is essential for future generations.

Regardless of the different costs incurred for each livelihood option, the important goal is sustainability. As indicated by O'Garra (2007), the key indicator of success is that the livelihood activity is able to persist long after subsidies and/or external funding organizations are utilized. Although assessment of livelihood options to identify the most appropriate option is vital, it is also important to diversify different options as a form of self-insurance so that when one option fails, the community can still have other options available that are still up and running (Haider et al., 2018). All in all, the requirements highlighted above are important for the success and sustainability of these different livelihood options.

CONCLUSIONS

A management that combines traditional and indigenous knowledge to modern-day science is very likely to succeed. This is possible for contemporary communities in the South Pacific region because such an approach will reflect local knowledge

and help the community people to make plans that build essentially on what they have. From the study, it was obvious that despite the weaknesses identified during the diagnosis workshop, the development strategies formulated from the strengths and opportunities will help SVTA management and the member communities to overcome their weaknesses and actually progress. Per se, the most crucial strategies that may leverage sustainability in any conservation program in pacific Island countries include; capacity building to enhance quality leadership and technical skills within the communities, collaboration and networking, and sustainable supplementary livelihood options. Implementation of the strategies will promote social cohesiveness, growth, development and effective management of natural resources. Despite threats such as land dispute, high illiteracy, poor leadership, and poor organization to resource management, we have seen that contemporary community based organizations like SVTA can build on their most important strengths and utilize every possible opportunity to easily move away from these threats. Addition to that, identifying the most appropriate supplementary livelihood options which are fitting for the communities is also very crucial.

It is therefore important that a community participatory approach such as CBRM is adopted to avoid being oblivious of the management challenges faced on the ground however, management also needs to be supplemented with appropriate livelihood activities to keep abreast of other needs in the community. Hence, we have chosen to use results from the diagnosis study to enhance actualization of the livelihoods activities being considered. Specifically, for SVTA communities we have concluded that betel nut, canteen, banana, piggery, kava and fishing are the most appropriate livelihood activities that can work well to supplement their forest conservation initiative. Moreover, we recommend that consideration of livelihood options for assessment must be based on real situations otherwise they may lack feasibility. Thus, despite any cost that can be incurred to start and/or operate the livelihood options, the important objective is that, the options chosen are realistic and sustainable.

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EDITORIAL POLICY

Aims

The AGRIKULTURA CBSUA Research and Innovation Journal aims to serve as a knowledge hub by publishing ridge-to-reef and transdisciplinary research and development projects in agriculture and fisheries. This will focus on technology development and policies for smart agriculture and fisheries, fundamental changes in employing computerization as well as other technological breakthroughs, biotechnology, agriculture and food security, natural resources conservation and environmental protection.

Scope

Journal welcomes submission of quality researches in any of the following academic domains: Agriculture and Fisheries; Socio-economics, Policy and Ethics; Agricultural Technology and Biosystems; Food Technology and Nutrition; Environmental Sciences; Genetics and Biotechnology; and Innovative Extension Modalities. The journal has two(2) issues, one in December and the other in June, printed and on-line.

Recruiting Referees

Letters to the prospective referees will be done by the Editor-in-chief with the support of the Editorial Adviser. Once the invitation is accepted, these referees will be sent a confirmation and with the inclusion of the article which they will review. The peer reviewer must be in the same field as the author. They will be acknowledged by the university with their names printed in the journal issue as Associate Editor.

Peer Review Process

There are two or three referees for a given article. Two are experts of the topic of research and one is an expert in research and statistics who shall review the technical components of the research. These referees return to the board the evaluation of the work that indicates the observed weaknesses or problems along with suggestions for improvement. The board, then, evaluates the referees' comments and notes opinion of the manuscript before passing the decision with the referees' comments back to the author(s).

Criteria for Acceptance and Rejection

A manuscript is accepted when it is

(1) endorsed for publication by 2 or 3 referees,
(2) the instructions of the reviewers are substantially complied;
(3) ethical standards and protocols are complied for studies involving humans and animals;
(4) the manuscript passed the plagiarism detection test with a score of at most 10% or less Similarity Index and a Grammarly Rating of 95% or more. Otherwise, the manuscript is returned back to the author(s).

The referees' evaluations include an explicit recommendation of what to do with the manuscript, chosen from options provided by the journal. Most recommendations are along the following lines:

Accept without revisions
Accept with minor revisions
Accept with major revisions
Reject with option to resubmit
Reject

In situations where the referees disagree substantially about the quality of a work, there are a number of strategies for reaching a decision. When the editor receives very positive and very negative reviews for the same manuscript, the board will solicit one or more additional reviews as a tie-breaker. In the case of ties, the board may invite authors to reply to a referee's criticisms and permit a compelling rebuttal to break the tie. If the editor does not feel confident to weigh the persuasiveness of a rebuttal, the board may solicit a response from the referee who made the original criticism. In rare instances, the board will convey communications between an author and a referee, thereby, allowing them to debate on a point. Even in such a case, however, the board does not allow referees to confer with each other and the goal of the process is explicitly not to reach a consensus or to convince anyone to change his/ her opinions.

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