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COCOINFO INTERNATIONAL

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A Unique Oil with More Than
a Hundred Uses

Coconut Flour
As a Functional Food/Ingredient:
Future Perspective

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Creative Efforts on
Coconut Products

3rd International Certificate Course
for Coconut Development Officers

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International Coconut Community

Collective & Integrated Resources to Minimize the Impact of Global Uncertainty on Coconut Development

It is urgent to transform the current condition impacted by the global uncertainty of diseases risks, geopolitical instability, and climate variability and extreme to a resilient coconut sector. Achieving these imperatives needs collaborative and integrated efforts, capabilities, and resources among local, national, and international actors and communities, governments, and the private sector. The sector needs collaborative efforts to increase production efficiencies, lower production and transportation costs, develop more resilience to climate change impacts, and create a conducive environment to work and do business.

The supply chain bottleneck caused by various factors including natural disasters, severe weather, labor issues, higher fuel prices and transportation failure has led to the higher production cost and lower selling price and has reduced the ability of both the industry and farmers to achieve the optimum production and benefit potential. Though some threats and risks are predictable, others come from sources and directions we do not normally anticipate.

The greater impact of the typhoon in the Philippines and natural disasters in some Pacific countries on the supply chains of coconut was reported. The negative direct and indirect impacts of the extreme weather on coconut production through the buildup of pest population and disease incidence and to the reproductive organs of coconut palms or nut setting have also been documented. The impacts of COVID-19 and its variants and geopolitical instability to disrupt the coconut supply chain including, but not limited to high transportation costs, were also published. These global issues have carried the greatest burden on small coconut farmers and MSMEs and have the potential to affect large industries if there is no significant improvement in the global situation. It could also affect the livelihoods of millions of workers depending on large industries for their source of income.

The International Coconut Community (ICC) is working and must be continually working with various national and international coconut research institutes, coconut authorities, coconut boards, International agricultural research centers, and universities to promote the generation of better technologies and systems that support improved coconut productivity, and resilience to climate change impacts. Such productive collaboration is also needed to develop predictive and prescriptive analytics to better prepare for future changes in the coconut supply chain.

Research and development to generate innovative products and technologies and sustain global demand should be encouraged. Coconut varieties that are tolerant to extreme weather fluctuation, and the cultivation and planting systems to resist and adapt to climate extreme are being developed by some institutes and centers such as Central Plantation Crops Research Institute (CPCRI) India, and the Philippines Coconut Authority (PCA). Other improved characteristics such as a high number of nuts produced, high tolerance to pests and diseases, early bearing fruits, and rich functional traits have been developed in many research institutes and centers of Fiji, India, Indonesia, Jamaica, Malaysia, Papua New Guinea, Philippines, Sri Lanka, Thailand, Vietnam, and other countries. The power of knowledge, technology, and innovation should be enhanced and shared, the power of networks must be lifted and spread, and the capacity building of farmers and the community should be continued, to achieve a more resilient supply chain.

DR. JELFINA C. ALOUW
Executive Director
Editor-in-Chief

Coconut Oil
A Unique Oil With More Than a Hundred Uses

Fabian M. Dayrit[1]

The coconut palm produces a fruit that has more than a thousand uses. This coconut fruit contains a nourishing drink and a highly nutritious coconut meat. The dry coconut meat is a complete natural food: proteins (7%), carbohydrates (22%), fiber (16%) and oil (56%) (USDA Food Data Central, 2022). In addition to its food uses, the coconut fruit has over a hundred other non-food uses (Coconut Products, 2011).

This essay will focus on the nutritional benefits of coconut oil, which has been used by people in the tropics for millennia in more than a hundred ways.

What is Coconut Oil?

Coconut oil makes up more than half of the weight of coconut meat on a dry basis (about 35% on a fresh weight basis). Consuming coconut meat with meals or as part of a recipe means that one will be able to ingest coconut oil in the meal. Coconut oil is often extracted from the coconut meat to make virgin coconut oil (VCO) or refined coconut oil which is used for frying.

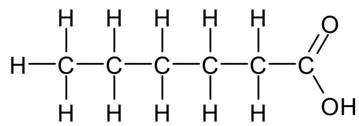
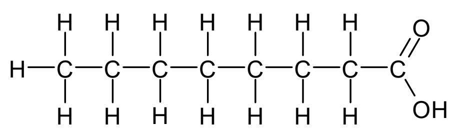
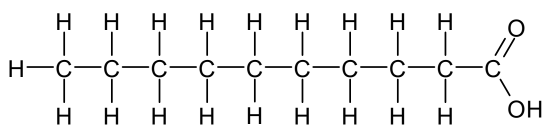
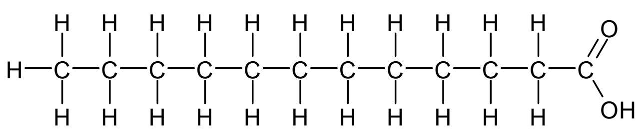
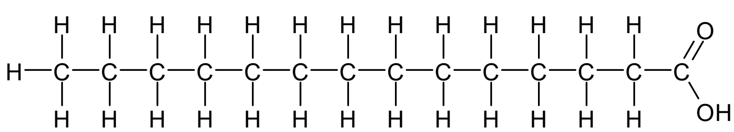
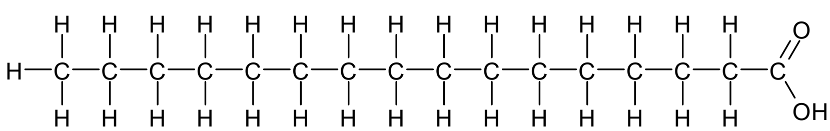
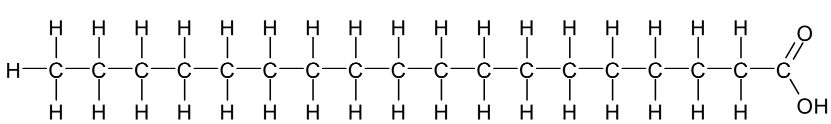
Coconut oil, like other seed oils and animal fats, is made up of natural compounds called fatty acids, which are among the most fundamental biochemicals found in all organisms, from microorganisms to plants and animals. Fatty acids are compounds that are made up of a linear chain of carbon atoms. The fatty acids of common fats and oils are shown in Table 1. Although the structures of the fatty acids look very similar, they can be differentiated in two ways: by the number of carbons and by the number of double bonds (or the degree of unsaturation).

Based on the number of carbons, fatty acids can be classified into medium-chain (six to twelve carbon atoms) and long-chain (fourteen to eighteen carbon atoms). Based on the presence of double bonds, fatty acids can be classified into saturated (no double bonds), mono-unsaturated (one double bond), omega-6 (18 carbon atoms with two double bonds), and omega-3 (18 carbon atoms with three double bonds). This classification is based on the physico-chemical properties of these fatty acids, as well as their metabolic properties. The significance of these properties with respect to the health effects of the various fats and oils will be discussed below.

Different fats and oils have their characteristic fatty acid compositions (Table 2 and Figure 1) and their fatty acid compositions determine their health effects. Coconut oil is a predominantly saturated oil, with a composition that is about 63% medium-chain saturated, 28% long-chain saturated, and about 9.5% unsaturated. One can therefore classify coconut oil as "medium-chain saturated".

Animal fats are not saturated fats

Animal fats, in particular butter, pork and beef fat, have been labeled as "saturated fats" by the American Heart Association (2021). However, the proportion of their fatty acid content show them to be less than 50% saturated fat by weight. In the

Name and Structure	Classification
Caproic acid, C6:0 	Saturated Medium-chain
Caprylic acid, C8:0 	Saturated Medium-chain
Capric acid, C10:0 	Saturated Medium-chain
Lauric acid, C12:0 	Saturated Medium-chain
Myristic acid, C14:0 	Saturated Long-chain
Palmitic acid, C16:0 	Saturated Long-chain
Stearic acid, C18:0 	Saturated Long-chain

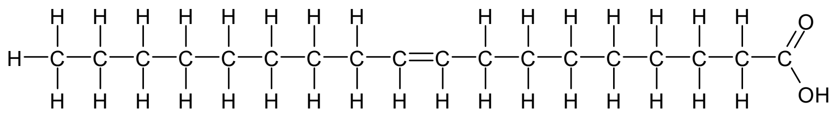
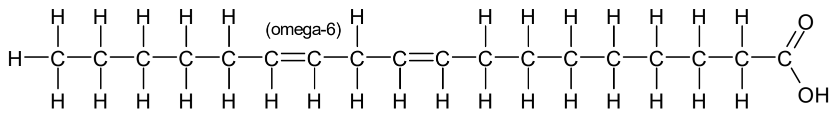
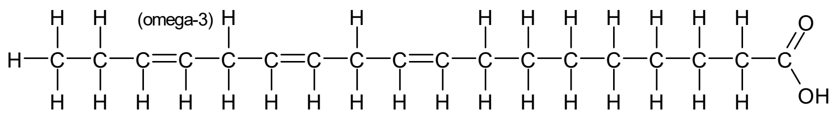
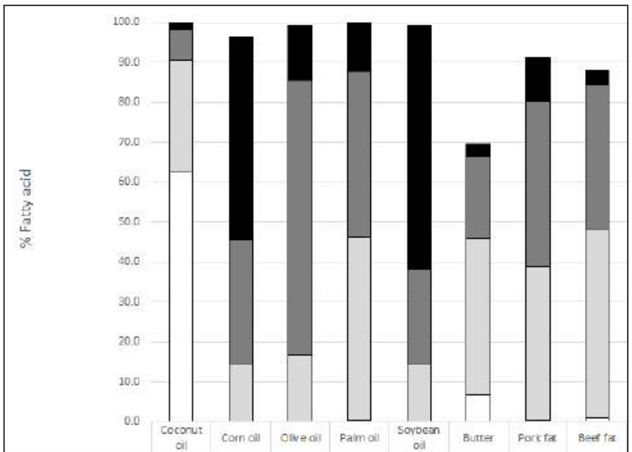
Name and Structure	Classification
Oleic acid, C18:1 	Mono-unsaturated Long-chain
Linoleic acid, C18:2 	Omega-6 Long-chain
Linolenic acid, C18:3 	Omega-3 Long-chain

Table 1. The fatty acids of common fats and oils and their classification. The short-hand designation of a fatty acid indicates the number of carbon atoms and the number of double bonds. For example, lauric acid is designated as C12:0 and linoleic acid is C18:2.

Classification	Fatty acid	Coconut oil	Corn oil	Olive oil	Palm oil	Soybean oil	Butter	Lard, Pork fat	Tallow, Beef fat
Saturated, Medium-chain	Capoic C6:0	0.4					1.6		
	Caprylic C8:0	7.0					0.9		
	Capric C10:0	6.3					2.0	0.1	
	Lauric C12:0	49.0	0.2		0.3	0.1	2.3	0.2	0.9
Saturated, Long-chain	Myristic C14:0	18.9	0.2	0.1	1.0	0.1	8.2	1.3	3.7
	Palmitic C16:0	7.0	12.6	13.8	40.8	10.8	21.3	23.8	24.9
	Stearic C18:0	2.0	1.7	2.8	4.3	3.7	9.8	13.5	18.9
Mono-unsaturated	Oleic C18:1	7.5	31.1	69.0	41.6	23.5	20.4	41.2	36.0
Omega-6	Linoleic C18:2	1.8	49.8	12.3	11.8	53.5	1.8	10.2	3.1
Omega-3	Linolenic C18:3	0.1	1.0	1.5	0.3	7.8	1.2	1.0	0.6
Others: Cholesterol mg/kg		≤3	0.2-0.6	<0.05	2.6-6.7	0.2-1.4	219	95	109

Table 2. Fatty acid composition (% by weight) of some common fats and oils. Fatty acids can be classified by saturation level and by chain length. Fats and oils can be classified according to its fatty acid profile. Thus, coconut oil can be considered as medium-chain saturated, while corn oil and soybean oil are long-chain omega-6. Palm oil is long-chain and is a balanced mix of saturated and unsaturated. Therefore, it is erroneous to label palm oil as a saturated fat. Butter, pork and beef fat are not saturated fats and contain high amounts of cholesterol.

Comparison of fatty acid profiles of selected vegetable oils



	Coconut oil	Corn oil	Olive oil	Palm oil	Soybean oil	Butter	Pork fat	Beef fat
■ Omega-6 + Omega-3	1.9	50.8	13.8	12.1	61.3	3.0	11.2	3.7
■ Mono-unsaturated	7.5	31.1	69.0	41.6	23.5	20.4	41.2	36.0
□ Saturated, Long-chain	27.9	14.4	16.6	46.0	14.6	39.3	38.6	47.5
□ Saturated, Medium-chain	62.7	0.2	0.0	0.3	0.1	6.8	0.3	0.9

Figure 1. Fatty acid profiles of some common fats and oils. See Table 2 for specific fatty acid composition. This plot visually shows that coconut oil has a unique fatty acid profile that is medium-chain saturated (clear bar).

case of pork fat, there is more unsaturated fat than saturated fat by weight (Figure 1). Thus, the claim that all animal fats are the same and that they are all saturated are incorrect. In addition, animal fats contain high amounts of cholesterol. Therefore, to put coconut oil and all animal fats in the same category is clearly erroneous.

When the AHA in 1961 first declared that animal fats were "saturated fats" and similar to coconut oil, the AHA did not provide any scientific data to support this classification (Page et al., 1961), despite the availability of suitable chemical methods of analysis. The only physical property which coconut oil and animal fats share is that they are solid, but at the colder temperatures of the temperate countries. This error was carried over in the Seven Countries Study headed by Ancel Keys, where all types of animal fats and margarine (trans fats) were considered as "saturated fat" (Keys et al., 1986). Thus, sixty years of dietary research have to be reassessed because of this erroneous definition of "saturated fat." And the various dietary guidelines that assume that all animal fats are saturated fats must likewise be reassessed.

Only coconut oil can be said to be truly saturated and as we shall see below, coconut oil is one of the healthiest oils in the world.

The Dietary Guidelines for Americans (DGA) is the most important advisory on diet that is issued by the US government. The DGA was first issued in 1980, and it is reviewed every five years with the release of a new edition. A number of changes have been made since its first edition. Significantly, the warning against trans fats was added in 2005 (6th edition) while the advisory against cholesterol in the diet was dropped in 2010 (7th edition) when this was shown not to be supported by the data.

However, there are two things that have remained the same in the DGA since 1980: the warning to keep "saturated fat" low and the absence of a limit on unsaturated fat. Since "saturated fat" is defined erroneously, this warning is erroneous as well. On the other hand, the excessive consumption of linoleic acid has been identified as one of the causes of the epidemic of obesity among Americans. In particular, the amount of linoleic acid increased from about 10% of calories before 1980 increasing to 23% in 2008 (Guyenet & Carlson, 2015). The high linoleic acid in the diet, which is encouraged by the DGA, can be correlated with the epidemic of obesity among Americans, which was observed to increase in 1980 with the first edition of the DGA (US NIH, 2017). The increase in obesity in the US has been observed also in many countries that followed the advice of the DGA (Figure 2) (GBD, 2015).

This increase in obesity has also been observed among people in the South Pacific Islands. In 2003, the World Health Organization Regional Office for the Western Pacific noted that: "In 1998, it was determined that people were 2.2 times more likely to be obese and 2.4 times more likely to be diabetic

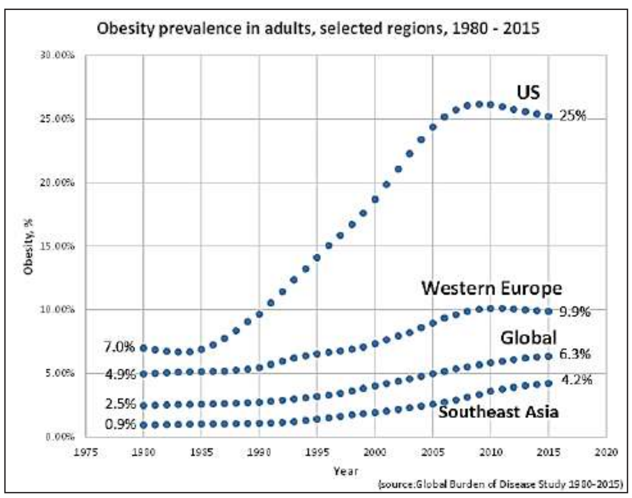


Figure 2. The prevalence of obesity has been increasing since 1980. The first edition of the Dietary Guidelines for Americans was published in 1980, and has been adopted by many other countries.

if they ate imported fats than if they ate traditional fat sources," (WHO, 2003).

Unsaturated fats produce free radicals and aldehydes when heated

The chemical structure of the fatty acid determines its stability against oxidation: the more double bonds a fatty acid has, the easier it is to oxidize. The tendency to oxidize fatty acids follows the following trend: linolenic acid (C18:3) > linoleic acid (C18:2) > oleic acid (C18:1) >> saturated fatty acids. Seed oils which are highly unsaturated, such as soybean oil and corn oil, readily oxidize.

The oxidation of a fatty acid can take place by exposure to oxygen in the presence of high temperature and light. Storage of highly unsaturated oils leads to oxidative rancidity. Rapid oxidation happens when one heats such oils during frying. Oxidation leads to the formation of free radicals and degradation products such as peroxides and aldehydes. These compounds attack proteins and cell membranes and can lead to cellular damage, inflammation, obesity, diabetes, cancer and other diseases, such as Alzheimer's disease. In particular, soybean oil, the most widely consumed oil in the US, has been linked to obesity and diabetes, and cause neurological conditions, such as Alzheimer's disease, anxiety, and depression (Deol et al., 2010). On the other hand, coconut oil, because it is a predominantly saturated fat (>90% saturated), is stable to oxidation and is therefore a healthy frying oil.

The rise of virgin coconut oil (VCO)

Codex Alimentarius defines virgin oils as oils that are obtained by mechanical methods and the application of heat, without altering the nature of the oil. (*Codex Standards for Fats and Oils from Vegetable Sources*, n.d.) The year 2000 witnessed the revival of interest in coconut oil with the rise of virgin coconut oil (VCO). Before the development of VCO, coconut oil was commercially available as edible oil, known as refined, bleached and deodorized coconut oil, and was used mainly as a frying oil. On the other hand, VCO found use as dietary supplement, salad oil, food ingredient, skin and hair care, moisturizer, massage oil, and other applications.

The world market for VCO has been projected to reach about USD 5 Billion by 2024 and its popularity has been rising steadily in various parts of the world. Unfortunately, as the value of VCO has increases in value, so also has the threat of adulteration. The most common adulterants of VCO are refined coconut oil and palm kernel oil. The development of tight product standards is essential to ensure the quality of VCO and advanced techniques, such as nuclear magnetic resonance (NMR) spectrometry, can be used to detect adulteration.

The many beneficial properties of VCO

VCO has been widely reported to have numerous beneficial effects, in particular, for health and beauty. With the rapid rise in the use of VCO, many scientific studies have shown that VCO is beneficial for many things. A few are cited below:

- VCO increases HDL. In a study that compared VCO, virgin olive oil (VOO), and butter, VCO significantly raised HDL-cholesterol compared with VOO and butter but did not significantly raise LDL-cholesterol, as often reported in other studies. The surprising finding from this study was that there was no significant difference between VCO and VOO in terms of LDL-cholesterol and total cholesterol results despite their very different fatty acid profiles. (Khaw et al., 2018) This contradicts the claims of the AHA that VCO raises the risk of cardiovascular disease.

- VCO can help lower obesity. Unlike other seed oils which are made up mainly of long-chain fatty acids, VCO is a non-fattening oil because it is made up predominantly of medium-chain fatty acids which are not deposited as fat in the body. Consistent with this, VCO consumed moderately does not lead to obesity, and may even decrease obesity. The effects of dietary supplementation with coconut oil versus soybean oil on the biochemical and anthropometric profiles of women with abdominal obesity showed that coconut oil reduced waist circumference and improved lipid profiles of HDL-cholesterol (Assuncao et al., 2009).

- VCO is antibacterial. Numerous reports have been published on the antibacterial properties of lauric acid and monolaurin both in vitro and in vivo against Gram-bacteria and fungi. These compounds are unique in their ability to avoid the development of microbial resistance which may be due to their multiplicity of action, which includes disruption of the cell wall and interference with cell signaling and transcription (Dayrit, 2015).

- VCO is good for skin care. VCO has been traditionally used as moisturizer by people in the tropics. Clinical studies have shown that VCO improves the symptoms of skin disorders by moisturizing and soothing the skin. VCO suppresses inflammatory markers and protects the skin by enhancing skin barrier function (Varma et al., 2019).

- VCO is good for hair care. Coconut oil has been shown to prevent combing damage of various hair types. A study comparing coconut oil, mineral oil, and sunflower oil showed that coconut oil reduced protein loss in both undamaged and damaged hair, while sunflower oil and mineral oil did not reduce protein loss from hair (Rele & Mohile, 2003).

VCO is effective against COVID-19

Coronavirus disease 2019 (COVID-19) is a respiratory disease that has caused significant morbidity and deaths worldwide for over two years. The first clinical on the use of VCO evaluated its efficacy in mild cases of COVID-19 against a control group. Overall, the VCO group experienced more rapid relief from symptoms of COVID-19 and a significantly higher reduction in mean C-reactive protein levels compared to the control group after 28 days. These results are consistent with the anti-viral and anti-inflammatory properties of VCO. This study showed that VCO is an effective, safe, and affordable treatment for mild COVID-19 infection (Angeles-Agdeppa et al., 2021).

Conclusions

Coconut oil is a unique oil with over a hundred uses which includes food and nutritional supplement with anti-obesity and anti-inflammatory activities, antibacterial and antiviral agent, and skin and hair care. Coconut oil is the most stable frying oil, which avoids health damage from the use of unsaturated oils. This brief review of coconut oil shows that it is perhaps the best oil that one can obtain from nature.

[1] *Professor, Ateneo de Manila University, Philippines & Chairman, Scientific Advisory Committee on Health, ICC.*

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Coconut Flour as a Functional Food/ Ingredient: Future Perspectives

Domina Esther Mbela Nkuba[1]

In tropical regions, coconut is the tree of great significance: it provides millions of people with food, employment, and business opportunities. The fruit is called 'miracle fruit'. Coconut flour is made by milling dried/desiccated coconut endosperm (copra). Coconut flour is a functional ingredient with high nutritional content and is naturally gluten-free, giving it many uses in bakery products. The term functional ingredient is meant to convey the function of ingredients, which is to produce a positive health outcome via physiological activity in the body. Compared to wheat flour, coconut flour has more fat, protein, and fiber. Iron is the primary mineral present in coconut flour. Coconut flour is used as a substitute for wheat flour. It can be incorporated into various food products, such as bakery, extruded products, snacks, and sweets. The functionality of coconut flour in terms of prevention for chronic diseases, e.g., diabetes mellitus, cardiovascular diseases, and colon cancer, leads to increased coconut and coconut flour production. The increase in health consciousness by the population following post-pandemic COVID-19 can lead to increased consumption of healthy foods, including coconut flour. Consumer demand for functional foods and organic products is growing nowadays. Increasing demand for safe, efficacious, and quality natural therapeutic products considering mushrooming world population and high cost of drugs can lead to increased consumption of coconut flour—growing awareness of the value of food and nutrition in preventing diseases. Different recipes from coconut flour are needed for increased consumption and improved health by populations.

INTRODUCTION

Coconut flour is one of the many food products made from the fruit of the palm tree Cocos nucifera. In tropical regions, coconut is the tree of great significance: it provides millions of people with food, employment, and business opportunities (Karandeep *et al*., 2019). The fruit is called 'miracle fruit' due to its inherent rich profile of macro-and micro-nutrients for human nutrition and health (Karandeep *et al*., 2019). Coconut flour is made by milling dried/desiccated coconut endosperm (copra). Thus, it is from dried, ground coconut meat.

Production of this flour is very economical. Coconut flour has high nutritional content and is naturally gluten-free, giving it many uses in bakery products such as bread or cookies (Trinidad *et al*.,2006).

Functional food is any food that imparts a positive effect on people's health and provides essential nutrition. Functional ingredients are a diverse group of compounds intended to affect the consumer's health positively. The term functional ingredient is meant to convey the function of these new ingredients, which is to produce a positive health outcome via physiological activity in the body (Trinidad *et al*., 2006). Compared to wheat flour, coconut flour has more fat, protein, and fiber. Iron is the primary mineral present in coconut flour, making it a good option for people on vegan or vegetarian diets who are concerned about getting enough iron (Trinidad *et al*., 2006). Nevertheless, coconut meal has nutraceutical properties, making it useful for human consumption, and should be incorporated in various food products. Coconut flour is also gluten-free, and its nutritional composition is quite comparable to that of wheat flour. Gluten-free food products enriched with coconut flour are a healthy and viable option for people with celiac disease (Karandeep *et al*., 2019). Coconut palm can be processed into coconut water, coconut milk, coconut sugar, coconut oil, and coconut meat. Coconut consists of an outer fibrous coat or husk is known as exocarp, and inner hard protective endocarp, or shell. A white albuminous part is an endosperm or coconut meat, and the inner cavity is filled with a clear fluid called coconut water (Karandeep *et al*., 2019).

DISCUSSION

Processing of coconut flour

The manufacturing of coconut flour involves two processing methods: dry and wet ones, and this also depends on the technology used and the type of industry.

The dry process involves drying grates from fresh mature coconut meat and virgin coconut oil extraction/pressing. The white low-fat residue/meal obtained is ground to make coconut flour. The process produces a high protein coconut flour (33%) which can be used as a wheat substitute. The advantages of this process is the high oil recovery at 88% based on the oil content of the meat (65%) or 58% of the dried granulated meat and good quality of the oil with a free fatty acid content of 0.1% (Karandeep *et al*., 2019). The oil is removed by pressing and/or solvent extraction, and the remaining coconut meal is milled into a fine flour(Srivastava, *et al*., 2011).

On the other hand, Virgin coconut meal is obtained after removing virgin coconut oil from fresh coconut meat. It is high in insoluble dietary fiber and protein. Coconut flour is a by-product of coconut milk and the oil industry made from coconut meal leftover after processing (Karandeep *et al*., 2019). The coconut flour contains carbohydrates, protein and dietary fiber, which can also be used for food enrichment (Srivastava, *et al*., 2011).

Wet process wherein the meat is extracted with milk, drying of the residue and grinding to produce the flour. In the wet process, almost 52% of the available oil in the fresh meat is recovered. The meal or residue that remains still contains a lot of oil - 35-48% fat content in which 38% colorless oil is recovered and 40% coconut flour is obtained as a by-product. In wet processing, the coconut milk is extracted from the fresh kernel, which is then fermented naturally (at 35–40°C for 16–24 h) to obtain VCO from coconut curd by phase separation. The meal is milled into coconut flour (Yalegama *et al*., 2013). The solvent extraction method is generally avoided because of health hazards and lowquality meals (Wolf,1992). Usually, the meal or the residue obtained after the extraction of coconut oil is used as cattle and poultry feed (Karandeep *et al*., 2019).

Properties of coconut flour

Like wheat flour, coconut flour is a white or off-white flour commonly used in baking. Slightly nutty odor; It has less coconut flavor (almost bland taste)

Because it is gluten-free, doughs made with coconut flour need to be mixed longer. Cococonut flour as a substitute for wheat flour in bread and cakes provides the limiting amino acids in wheat flour. This can be used in nutrition feeding programs. As a food supplement/additive in bread, cookies, snack food to provide dietary fiber sources, this can be used as fiber food to help in preventing constipation, as fiber food for patients with diabetes and moderately raised cholesterol levels. It is time now to promote the use of coconut four in different food products. Different recipes from coconut flour are needed for increased consumption and improved health by populations (Karandeep *et al*., 2019).

due to reduced fat content; Coconut flour is bulkier; Coconut flour has a shelf-life of six months at room temperature. Since it doesn't contain gluten, people on gluten-free diets can substitute coconut flour in their recipe for baked goods.

Coconut flour is sub-classified according to its fat content (low, medium and high), protein content (high protein) and fiber content (high fiber). Being a rich source of dietary fiber and protein, it has found numerous applications in different functional foods (Karandeep *et al*., 2019). Coconut flour can be successfully incorporated into various food products, such as bakery, extruded products, snacks, and sweets (Karandeep *et al*., 2019). Non-starch polysaccharides (NSP) or dietary fiber are protective against gastrointestinal cancer, including esophageal ones (Karandeep *et al*., 2019).

Uses of coconut flour

Although coconut flour can be used as a substitute for wheat flour, many recipes must be adjusted to account for its different compositions. Coconut flour is thicker than wheat flour and retains more liquid.

Bakery products include cereal-based cookies, bread, and crackers account mainly for an energy source in human nutrition; therefore, they are good vehicles for supplementation nutrients (Wani *et al*., 2012). Gunathilake *et al*. 2009 used coconut flour in different proportions (10, 20, and 30%) for refined wheat flour bread to enhance proteins, amino acid profile, and dietary fibers. Cereal proteins are not a valuable source of lysine (Panghal *et al*., 2006).The mixing behavior of the wheat flour and coconut flour blends were analyzed. It was found that water absorption decreased while dough development time, arrival time, and stability increased with 20% substitution. The study concluded that acceptable quality of bread could be made by 20% substitution of the wheat flour with coconut flour.

Nutritional composition of coconut flour

Compared to wheat flour, coconut flour has more fat, protein, and fiber. Iron is the primary mineral present in coconut flour, making it a good option for people on vegan or vegetarian diets who are concerned about getting enough iron.

The composition of coconut flour mainly depends upon the method employed for the extraction of coconut oil. However, varieties and agroecological zones have a slight influence on the oil content of coconut and, thus, on flour. Coconut flour is superior to wheat flour in protein, fiber, mineral, and lipid profile (Gunathilake and Abeyrathne, 2008.). Results from Khan *et al*., 2015 showed that coconut flour composition obtained by dry processing method was: moisture, 6.7%; ash, 1.55%; protein, 14.3%; fat, 54.0%; fibre, 20.50%; and carbohydrates, 23.40%. While Igbabul *et al*.,2014 found that the composition of coconut flour made by wet method had 5.27% moisture; 2.76% ash; 12.31% protein; 0.48% fat; 11.81% fibre; and 67.37% of carbohydrates. Thus, it is suggested that coconut flour produced by dry processing is rich in protein and fiber.

The general composition of coconut flour : 3.6% moisture, 3.1% ash, 10.9% fat, 12.1% protein, 60.9% total dietary fiber (56.8% insoluble and 3.8% soluble) and 70.3% carbohydrates.

Health benefits of functional coconut flour

Functional food is any food that imparts a positive effect on people's health and provides essential nutrition. Coconut flour has a lower glycemic index rating than wheat flour, meaning it takes longer to digest and absorb carbohydrates. It also contains more fiber and protein than wheat flour (Yalegama *et al*., 2019). Dietary fiber is the best ingredient to be used in developing functional foods due to its health-promoting effects, such as controlling cholesterol and blood sugar levels, increasing the fecal bulk volume, proliferation of gut microflora, decreasing intestinal transit time, trapping carcinogenic agents, etc. Fiber can be supplemented using coconut flour to develop healthy foods low in calories and fats. Coconut flour is a potential functional ingredient used in food products with wide health benefits such as Antidiabetic effect; Cardiovascular diseases prevention; Anticancer effect; Weight control; Prebiotic; immune modulator; lowering glycemic index and serum cholesterol levels (Karandeep *et al*., 2019). Coconut flour can be considered a good substitute for gluten-free products and other processed products due to the absence of an antinutritional factor (Wolf WJ, 1992). Antinutrients lower the bioavailability of minerals and inhibit the protein digestion. Gluten-free food products enriched with coconut flour are a healthy and viable option for people with celiac disease.

Future perspectives of coconut functional flour

The production of coconut flour is very economical because it can be produced on a small or large scale. The functionality of coconut flour in terms of prevention for chronic diseases, e.g., diabetes mellitus, cardiovascular diseases (CVD) and colon cancer, reveals increased production of coconut and coconut flour. The increase in health consciousness by the population following post-pandemic COVID-19 can lead to increased consumption of healthy foods, including coconut flour. Modern lifestyle improved living standards, and changing eating habits can lead to a vast market of snacks. A serving of coconut provides 61% of dietary fiber. Overall, coconut flour is an excellent alternative for a gluten-free and grain-free diet.

- Availability of convenient alternatives like bread, biscuit, cakes, cookies, chapatti, noodles, buns, etc.
- Increase demand for healthy bread such as oatmeal, wheat, rye, multi-grain, and others as more and more consumers are becoming health-conscious.
- Specialty bread-like high fiber white bread is on the rise. People are becoming more conscious of quality and nutritional content.
- Campaign on fortification of products like bread, maize flour, noodles.
- Create a market for high-protein coconut flour and encourage existing VCO producers to process their by-products further.
- The spread of cafeterias, hotels, and coffee shops is expected to increase bread consumption, complementing coffee and tea.
- Consumer demand for functional foods and organic products is increasing nowadays.
- Acceptance of herbal/natural medicine as alternative products to complement, if not replace, synthetic drugs.
- Increasing demand for safe, efficacious, and quality natural therapeutic products considering mushrooming world population and high cost of drugs can lead to increased consumption of coconut flour.
- Growing awareness of the value of food and nutrition in preventing diseases. Aging global population. Increasing interest in natural products. Increased promotion and advertisement is resulting in testimonials.

CONCLUSION

Coconut meal obtained from the extraction of virgin coconut oil can be used in coconut flour as it is nutritious and a good source of proteins, minerals, and dietary fiber. Coconut flour made from coconut meals promotes health and prevents diseases like diabetes, obesity, colon cancer, and cardiovascular diseases. The flour can be used in the preparation of gluten-free products for individuals with celiac disease. The use of coconut flour aims to incorporate dietary fibers and proteins into gluten-free food.

Coconut flour is an underutilized product of the coconut industry, and its present use is minimal. There is an immense need for commercial processing techniques to enhance the utilization of coconut flour from coconut meals. Coconut flour extruded products will be convenience products with nutritional and health benefits. Coconut flour is a high protein, fibre-rich, and gluten-free functional food product.

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3rd International Certificate Course for Coconut Development Officers

Athula D. Nainanayake [1], Mridula Kottekate[2]

The Coconut Research Institute of Sri Lanka (CRISL) has emerged as a leading research institute amongst the countries across the globe. The institute has taken initiatives to disseminate its findings and technologies on all aspects of coconut development covering research and development, education, training, and extension, private - public partnerships, international relations, and services to the coconut industry for the benefit of growers and industry people through its training programs.

The ICC-CRISL international certificate course for coconut development officers is one of the apex programs of the CRISL that enables coconut industry related people across the globe to access latest technology developed by the scientists at the CRISL in different aspects of the coconut industry including agronomy, breeding, pest and disease management, product development, economics and business management and technology transfer. CRISL has conducted two residential programs in 2018 and 2019 for participants from ICC member countries. The training program included lectures and hands on practical sessions in all aspects of coconut industry. Outcomes of this prestigious training course lead many coconut growing countries to develop their coconut industry. In the year 2021, due to the COVID-19 pandemic situation prevailed all over the world, International Coconut Community (ICC) and CRISL conducted the training program virtually from **4th October to 5th November 2021**. It was discussed and decided that when the pandemic allows, and international travel ban lifted two weeks practical session would be arranged at CRI Campus for the trainees.

Dr. Athula D. Nainanayake, Head Plant Physiology Division was the course director for the course and assisted by Dr. D. M. A. C. Dissanayake, Acting Head, Genetics & Plant Breeding and Dr. M. D. P. Kumarathunge, Senior Research Officer, Plant Physiology Division.

The inaugural session was chaired by the Chairman of the Coconut Research Board, Dr. Saranga Alahapperuma. Other participated dignitaries were Mr. Ravindra Hewavitharana, Secretary, Ministry of

Figure 1. Opening ceremony of the course

Plantation, Sri Lanka, Dr Jelfina C Alouw, Executive Director, ICC, Dr. Sanathanie Ranasinghe, Director, CRISL. The other officials: represented from the ICC partner organizations were Ambassador Diar Nurbintoro, Acting Director, NAM Centre and Mr. William Castro Rodriguez, International Trade Centre. Course Director, Dr. Athula Nainanayake introduced the lecture panel and briefed the course content to the participants and the participants were given an opportunity to provide a brief introduction to the coconut industry of their respective countries.

Mr. Ravindra Hewavithrarana, Secretary, Ministry of Plantation, Sri Lanka, mentioned that participants from different countries gathered to learn knowledge on coconut production and the related Industries. In this process, if millions of growers and industrialists are inbound and contribute to uplift the industry, it would be a great relief to the coconut community as well as to the millions of related parties in those countries. The entire world has recognized the health benefits, cosmetic advantages, and nutritional value of coconut and coconut products. He highly appreciated the timely initiative taken by the International Coconut Community to broaden the horizon of the leaders of coconut development along with CRI, Sri Lanka amid the existing COVID-19 pandemic.

Dr. Jelfina C. Alouw, Executive Director, ICC, informed that the primary aim of the training is to assist the member countries in addressing various issues in the coconut sector, including research, knowledge, technology, innovation gaps, by building and enhancing the capacity of field level coconut officers in their respective countries. Development of strong science, technology, and capacity are some of the keys to addressing the persistence and emerging challenges associated with the low productivity of coconut, poverty of small-scale farmers, low product diversification, and value-added product development, and trade-related issues that ICC member countries are facing now. ICC is united to support each other, through collaboration with other international research institutions and organizations, like CRISL, NAM Centre, ITC, ACIAR, other coconut research institutes, coconut development boards of the countries.

Dr. Sanathanie Ranasinghe, Director, CRI, Sri Lanka, expressed her happiness to see the increase in number of trainees from various countries to attend this training program. In 2018 the participants were only 14 from 8 countries whereas the number increased to 21 participants from 14 countries during 2019. This year 38 participants from 19 countries are registered to attend the course. She hoped that all participants take maximum benefits of the training with their active participation, not only to gain knowledge and experience but also to strengthen the link and friendship amongst the participants from different continents of the world. She also hoped that the participants would work as one team and exchange ideas during the training period.

Mr. William Castro Rodriguez, International Trade Centre, Geneva, mentioned that this course underlined the importance of promoting the coconut industries all around the world and sharing linkages between the coconut growing communities. As the coconut demand continued to increase, it is important to target the main issues to increase coconut production. This comprehensive course will address all these issues and it will be of great benefit for participants all around the world. Although this training could not be conducted physically, he appreciated the effort of the CRI and ICC for organizing this event and hoped that through this course participants can replicate to share the knowledge. The ITC promotes "answer-for-action approach" which is building partnership, sharing experiences, having a comprehensive approach for activities that they do, those all are in line with the international course's approach.

There were 38 registered participants from 19 countries for the training course which includes FSM (3), Fiji(3), Guyana (2), India(5), Indonesia(4), Jamaica(1), Kenya(1), Papua New Guinea(3), Samoa(2), Solomon Islands(2), Thailand(3), Vietnam(1), Republica Dominican(1), Belize(1), Grenada(1), Trinidad(1), New Caladenia(1), Cambodia(1), and Suriname(2).

COURSE CONTENT AND THE LECTURE PANEL OF THE COURSE

The full course was covered in 23 days for 63 hours. The lecture panel of the training course included scientists of CRISL and selected experts from outside institutes including University lecturers and scientists from other research institutes (i. e. Tea Research institute of Sri Lanka, Plant Quarantine Service of Sri Lanka etc.). The major topics covered are Current status of Global Coconut Industry, breeding and hybridizations aspects; pest and disease management; coconut and its value-added products and processing aspects, coconut production policies & programs, market behaviour supply and demand of coconut and coconut-based products, role of plant quarantine institute in pest & disease control specially in island nations, certification of organic products & international sustainable certification, different aspects of good agriculture practices, planting and maintenance of coconut garden with seed garden and nursery management concept.

TRAINING MANUAL

The CRISL released the 3rd volume of the training manual compiled and edited by Dr. Lalith Perera, Additional Director, Dr. Athula Nainanayake, Dr. Auchithya Dissanayake and Dr. Dushan Kumarathunge. In the training manual, the results of extensive research carried out over decades were bundled and streamlined to create a series of recommendations and guidelines to give the participants a wide range of knowledge on both theoretical and practical aspects of coconut plantation management. The training manual was built up on the 2nd edition with substantial improvements in the content to best suit for the virtual teaching and learning platform. It contained 24 chapters on different aspects of coconut industry with a practical guide for coconut processing.

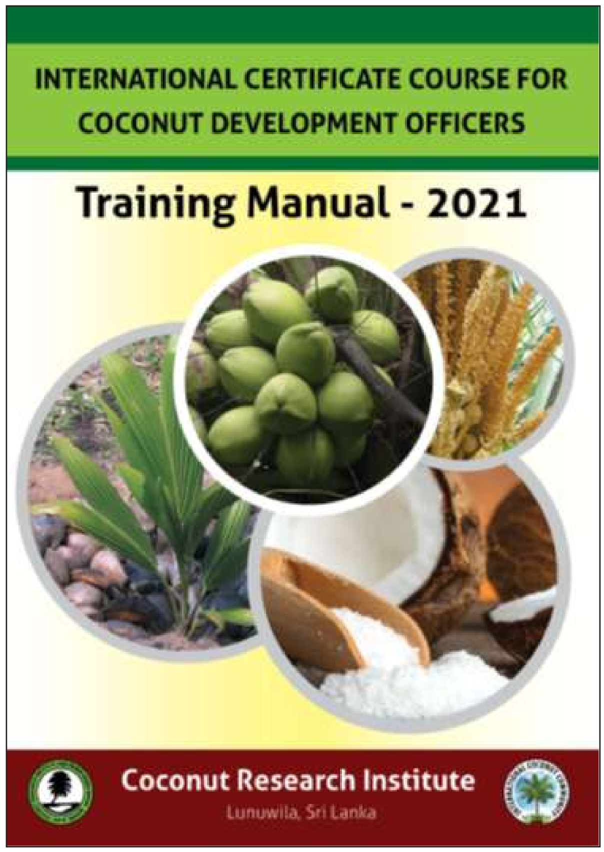

Figure 2. Front cover of the training manual of the certificate course for coconut development officers (2021), 3rd edition. Coconut Research Institute of Sri Lanka.

CONCLUDING SESSION

The closing ceremony of the international certificate course for coconut development officers was held

Figure 3. Certificate awarded for participants who completed the training successfully.

virtually on 5th November 2021. The session was chaired by Dr. Saranga Alahapperuma, Chairman of the Coconut Research Board, Sri Lanka.

Dr. Saranga Alahapperuma, Chairman, CRISL expressed his happiness to hear the trainee's testimonials that they were extremely happy with the way CRI conducted the program and hoped that they have absorbed the knowledge and experience the CRI scientists have shared. He added that the participants will be able to implement what they gained during these 23 days in their countries for the betterment of their country, people, all human being, and the environment. In this pandemic situation, this is one of most successful virtual training programs conducted by CRISL as the first coconut dedicated research center. He also proposed to arrange in trainee's countries this kind of training program, so they can gather more officers in their areas with a less cost, in which CRI's experts can enter to their countries, and apply their knowledge. he assured that when the situation allows the participants were invited for a one-week practical session at CRI Campus.

Dr Jelfina C. Alouw, Executive Director, ICC, in her closing remarks emphasized that information and technologies are essential in the entire value chains from the upstream to the downstream process and the development of strong science technology. Competent coconut development officers are very essential to facilitate linkages in the capacity building and technology transfer program to farmers to micro and small enterprises in collaboration with other actors, such as private companies and local government. The certificate of participation in this course will be more beneficial if it can be transformed into a real and significant contribution to the sustainability of coconut sector development. Substantial knowledge technology shared in the training will enable coconut development officers to be applied not only to themselves, or the organization who nominated them but also to other stakeholders, so there will be multiplying effects to many beneficiaries, including our beloved farmers. With the spirit of coconut, we are united in global solidarity to address challenges in the coconut sector.

H.E Ambassador Diar Nurbintoro, Acting Director, NAM CSSTC, hoped that participants can apply these experiences and knowledge to their work and share them with colleagues in their home country. This is the beginning of collaborative efforts with the new networks, either with fellow participants or with trainers, to support the capacity needed to further revitalize coconut cultivation. He hoped that participants can create a platform where they can continue to share information and experiences. NAM Centre ensures to continue promoting capacity-building activities in developing countries to improve agriculture sector.

The session followed by the certificate awarding ceremony which was conducted virtually and the certificates were sent to the participants.

In addition to the addresses by dignitaries during the closing ceremony, each participant was given a chance to share their experience, feed-back and suggestions over the training program they attended and completed.

SELECTED COMMENTS OF THE PARTICIPANTS ABOUT THE TRAINING COURSE

Thank you to all Sri Lanka Coconut Research institute and fabulous team for your contribution in promoting the global coconut industry. I'm inspired and will miss this interaction.

Mr. Allan Wahwa - *Papua New Guinea*

Personally, it was an honor for me to participate this well-planned workshop. Thank you very much ICC for organizing this important training program.

Mr. Yulianus Rompah Matana - *Indonesia*

I have gained a lot of knowledge on coconut from the leaf tip to the root hairs. The training allows me to identify the limitations for coconut production and provide solutions to overcome those limitations with minimum harm to the environment. Topics discussed in the training such as mother palm selection and coconut hybridization techniques were very interesting and useful.

Mr. Niklesh Nand Ram – *Fiji*

I joined this course because I wanted to upgrade my knowledge on coconut industry as an employee in coconut development board, India. It is remarkable to observe that the lectures and course materials have been planned in such a way that the participants were able to get the maximum knowledge out of it even under global pandemic situation. Moreover, the opportunity to interactive with people from 19 countries was very important. I would like to suggest the organizers to Include videos of practical aspects in future programs.

Mrs. Vincy Varghese - *India*

Not only the sessions were very informative, but also the training materials and presentations shared were extraordinary and will be very useful in our future activities. The course content and lectures were presented simple, informative and interactive way. I'm sure that we may be able to improve the coconut industry in our country with the knowledge gathered during the training program.

Mrs. Jayashree A. – *India*

The training allowed me to gather information on how coconut is produced in other countries and how to overcome the challenges we faced in the field. The training has been comprehensive and very informative. It would be very useful if CRISL can organize a short practical session once the pandemic situation is over. I'm hoping that the participants may be able to share their field experience to collaboratively solve issues related to coconut industry in their countries through the friendship built during the training program.

Mr. David Napwora Makokha – *Kenya*

Things I learned from this training will be definitely useful in developing the coconut industry in Vietnam. We are looking forward for more training programs like this.

Mr. Cuong Truong Tri – *Vietnam*

ACKNOWLEDGEMENT

The team of CRISL acknowledged the dedication, encouragement and commitment extended by Dr Jelfina C Alouw, Executive Director, Ms Mridula Kottekate, Assistant Director, and the team at ICC, Jakarta, Indonesia. The training course was sponsored by the International Coconut Community.

The support extended by Dr Saranga Alahappperuma, Chairman, Coconut Research Board, Sri Lanka, Dr Sanathanie Ranasinghe, Director, Dr Lalith Perera, Additional Director, Dr Nayanie Aratchige , Deputy Director (Research) and all scientists from CRISL and other R & D institutions of Sri Lanka was also acknowledged and highly appreciated.

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GO-Bojong:
Creative Efforts on Coconut Products

Muhammad Safrudin[1]

Pagebluk (in Javanese) or now called the coronavirus outbreak that first appeared in Wuhan, China. According to data from the Covid-19 Task Force on Saturday, August 7, 2021, the State of Indonesia has 3,639,616 confirmed positive cases, 3,036,194 recoveries and 105,598 deaths. The increasing number of positive cases in Indonesia has made the government implement various policies, one of which is the Enforcement of Community Activity Restrictions levels 1-4. According to the Cabinet Secretariat of the Republic of Indonesia, this policy includes restrictions on workplaces, online/ online schools, activities at public facilities and socio-cultural activities being temporarily suspended. The impact of these policies has resulted in new habits in the community. This new habit is not only a matter of how to maintain health, but this new habit also affects the people's economy to maintain life.

Various regions in Indonesia have experienced setbacks due to Covid-19, including the Bojong Village area, Panjatan District, Kulon Progo Regency, Central Java Province. The impact of government policies has caused many people to experience termination of employment, markets that are often locked down, and losses to small community businesses. In March 2021, there was the addition of 25 new case clusters in Bojong Village. Not to mention the policy of stopping social assistance for victims affected by Covid-19 so that the economy of the people of Bojong Village is getting worse.

Nevertheless, Bojong Village has the potential of a reliable agricultural sector, one of which is the potential of coconut (*Cocos nucifera*). Based on data from the Central Statistic Agency (BPS) of Kulon Progo Regency in 2016, showing that coconut plants are still the prima donna of plantation commodities, in 2015 coconut production reached 31,355.25 tons or an increase in production of 1.21 percent. According to Legrand (2018), Coconut (*Cocos nucifera*) is a perennial tree crop. Coconut plants are included in the plantation sector which is widely developed and spread in tropical areas such as Indonesia and Asian countries. The main product of coconut is copra, which is derived from the dried flesh of the fruit.

Coconut Bojong variety

The most superior coconut potential in Bojong Village is the Bojong Bulat type coconut. Bojong Bulat coconut is a superior variety coconut because it has high oil content, high sugar content, and a thicker flesh of about 1.26 cm, weighing 500 grams. Almost every community yard in Bojong Village is planted with this coconut. The highest production of Bojong Round Coconut annually is 80-120 coconuts per year. Bojong Bulat coconut continues to grow until the demand for this coconut reaches out of town and nationally (Balit Palma, 2018)

However, the lack of ability of Bojong Bulat coconut farmers to make optimal use of their harvests, especially to make processed products that can increase prices. In addition to these problems, the coconut farmers of Bojong Bulat are constrained by the marketing of their harvests during the pandemic. As a result, the Bojong Bulat coconut harvest in Bojong Village is immediately sold to collectors in wet form, because there are no people who have moved to make Bojong Bulat coconut in product form.

Based on the various problems above, innovative solutions are needed to optimize the yield of Bojong Bulat coconut in Bojong Village to improve the economy of the village community. Making superior products by utilizing the harvest in Bojong Bulat coconut every hamlet in Bojong Village is a step that can be taken. By making superior products, Bojong Bulat's coconut harvest will be of high selling value and can be marketed more easily. The manufacture of superior products is integrated with empowering farming communities with the O.V.O.P (*One Village One Product*) method to create an even distribution of production in each hamlet. The application of the O.V.O.P method in each hamlet will have superior products that are different from other hamlets so that there is no product competition in each village. In addition to methods of O.V.O.P, empowerment is to apply the concept of an E-commerce based website named GO-Bojong. E-commerce serves as branding in businesses and online product marketing.

DISCUSSION AND ANALYSIS

GO-Bojong is a website marketing for local agricultural products through community empowerment activities in Bojong Village to change the results of Bulat Bojong coconut farming into various superior product innovations that have economic value. GO-Bojong applies the method O.V.O.P (*One Village One Product*) which aims to improve the economy of the residents of Bojong Village through equal distribution of production in each village area. The O.V.O.P concept is a step towards clustering rural community industries which aims to develop regional products so that they can develop and enter a wider market. This is supported by Gani and Muliati (2018) that the purpose of O.V.O.P is to build the sustainability of activities through expanding market access produced by each hamlet in Bojong Village.

Bojong Village is an area that has Bojong Round Coconut farming spread over 12 hamlets. However, so far the utilization of Bojong Round Coconut has

No	Name of Dusun	GO-Bojong Products
1	Wojowalur	Copra
2	Keboran	Coconut Oil
3	Ngangrangan Lor	Dried Grated Coconut
4	Ngangrangan Kidul	Coconut Shell Charcoal
5	Ngangrangan Kulon	Coconut Fiber
6	Ngentak	Coconut Sugar
7	Ngaran Lor	Nata de Coco
8	Ngaran Kidul	Isotonic Drink
9	Bojong Kulon	Gudheg Manggar
10	Bojong Tengah	Agar-agar
11	Bojong Wetan	Wingko Babat
12	Wojowalur	Geplak

Table 1. Clustering of GO-Bojong Product Community Empowerment

not been optimized by local farmers, especially to become processed products that can increase prices. Therefore, in order to optimize the yield of Bojong Round Coconut in each hamlet, the first step is to cluster resources before processing them into superior products that are characteristic of each hamlet. The benefits of turning Bojong Round Coconut into a product, apart from increasing the economy, also makes Bojong Round Coconut from Bojong Village better known and makes an icon new in every hamlet of Bojong Village. The following is the result of product clustering in Bojong Village.

Presence of GO-Bojong as access to help make the community empowerment program of Bojong Village based on O.V.O.P and successful E-Commerce. The O.V.O.P (One Village One Product) program is a-based program for community development. O.V.O.P development has three basic principles in its implementation, namely local but global, independence and creativity, and human resource development. According to Karl Marx in Mardi (2000), community empowerment is a process of struggle of the powerless to obtain surplus value as their normative right. Mardikanto (2015) argues that the community empowerment process combines a close relationship between internal and external factors. GO-Bojong through this O.V.O.P program has several structured stages. The Development method according to Mardikanto (2001) is a series of stages that are arranged

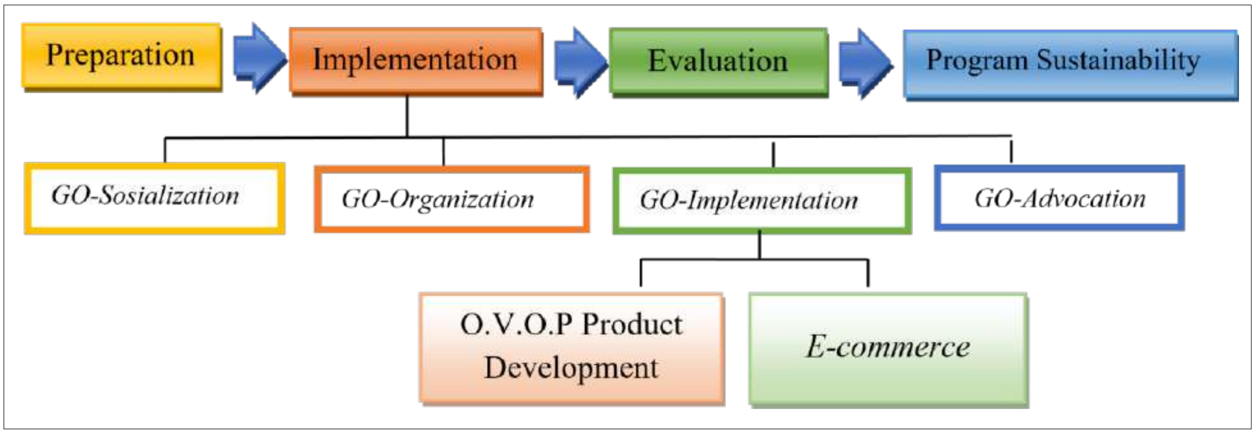

Figure 1. Flow Map of GO-Bojong Empowerment Program Based on OVOP and E-commerce

systematically. The empowerment method is carried out using Participatory Rural Appraisal (PRA), which is a method that prioritizes active participation from the community in all activities starting from program planning and evaluation. The community is actively involved in identifying problems, setting priorities for problems to be resolved, making alternative solutions to problems and evaluating programs (Muslim, 2017). The method used in the program is illustrated in the flow map of Figure 1.

Phase **Preparation**, namely the determination and introduction of work areas in Bojong Village. Before carrying out activities, the determination of the working area needs to obtain an agreement between the facilitator team, local government officials, local community representatives, and other stakeholders such as business people, community leaders, activists, and academics. The next stage is **implementation**, the first implementation technique is ***GO-Socialization***. The socialization is carried out as an effort to communicate the planned community empowerment activities that will be carried out. The next technical implementation is ***GO-Organization***, community organizing, including the selection of leaders and task groups that will be formed to strengthen institutions within the scope of GO-Bojong.

The implementation of the next program, namely ***GO-Implementation***, consists of various trainings to increase and improve technical knowledge, managerial skills and various development activities related to increasing income. Training in developing superior products from each village that describes the concept One Village One Product as well as in terms of marketing through E-commerce in the form of the website GO-Bojong which is a global marketing strategy during the pandemic. The implementation of activities that are also very important in this O.V.O.P program is ***GO-Advocation***. Policy advocacy will greatly impact the sustainability of the program because all community empowerment efforts require policy support that favors the interests of the community. Approaching various stakeholders, the program that will be made will be more mature and the policymakers can provide an umbrella for existing policies. Many innovator agents produce many menus of innovative activities in the village that can be used as a place to learn from each other and replicate each other in managing the potential of local resources to increase the income and welfare of the village community. However, on the other hand, many innovations are suspended due to the absence of program sustainability. One of the important aspects of the sustainability of the program is assistance.

The next stage is **evaluation**. The evaluation stage is carried out after the program is implemented. This evaluation was conducted to obtain information about the shortcomings that occurred during the process of implementing this program, from preparation to completion of the program to obtain inputs for program improvement. Evaluation is also carried out by comparing skills before and after the program. After the program is implemented, it is hoped that the **sustainability of the program** must continue to develop. Through various approaches with various stakeholders as well as approaches to partners will be able to support and continue to develop GO-Bojong.

The implementation of the system E-commerce at GO-Bojong is Business to Consumer (B2C), this system is one type of E-commerce where the seller in transaction activities comes from the business owner without an intermediary. The advantage that can be obtained from this B2C business is the

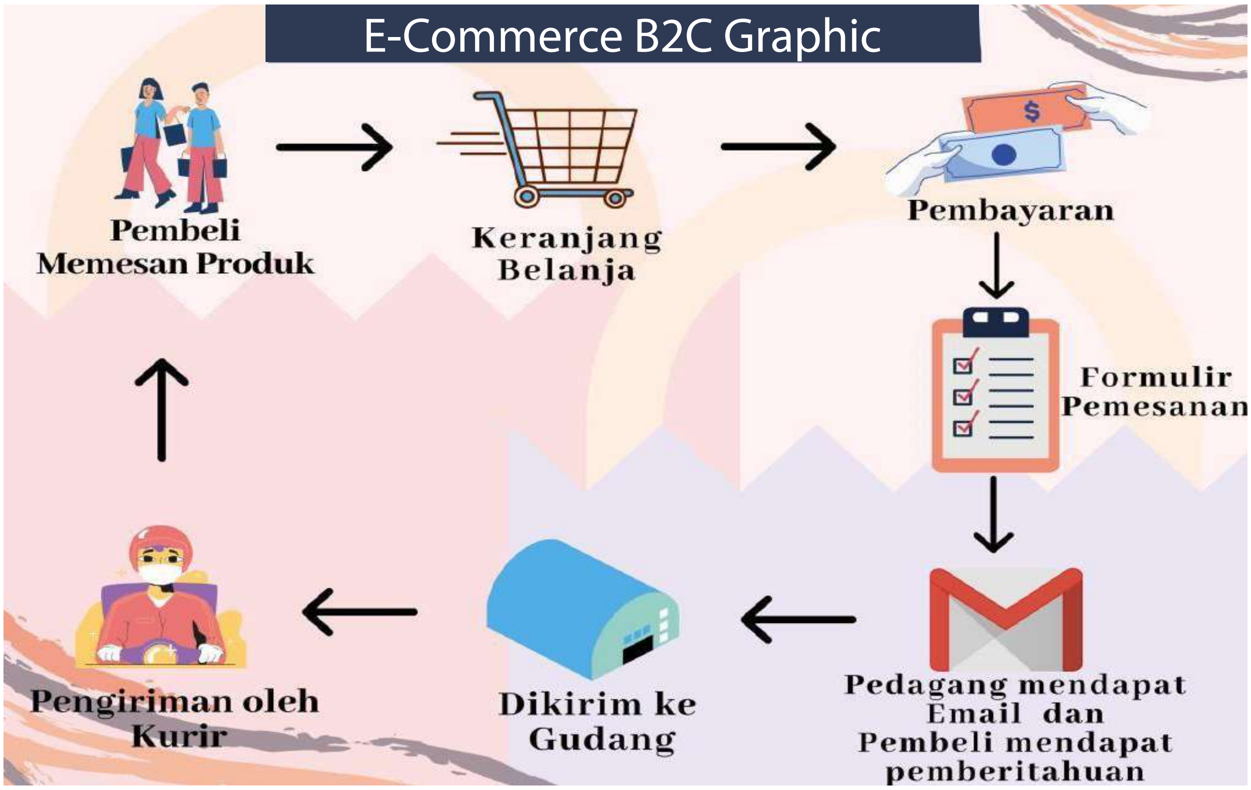

Figure 3. Sales flow of website GO-Bojong using B2C type

profit from the profit from selling goods which one hundred percent can be enjoyed by yourself. The B2C sales flow begins with the buyer ordering a product through the GO-Bojong website, then the product selection will be added to the shopping cart. The next step for the buyer is to make payments via ATM transfer or mobile banking. Buyers will get an order form that will be sent via email as a notification, while traders will provide information to order the product chosen by the buyer. Then the last one is delivered by courier to the buyer's destination.

CONCLUSION

GO-Bojong focuses on creative efforts to develop Bojong Round coconut in the form of superior products in Bojong Village which is spread over 12 hamlets. GO-Bojong applies the O.V.O.P method so that each hamlet has its superior product, so that competition can be avoided and can improve the economy in each hamlet. Marketing is carried out using a system E-commerce in form of a website with the type of sales Business to Consumer (B2C) so that it will facilitate the process of buying and selling transactions and can reduce physical contact. In addition, the implementation of B2C is useful in providing information about GO-Bojong, introducing to the wider community what Kelapa Bulat Bojong is and at the same time creating promotions that support the sustainability

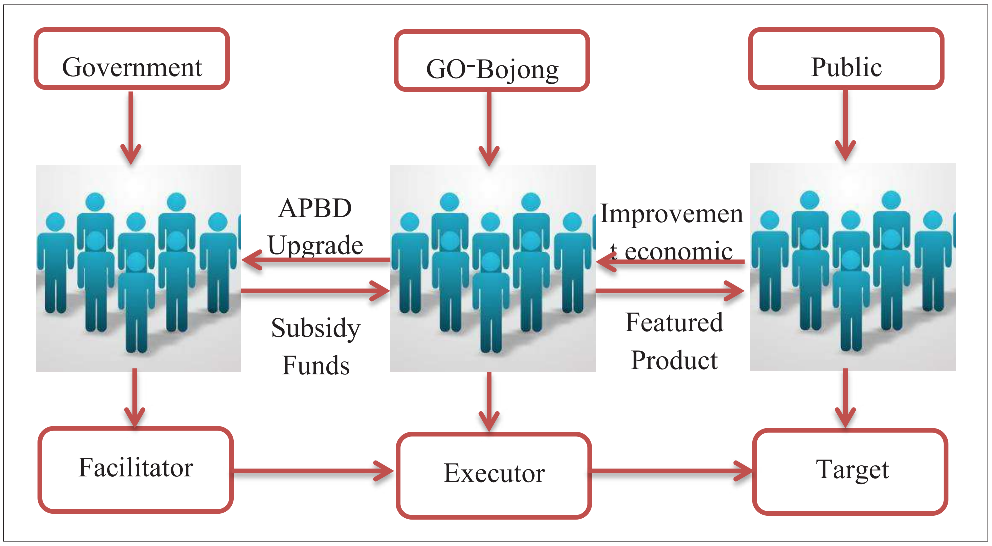

Figure 3. Flow Map Cooperation GO-Bojong through O.V.O.P Program

of GO-Bojong. Based on this explanation, the existence of GO-Bojong can be a community empowerment program based on O.V.O.P and E-commerce can improve the economy of the community in Bojong The village, Kulon Progo Regency.

[1] *Sebelas Maret University Student*
* *This article is the Second Winner, Writing Category, of World Coconut Day Competition 2021.*

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Coconut Testa
A Valuable By-Product of Coconut Oil Industry

Prakruthi Appaiah[1], L. Sunil[2], P. K. Prasanth Kumar[3], G. Suresh Kumar[4], A. G. Gopala Krishna[5]

The brown skin covering the coconut kernel is testa, mainly a by-product obtained from coconut processing industries. During the preparation of desiccated coconut, coconut milk, and virgin coconut oil, the testa is removed by paring the dry/wet coconut as it imparts a brown color to the oil and a dull appearance to other products. As the coconut matures, the thickness of the testa increases and gives brown color to the bottom layer of the kernel. Testa earlier was usually used as animal feed, and raw material for the production of bio-diesel. In contrast, nowadays, it is used in bakery products as a substitute for wheat flour and feed. It is found that coconut testa flour substitution of up to 30 % was acceptable without affecting the overall quality of cookies. The use of 5 % coconut testa in fish feed showed that the growth rate of the red tilapia breed was effective.

The potential of coconut testa, oil and cake in India

Currently, over 150 desiccated coconut powder production units are present in India, of which the total production capacity of all the production units would come around one lakh metric tones. India is one of the largest exporters of desiccated coconut powder globally, next only to the Philippines. Coconut testa constitutes about 18% of the total dry weight of kernel. About 23.7 thousand tonnes of testa is produced annually in Hainan Island, Sri Lanka. In India, about 88,884 tons of testa is available to produce oil and other value-added products. Worldwide, the production of testa waste is still more and hence needs alternative ways to reuse it as valuable products. Table 1 shows data on the potential availability of testa (88,884 tonnes), testa oil (44,442 tonnes), and testa cake(44,442 tonnes) valued at Rs.1200 crores per annum.

Proximate composition of testa

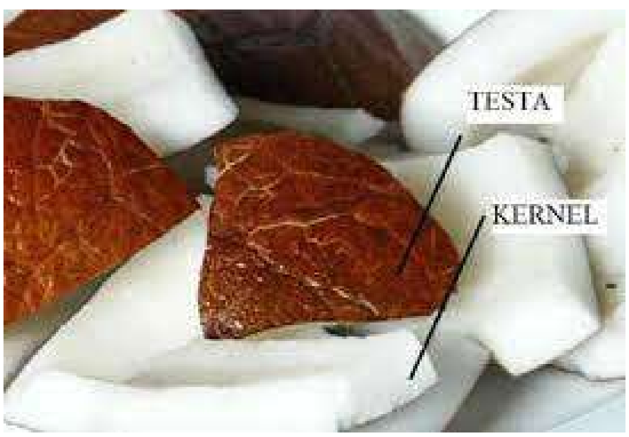
Proximate composition of dry and wet coconut and dry and wet coconut kernel and the dry and wet coconut testa has been reported in various studies. A study by Prakruthi Appaiah et al. 2014) was based on laboratory scale dry and wet coconut testa and the dry and wet coconut kernel, and the

Production of coconuts	Dry coconut whole (copra)	Dry coconut testa (18% of copra) ***
India*,**	2,469 million nuts	444.42 million nuts equivalent
Potential in tones		444.42 million nuts x 200g/nut = 88,884 tones (4% moisture basis) valued at Rs.60/kg = INR 533.3 crores
Potential of oil (50% basis)	-	44,442 tones valued at Rs.1111.1 Crores (Rs.250/kg oil)
Potential of cake (50% basis)	-	44,442 tones valued at Rs. 88.9 Crores (Rs.20/kg)
Total value (oil +cake)	-	INR 1200 crores

*Jnanadevan R. Coconut sector experiencing an all-time high price. Indian Coconut Journal. February 2018, pages 8-11.
** Current coconut production reported is 21,206.74 million nuts during 2019-20, internet data from CDB website 11th October 2021).
*** Marikkar and Madhrapperuma, 2012

Table 1. The potential availability of coconut testa, testa oil, and testa cake in India

starting whole dry and wet coconut. The proximate composition of dry coconut (copra) whole, copra testa, and testa removed coconut (copra) kernel had moisture 3.6-4.3%; fat 59.0 – 63.6%; protein 8.1 – 10.2%; carbohydrates 22.4 – 26.3%; ash 1.4 – 2.1%; and potassium was the major mineral present at 120.3 – 124.1 mg%. The proximate composition of wet coconut whole, wet coconut testa, and testa removed wet coconut kernel. 'had moisture 32.9 – 43.5%; fat 34.7 – 38.8%; protein 6.2 – 7.5%; carbohydrates 10.6 – 24.6%; crude fibre 11.7 – 17.2%; ash 0.7 – 1.0%; and potassium was the major mineral present at 107.8 – 123.8 mg%. The coconut testa contained other minerals like sodium, calcium, iron, and zinc. The samples had fat as a major component ranging from 34.7 to 63.6 %. Dry coconut testa yields more oil than wet coconut testa, and wet coconut kernels and dry coconut kernels yield almost the same amount of oil expressed on a dry basis. But the amount of oil present in



the testa is found to be lower than in the kernel. Marasinghe et al., 2019 investigated the proximate composition of four local cultivars, namely San Raman, Gon Thambili, Ran Thambili, and Tall x Tall, and compared with the commercial hybrid grown in Sri Lanka. These had moisture content of 2.27 -4.27 %, crude fat content 7.93 – 23.49 %, crude protein 23.83 – 32.22 %, ash content 3.7 - 5.3 %, and total carbohydrate content by difference 42.55 – 4.27 %, crude fat content 7.93 – 23.49 %, crude protein 23.83 – 32.22 %, ash content 3.7 - 5.3 %, and total carbohydrate content by difference 42.55 – 59.24% respectively. Compared to Indian coconut these had a higher protein content probably due to varietal differences.

Physico-chemical characteristics of coconut testa oil/coconut pairing oil

Some of the physico-chemical characteristics of commercial coconut oil and laboratory solvent extracted coconut testa oil from India and the commercial coconut oil and commercial coconut testa oil(coconut pairing oil) from Sri Lanka are given in Table 2. Only fatty acid composition and iodine value are available for commercial Sri Lankan coconut pairing oils compared to normal commercial coconut oil. Coconut pairing oil is allowed as an edible oil in Sri Lanka. The data is not available for the Indian coconut pairing oils, probably because the pairing oil is not allowed as an edible oil in India. However, the data provided by Prakruthi Appaiah et al. (2014) for

Parameters	*Sri Lankan commercial Coconut (copra) oil	*SriLankan coconut (copra) testa oil (also known as coconut pairing oil)	***Indian commercial Coconut (copra) oil*	****Indian coconut testa oil (laboratory prepared testa solvent extracted)
Moisture	na	na	na	na
Colour (Lovibond unit)	na	na	2.4	na
Peroxide value meq O2/kg	na	na	2.67	na
Free fatty acid value (as % lauric)	na	na	0.32	na
Iodine value Wij's cgI2/g	4.75	17.46	5.3	na***** (20.60)
Saponification value mg KOH/g	na	na	255.1	na
Saponification value mg KOH/g	**Sri Lankan coconut oil (CNO-3)	**Sri Lankan testa oil (CPO-3)	***Indian Coconut oil MYS-1	****Indian coconut (copra) testa oil
C8:0	5.06	3.23	8.06	3.9
C10:0	4.45	3.17	5.78	3.8
C12:0	48.47	36.78	51.66	40.9
C14:0	21.15	22.49	21.05	20.9
C16:0	9.08	13.32	8.64	11.3
C18:0	2.75	0.42	0.28	1.6
C18:1	6.57	17.88	4.01	12.2
C18:2	2.63	2.62	0.53	5.3
SFA	90.96	79.5	95.47	82.5
MUFA	6.57	17.88	4.01	12.2
PUFA	2.63	2.62	0.53	5.3
MCFA	57.98	43.18	65.5	48.6
Iodine value Wij's	4.75	17.46	5.3	-

*J.M.N.Marikkar and A.R.Nasyrah. Distinguishing Coconut Oil from Coconut Paring Oil using Principle Component Analysis of Fatty Acid Data, Cord 2012, 28(1) 9;
**Sri Lankan specification for coconut oil SLS 32: 2002 amended in 2009 of 2009-03-30. AMD 387. AMENDMENT NO: 1 APPROVED ON 2009-03-30 TO SLS 32: 2002.
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**** Prakruthi Appaiah, Sunil L., Prasanth Kumar PK, and Gopala Krishna AG. 2014, Composition of coconut testa, coconut kernel and its oil. J.Amer. Oil Chem. Soc.,
91, 917-924.
*****Calculated from fatty acid composition refer to Table 4 footnote, na = not available

Table 2. Some physico-chemical characteristics of commercial coconut pairing (testa) oil and coconut oil in comparison to Indian commercial Coconut oil and lab prepared coconut testa oil

Fatty acid (%)	Dry coconut (copra) whole	Dry coconut (copra) testa	Dry Coconut (copra testa removed) kernel	Wet coconut whole	Wet coconut testa	Wet Coconut (testa removed) kernel
Caprylic	9.6	3.9	6.7	8.1	1.6	5.6
Capric	6.4	3.8	6.2	7.8	2.2	5.8
Lauric	51.5	40.9	52.6	50.5	32.4	52.8
Myristic	19.1	20.9	18.9	16.1	20.2	19.2
Palmitic	6.9	11.3	7.4	6.8	14.1	7.4
Stearic	1.1	1.6	1.9	2.3	1.2	1.9
Oleic	4.3	12.2	4.8	5.6	17.8	5.5
Linoleic	1.1	5.3	1.6	1.8	10.6	1.0
SFA	94.6	82.5	93.7	92.6	71.6	92.7
MUFA	4.3	12.2	4.8	5.6	17.8	5.5
PUFA	1.1	5.3	1.6	1.8	10.6	1.0
MCFA	67.5	48.3	65.5	66.3	36.2	64.2
Calculated iodine value from fatty acid composition: IV= 0.9007x%oleic +1.8143x%linoleic+2.7410 x %linolenic acid; IV=.5.87, 20.60, and 7.23 for dry copra whole oil, testa oil, and testa removed kernel oil, respectively; IV =13.35, 35.26, and 6.77 for wet coconut whole oil, testa oil, and testa removed kernel oil, respectively.						

Table 3. Fatty acid composition of oils from dry and wet coconut (whole, testa, testa removed kernel) (Prakruthi Appaiah et al. 2014)

the laboratory solvent extracted testa oil shows the variation in fatty acid composition and iodine value among the testa oil, coconut whole, and kernel oils. Similarly, testa oil differed in fatty acid composition and iodine value with commercial coconut oil. A lower lauric acid content for testa oil was observed, and a higher oleic and linoleic acid content was observed. The data shows that the testa oil has lesser saturated fatty acid content and a slightly higher MUFA and PUFA content than the normal coconut oil. However, the fatty acid composition of coconut/ testa/ kernel oils from both countries was almost similar.

Chemical composition of coconut testa oil

Till now, testa oil has not been allowed in India for edible purposes, although a few proprietory products are available commercially. Prakruthi Appaiah et al. (2014) studied the chemical composition of testa oil in detail to make use of it as an edible oil similar to coconut oil. Table 3 shows the fatty acid composition of oil from dry coconut (copra) testa. The oil has a fatty acid composition similar to that of normal coconut oil. However, the content of fatty acids viz., lauric acid, palmitic acid, oleic acid, and linoleic acid show a low to high trend for the testa oil. Lauric acid showed a low value of 40.9 % compared to 51.5 – 52.6% for the kernel oils. Table 3 shows the fatty acid composition of wet coconut testa oil and the coconut whole and kernel oils. A still lower lauric acid content of 32.6% and a still higher amount of oleic and linoleic acids, 17.8% and 10.6%, were observed for the wet coconut testa oil than the dry coconut(copra) testa oil of 40.9%, 12.2%, and 5.3% respectively. The testa oil has a lower amount of SFA, MCFA, and higher amount of MUFA, PUFA, and hence a higher iodine value for the testa oils, which is normally provided for specifications for coconut oil. Marikkar and Nasyrah (2012) have shown that coconut pairing oil could be differentiated from normal coconut oil based on their fatty acid composition and iodine values considering the pairing oil and coconut oil produced in Sri Lanka. The SFA (SFA+MCFA) contents were lesser than about 90-92%, which is generally attributed to normal coconut oil (Prasanth Kumar and Gopala Krishna 2015).

The triacylglycerols content of dry testa oil and wet testa oil were almost similar, and that of dry coconut whole and kernel oil was slightly lower than that of the wet coconut whole and kernel oils . The oils from CT and WCT contained 94.1 % and 96.4 % TAG, 5.3 % and 3.2 % of DAG, and 0.6 % and 0.4 % of MAG, respectively. CT and WCT oils contained

slightly higher DAG content than testa removed kernel oils. The triacylglycerol composition of dry coconut (copra) testa oil and coconut whole and kernel oils shows variation in the composition for the dry coconut testa oil with regard to the content of trilaurin, LaMM, which was true for the wet testa oil .A lower amount of trilaurin is found in testa oils (wet. 12.34% and dry 15.9%), and a moderate amount of LaMM (wet 4.91% and dry 14.3%)is found for both wet and dry testa oils. The oil from WCT had a slightly higher triolein content of 3.35% than other coconut oil samples of 0.15%. For normal commercial coconut oils, the trilaurin content of 20.67% and LaMM of 9.7%, have been observed. In general, the MUFA and PUFA (oleic and linoleic acids) of testa oils are distributed more in the triacylglycerols. In contrast,the SFA (SFA+MCFA)are distributed more in the triacylglycerols of normal coconut oils.

An analysis of tocopherol and tocotrienol composition for dry and wet coconut testa oils and the dry and wet coconut whole and kernel oils show that both dry and wet coconut testa oils contained higher amounts of tocopherols and tocotrienols of 22.3 mg% and 100.14 mg% than the respective coconut whole and kernel oils of 2.9 – 6.7 mg% for dry and 2.5- 4.4 mg% for wet whole and kernel oils. Dry and wet testa oils contained 42.52mg %, 50.97mg% of phytosterols, 22.3mg%, 100.1mg% of tocopherols+tocotrienols, 1.9mg%, 0.5mg% of phenolics, 313.9µg%, 389 µg% of phenolic acids respectively. The normal commercial coconut oils have a phytosterol, tocopherol, and phenolics content of 74.5mg%, 1.2mg%, and 8.2mg%,respectively. These studies indicated that the oil from coconut testa (wet and dry) contained more natural antioxidants and probably conferred better health benefits than normal coconut oil. A study by Arivalagan et al., 2018 has reported that phenolics composition of coconut testa oils and a total of 28 phenolics were reported, of which 16 were phenolic acids and 12 were flavonoids. The primary phenolic acids found were protocatechuic acid, p-coumaric acid, and ferulic acid, whereas the principal flavonoids found were catechin, apigenin, and kaempferol.

Phytochemical composition of testa extract

The analysis of phytochemical composition and antioxidant activity of extracts from commercial wet and dry coconut, testa, and cakes found that the Copra Testa Extract (CTE) and wet Coconut Testa Extract (WCTE) contained carbohydrates, amino acids, glycosides, triterpenes, tannins, flavonoids, phenolics, and saponins. The extracts were rich in phenolics, flavonoids, tocopherols,and tocotrienols,

confirmed by HPLC. These contained high amounts of total phenolics 1.3g%; 6.3g%, total flavonoids content 2.3g%, 12.6g%; and phenolic acids 100.7mg%, 195.2mg% , tocopherols+tocotrienols content 18.7 mg%, 49.2 mg%; for dry and wet coconut testa extracts respectively compared to coconut whole and kernel extracts. A very low IC50 value of 0.06 mg/ml was observed for wet coconut testa extract. This study showed that the WCTE had high antioxidant properties and many phytochemicals compared to other coconut testa extracts. The extracts from coconut testa and seed coats of four different varieties of beans were investigated for total phenolic content, antioxidative and antidiabetic properties (Adekola et al., 2017) The study showed that the coconut testa and red kidney bean were found to have better antioxidant activity when compared to other seed coats. The study also showed that the coconut testa had strong α-glucosidase inhibition, an effective anti-diabetic agent. Ojha et al. (2019) showed that coconut testa extracts contain various polyphenolic and non-phenolic natural antioxidants, anti-inflammatory and antimicrobial compounds. The studies showed that coconut testa is a natural source of multiple phenolics, phenolic acids, and flavonoids with potent antioxidant capacity and may be used as a natural source of antioxidants.

Coconut testa oil, extracts and its probable health benefits in experimental animals

Extraction, physicochemical properties, and fatty acid composition analysis of coconut testa oil (CTO), antioxidant activity, and the protective effect on oxidative damage to human serum albumin (HSA) of coconut testa oil extract(CTOE) were investigated (Zhang et al., 2016) Results showed that the optimal extract condition of CTO was B3 A2 C2(temperature of 60°C, material-to-solvent of 1:4g mL-1 and extraction time of 3h) with the maximum oil yield (76.83%). The obtained CTO was non-drying oil with an iodine value of 14.69 g per 100 g, and lauric acid was the main component of 42.28%. Hydrogen peroxide scavenging activity of CTOE can reach 49.81% at 2.5mgmL-1,while antioxidant activity(AA) on the oxidation of linoleic acid dropped from 56.82% to 31.70% during the first 80 min. CTOE could prevent HSA from oxidative damage induced by hydrogen peroxide by inhibiting the formation of protein carbonyl and increasing hydroperoxides content effectively. Total phenolic content was 68 mg g-1, and the epicatechin and catechin were2.74 and 2.26 mg g-1 in their phenolic compositions. These all-suggested CTO and CTOE might be new worthy exploiting functional sources.

Defatted coconut testa extracts showed high amounts of phytonutrients such as phenolics, flavonoids, and tocopherols and have been shown to possess antioxidant and hypolipidemic effects in experimental animals. Geetha et al.(2016) carried out rat feeding studies on the impact of ethanolic extracts from defatted coconut testa in experimental animals(C57BL/6). Feeding of testa extract at 50 and 100mg/kg body weight showed increased body weight in high fat-fed animals when compared to starch fed control (SFD) group. Treatment with a ethanolic extract of coconut testa reduced their body weight dose-dependently. Lipid profiles like triglycerides, cholesterol, and LDL levels were significantly decreased, whereas HDL levels were increased, indicating its health beneficial effect (antiobesity effect). Catalase, SOD, GPx, TBARS in tissues, analysis of OGTT, serum insulin levels, advanced glycation, and atherogenic protection were augmented at different levels in the treated groups.

Analysis of serum showed increased HDL-C in the testa extract treated group and, therefore, higher protection against atherogenesis than the high-fat diet-fed group. Lesser fecal fat content and a higher level of liver cholesterol were observed in the high fat-fed group, and treatments with testa extract(rich in phenolics) ameliorated significantly. Fat content in the organs (liver, heart, kidney & adipose) of the HFD group was high. Furthermore, certain fatty acids observed in the tissues were 14:0, 16:0, 18:0, 18:1, 18:2, 20:0, 20:3, and 20:4, among which 14:0, 16:0 & 18:0 are the major saturated fatty acids that increased significantly in HFD when compared with the SFD group and ameliorated with testa extract (rich in phenolics) dose-dependently. Hence, coconut testa, a by-product of the coconut processing industries rich in natural phytonutrients, could be exploited to treat human diabetes and obesity conditions.

THE UTILIZATION OF COCONUT TESTA DEFATTED FLOUR IN BAKERY PRODUCTS

Sanjita Marasinghe et al. (2019) reported a study on the utilization of coconut testa defatted flour in place of wheat flour to prepare bakery products. For this purpose, coconut testa flour of four local cultivars, namely san raman (SR), gonthembili (GT), ran thembili (RT), TallxTall (TxT) against the commercial hybrid (COM) grown in Sri Lanka were used in the study. A hundred grams of coconut testa flour produced from partially defatted coconut pairings was extracted with a 70% ethanol-water mixture. The TPC and FRAP assays were conducted using a 96 well microplate reader. Percentage yield (%) of crude extracts of SR, RT, GT, TXT, and COM were 8.26, 6.87, 7.66, 8.06, and 11.17, respectively. The maximum TPC content was observed in TXT(62.58±5.99mgGAE/gofextract), while the minimum TPC content was recorded for GT (27.53 ± 4.54 mg GAE/g of extract). The lowest FRAP value was observed for SR (0.26 ± 0.02 mmol FeSO4/g of extract), while the highest FRAP value was observed for COM (0.67 ± 0.00 mmol FeSO4/g of extract) variety. In conclusion, coconut testa flour is a rich source of phenolics and antioxidants.

The presence of these bioactives (from testa) in bakery products would make the testa a potential functional ingredient in the food processing industry.

Coconut testa in feed formulation

A study by Nuha et al., 2019 aims to determine the coconut testa in the most effective feed formulation for red tilapia growth to provide a high survival rate. The treatment used was feed containing coconut testa A(0%), B(5%), C(10%), D(15%),and E(20%). The results showed that using 5% coconut testa in feed was effective for a growth rate of red tilapia because the response to feed was relatively faster, the highest survival rate was 92%, and the growth rate was 6,19g. The feed can fulfill the energy needs and help the growth of red tilapia because the range of

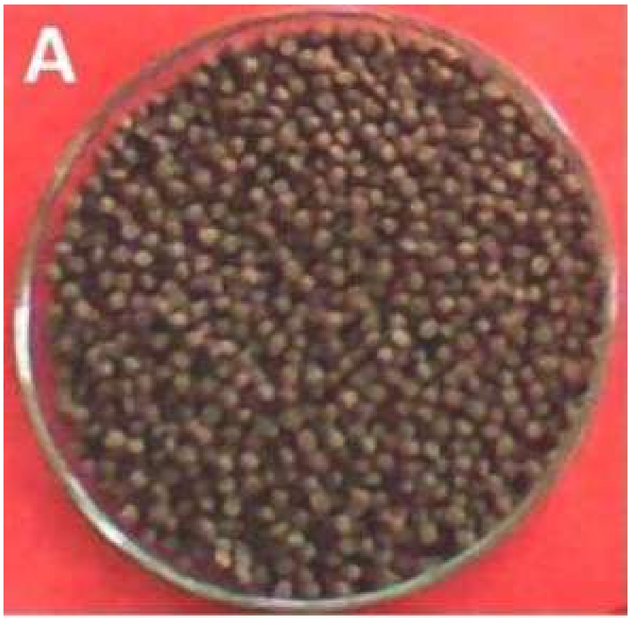

Figure 1. Fish feed from coconut testa (photo by Pradana et al.)

nutrient content of pellets is in accordance with the fish needs.

Coconut testa with banana peels for organic waste management

Organic waste produced by economic activities may create health, aesthetic, and economic problems. One of the approaches applied to solve this problem is the utilization of decomposer macro fauna to decompose the waste. One of the decomposers with great potential is Black Soldier Fly larvae (Hermetiaillucens), which can consume various types of organic manure and convert it in to biomass with high protein and lipid content. In this study, banana peels and coconut testa had been fed to the larvae at 200mg/larvae/day as the objects that represented organic wastes with low fiber content and high fiber content, respectively (Putra et al. 2020). This study aimed to observe the growth and efficiency of BSF larvae in decomposing those wastes. The analysis was conducted on some parameters such as the growth and consumption rate, the efficiency of conversion of digested (ECD), waste reduction index, and mortality rate. The results showed that BSF larvae that consumed banana peel had a higher final weight(58.24mg), growth rate, and consumption rate, while the mortality rate was lower than BSF larvae that consumed coconut testa. The ECD of the larvae group that consumed banana peel was higher than the larvae group that consumed coconut testa. The waste reduction index of banana peel was higher than coconut testa (1.5and1.4, respectively). The larvae that consumed coconut testa had a longer pupation period(9±1,75days) than the larvae consumed banana peel. Based on this result, it can be concluded that the fiber content of organic waste affected the decomposition rate and growth of BSF larvae.

Coconut testa for preparation of value-added products

Solid-state fermentation (SSF) is an alternative low-cost useful process that has many vital applications in the field of biotechnology (Jamaluddin et al. (2016). In this study, SSF has been employed as a process for the production of value-added agricultural by-products using coconut testa (CT), rice bran (RB),and the combination of both substrates (CTRB). The effect of SSF by Monascus purpureus on total phenolic content (TPC), antioxidant, antityrosinase, and anti-elastase of the substrates were studied and compared with its non-fermented counter parts. The results showed that the SSF had improved the TPC up to three-fold higher in the studied substrates. Antioxidant potential evaluated using FRAP analysis also exhibited an enhancement in fermented substrates with the values ranging from 23.70 to 63.15mg AAE/g sample. On the other hand, the radical scavenging activity evaluated using DPPH assay showed a different trend than the TPC and FRAP analyses. In other studies, tyrosinase and elastase inhibition activities were enhanced in most substrates upon the fermentation. The free phenolic acid content changes(p-coumaric, caffeic, ferulic, sinapic, vanillic, protocatechuic, gallic, and 4-hydroxy benzoic syringic acid) of the substrates after fungal fermentation was also examined through high-performance liquid chromatography (HPLC) analysis. In summary, SSF offers a tool further to increase the bioactive potential of the studied substrate.

Other uses of coconut testa

The testa is currently being used in industry for the production of value-added products like biodiesel, edible oil, cosmetics, hair oil, pharmaceutics and other allied industries.

Conclusion

Coconut testa is a by-product of the coconut oil/virgin coconut oil industry. About 18% of the coconut (copra and the wet coconut) equivalent to about 88,884tones are removed as testa during pairing of coconut. The testa has about 50-68% oil which may be used for edible purposes and may add about 44,442 tonnes of coconut pairing/testa oil to the edible oil pool. Already a number of brands of testa oil viz. sadhya, GFO coco kera Tripthi, Kaveri, Keratreat, Navaruchi, Kera Mudra, etc., are commercially available under specific product approval. The full potential of the testa is to be explored and the oil and cake to be put to edible use for maximum benefits in terms of commerce and health.

The cake contains residual oil and health beneficial compounds. Wet coconut testa has more tocopherols, tocotrienols, phenolics than dry coconut/copra testa. The oil may be included under the specification of coconut oil with suitable levels of iodine value, color, and fatty acid composition. As testa oils have higher amounts of unsaturated fatty acids and health-promoting compounds than normal coconut oil, the testa oil may provide more health benefits to consumers than normal coconut oil. The defatted testa and its extract may find application in preparing healthy foods, especially for diabetes and obesity-related population. More research on the antioxidant, antiviral, antimicrobial, and antidiabetic effects of testa oil and testa extracts, as well as related health benefits in humans, is needed so that the defatted testa can be used more effectively for health improvement, resulting in an increase in its commercial value.

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Photographer: Hendra Chandra (Indonesia)
World Coconut Day Competition 2021

Isolation, Identification and Pathogenicity of Entomopathogenic Fungi for Coconut Asiatic Palm Weevil Management in the Philippines

Sabiniano Q. Lamban[1], Johana C. Orense[2], Jayson S. Dungog[1] and Liberty H. Canja[3]

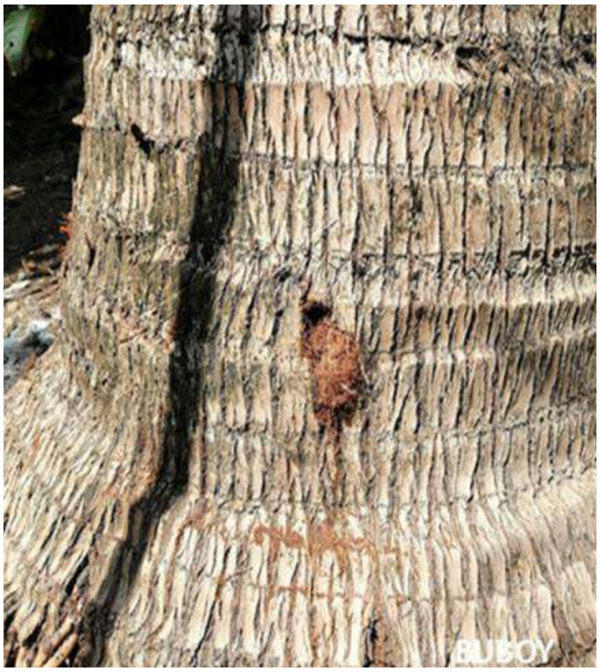
Figure 1. R. ferrugineus *larval feeding hole at base of coconut trunk*

Soil samples from coconut fields infested with Asiatic palm weevil (APW) in the Provinces of Leyte, Eastern Samar, Camarines Sur, Davao del Sur, and Sarangani, Philippines were assessed for the presence of entomopathogenic fungi. Using the insect bait method, entomopathogenic fungi were found in seven (7) locations. The seven geographical isolates of fungus belonged to three (3) genera. In the preliminary virulence testing, Isolate 003 and 005 of *M. anisopliae* were found to be the most virulent to APW larvae achieving 71% and 57% larval mortality within 5 days post-inoculation, respectively. These two isolates of *M. anisopliae* are deemed potential mycoinsecticides against the APW, *Rhynchophorus ferrugineus*.

INTRODUCTION

The Asiatic palm weevil (APW), *Rhynchophorus ferrugineus* Oliver (Coleoptera: Curculionidae) is a hidden, lethal tissue borer of the coconut palms and 40 other crops (FAO, 2019). The early stage of attack is very difficult to detect since the larvae feed on the soft internal tissues of coconut trunk and cabbage (PCA, 1994). Under careful observation, one may be able to detect infested palms with holes in the crown or trunk or base (Figure 1), with or without oozing brown liquid and chewed up fibers.

At high infestation level symptoms resembling drought stress and bud rot infection, like wilting or yellowing, may be observed (Figure 2). Young palms within the age group of 2 to 15 years are more prone to attack but 3-6 year-old palms that start to develop boles are more susceptible.

Validation of APW infestation by Davao Research Center (DRC) in the provinces of Leyte, Eastern Samar, Camarines Sur, Davao del Sur, and Sarangani last 2019 revealed that the percent infestation of coconut palms inspected ranged from 4%-63%.

Current recommended methods for APW management involved cutting down and burning severely infested palms, monitoring and mass trapping of adults with pheromone lures, cultural control and chemical treatments (ICPD Technoguide No.4, series of 2020). However, continous chemical application can lead to the development of pest resistance, thus creating public concerns about the adverse effect of widespread chemical use to human health and farm animals, food safety and to the environment. Consequently, other management techniques such as the use of entomopathogenic fungi (EPF) as biological control agents are explored.

EPFs are important natural control agents of insect pests. They infect their hosts through the external cuticles and are pathogenic to both soft and hard-bodied insects. Thus, EPFs have been widely studied and evaluated against many arthropods of agricultural importance. Recently, EPF's were discovered to have other ecological roles since many are known to be plant endophytes, plant diseases antagonist, rhizosphere colonizer and plant growth promoters. (Lacey et al., 2015).

There are few records on the occurrence of natural enemies of *R. ferrugineus*, which might be attributed to the cryptic habitat of the eggs, larvae and pupae which protect them from such natural enemies. Normally, the natural enemies do not play an important part in controlling of *R. ferrugineus*, though there were some attempts in using the predacious black earwig *Chelisoches morio* under

Figure 2. Extreme R. ferrugineus *damage to palm showing wilted spear leaf.*

laboratory and field conditions. However, these did not provide a measurable impact on the control of weevil (Sarwar, Muhammad, 2016).

In developed countries, there are numerous records of entomopathogenic fungi commercially produced to manage arthropod pests. In the Philippines, however, development on the use of these biorationals are still in progress, as there have been no records yet of EPFs being screened for mangement of APW.

The objective of the study is to isolate, identify and test the pathogenicity of indigenous entomopathogenic fungi (EPF) for the management of Asiatic palm weevil (APW).

MATERIALS AND METHODS

Soil sampling

Soil samples were collected from coconut fields in the Philippine provinces of Leyte, Eastern Samar, Camarines Sur, Davao del Sur, and Sarangani that were known to be infested with APW. Soils were scooped out one meter around the trunk by digging at a depth of 5-10 cm. In each sample area, soil was taken from five sample sites in a diagonal manner traversing the infested area. The samples were then combined. About 1 kg composite samples were taken from each sample area and labelled.

Isolation and culturing

Figure 3. Insect baiting for isolating EPF from the soil

Soil samples were sifted through a 1.5 cm mesh sieve. Isolation of the fungus was done using the insect bait method of Meyling (2007). In a plastic jar (11 x 14 cm) 100 g of the soil sample was placed and one (1) laboratory reared APW larva was added. There were six (6) set-ups per sample. The set-ups were incubated at 25 ± 2°C for a period of 14 days. The plastic jars were turned upside down every day. After 14 days, mycosed APW larvae were recorded and isolated (Figure 3). Entomopathogenic fungi were isolated from the sporulating cadavers by streaking spores on potato dextrose agar (PDA). Pure cultures were obtained and transferred to PDA slants and incubated at 25-28°C for 7 days to allow sporulation. These were maintained at 8°C as mother cultures for further screening.

Identification of the entomopathogenic fungi

The morphology of EPF was studied macroscopically by observing colony features (color and texture) and observed microscopically observes under a compound microscope for the conidia, conidiophores and spores arrangement. EPF were identified with the aid of manual prepared by Humber (2005).

Growth rates were also observed as basis for identification. The growth rate of the colonies was evaluated by inoculating a 7-day old 10mm agar disc in PDA medium in Petri plates and incubated at a temperature of 25°C. The colony diameter from each fungus was measured at 6 and 12 days after incubation.

Mass production of Asiatic Palm Weevil

APWs were reared in the laboratory to provide clean test insects for the pathogenicity testing. The insects were grown in an alternative diet of sago (*Cycas revolute*) flour. Adults were set to mate and oviposit in groups of at least five pairs placed on the substrate and allowed to develop. Uniform sized larvae in the same instar, were used in the pathogenicity testing.

Figure 4. Plastic containers with moist coconut cabbage as incubation chamber of APW larvae treated with entomopathogen.

Pathogenicity test

Two-week-old culture of each fungus isolate was inoculated to as many as 10 APW larvae of the same instar using the dipping technique. Subsequently, treated APW larvae were placed in plastic containers with moist coconut cabbage which was previously washed with sterile water (Figure 4). Fresh substrate was added to the boxes every week. Mortality of the larvae was observed everyday up to the 7th day after treatment.

Data analysis

Percentage larval mortality percentage was calculated using the formula:

$$\% \text{ Mortality} = \frac{A}{D} \times 100$$

Where: A = number of dead larva due to fungi infection
D = total number of insect being tested

The percentage mortality obtained was then corrected using Abbots's formula:

$$\% \text{ Mortality} = \frac{P_0 - P_c}{100 - P_c} \times 100$$

Where: P_0 = percentage of the dead test larva in the treatment
P_c = percentage of dead insects in the control

RESULTS AND DISCUSSION

Isolation and identification of the entomopathogenic fungi

The insect baiting technique was used to selectively isolate EPF from the soil sample. Mycosis was first observed in larvae after just five (5) days of inoculation. Mycosed APW larvae were the basis for isolation and identification of the spectrum of entomopathogenic fungi indigenously present in soils.

Based on Humber's Manual (2005), the cultural physical and morphological characteristics of isolates were assessed. The geographical isolates were distinguished through their difference in color of colony and conidial structures. Seven (7) geographical isolates of EPFs were found from the provinces of Leyte, Eastern Samar, Camarines Sur, Davao del Sur, and Sarangani. Three (3) genera of fungi were initially identified from the samples: *Lecanicillium*, *Peroconia* and *Metarhizium*. Five geographical strains of *Metarhizium*, with different characteristics and colony colors were noted (Table 1). A *Lecanicillium* isolate was found in Saranggani and *Peroconia* from E. Samar Province.

ISOLATE	ORIGIN	COLONY COLOR	HYPHAE	CONIDIA	IDENTIFICATION
001	Mangulon, Sarangani	White, Orange brown	Hyalin	Cylindris to elips, contain of single cell, no color	*Lecanicillium* sp.
002	Buenavista, Quinapondan, E. Samar	White	Hyalin	Round hyalin	*Peroconia* sp.
003	PCA-Davao Research Center, Davao del Sur	Light to dark green	Hyalin	Cylindris, hyalin	*M. anisopliae*
004	PCA-Albay Research Center, Camarines Sur	Light to dark green	Hyalin	Cylindris, hyalin	*M. anisopliae*
005	Cabacungan, Dulag, Leyte	Light to dark green	Hyalin	Cylindris, hyalin	*M. anisopliae*
006	Sta. Cruz, Jaro, Leyte	Light to dark green	Hyalin	Cylindris, hyalin	*M. anisopliae*
007	Guinapoliran, Balankayan, E. Samar	Light to dark green	Hyalin	Cylindris, hyalin	*M. anisopliae*

Table 1. Morphological characterization of the different isolates of entomopathogenic fungi in PDA.

Physiological characterization of entomopathogenic fungi

The observation on the colony growth rate of each of the geographical isolates was conducted 6 days and 12 days after inoculation (DAI). In general, the growth of *Lecanicillium* and *Peroconia* was faster than the *M. anisopliae* isolates (Table 2).

The three genera exhibited the following characteristics

Lecanicillium has upright conidiophore, differentiated from the negative hypha, and a lot of branches along the bar and is needle-shaped. Some colonies are flat shaped at the base. Fungal colony diameter grew rapidly in PDA medium for 12 days (Figure 5.A1 & A2). ***Peroconia*** has round spiny spores and hyaline hyphae. It grew rapidly in PDA medium with aerial white mycelia (Figure 5 B1 & B2).

Metarhizium has white colonies in the beginning but later changed to dark green as the colony aged (Figure 5 C1 to G1). It has insulated mycelium; upright coated branched conidiophore with varying sizes and filled with conidia, single celled hyaline coloured conidia, and spherical shaped cylinders (Figure 5 C2 to G2).

Screening for virulence against APW

Five isolates of *M. anisopliae*, one isolate of *Lecanicillium* and one isolate of *Peroconia* were subjected to an initial bioassay to select fungi with highest virulence against *R. ferrugineus*. After five days post inoculation (PI), APW larvae treated with *M. anisopliae* Isolates 003 and 005 had the highest mortality rate of 71% and 57%, respectively. Low pathogenicity rate of 14% was recorded for larvae treated with *Lecanicillium* Isolate 001 and *Metarhizium* Isolate 004, while a 29% mortality rate occurred when APW larvae was treated with *Metarhizium* Isolate 006. No larval mortality was observed in the control and larvae treated with *Peroconia* and *Metarhizium* isolate 007.

ISOLATE	ORIGIN	IDENTIFICATION	COLONY DIAMETER (mm)	
			After 5 days	After 10 days
001	Mangulon, Sarangani	*Lecanicillium* sp.	14	100
002	Buenavista, Quinapondan, E. Samar	*Peroconia* sp.	0	100
003	PCA-Davao Research Center, Davao del Sur	*M. anisopliae*	71	100
004	PCA-Albay Research Center, Camarines Sur	*M. anisopliae*	14	100
005	Cabacungan, Dulag, Leyte	*M. anisopliae*	57	100
006	Sta. Cruz, Jaro, Leyte	*M. anisopliae*	29	100
007	Guinapoliran, Balankayan, E. Samar	*M. anisopliae*	0	100

Table 2. Average diameter of entomopathogenic fungi colonies in PDA, 6 and 12 days after inoculation (DAI).

ISOLATE	ORIGIN	SPECIES	% MORTALITY	
			After 5 days	After 10 days
Control		Distilled Water	**0**	**0**
001	Mangulon, Sarangani	*Lecanicillium* sp.	14	100
002	Buenavista, Quinapondan, E. Samar	*Peroconia* sp.	0	100
003	PCA-Davao Research Center, Davao del Sur	*M. anisopliae*	71	100
004	PCA-Albay Research Center, Camarines Sur	*M. anisopliae*	14	100
005	Cabacungan, Dulag, Leyte	*M. anisopliae*	57	100
006	Sta. Cruz, Jaro, Leyte	*M. anisopliae*	29	100
007	Guinapoliran, Balankayan, E. Samar	*M. anisopliae*	0	100

Table 3. Pathogenicity of different isolates to R. ferrugineus *larvae, 5 days post-inoculation (PI).*

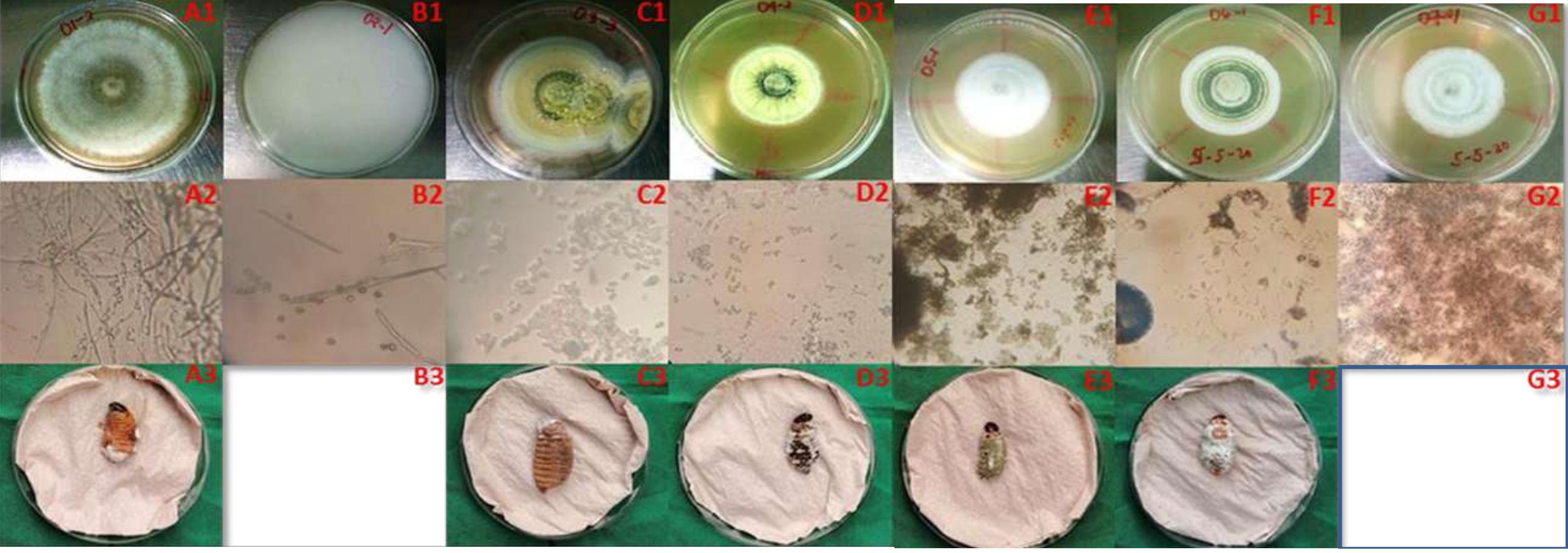

Figure 5. The character profiles of entomo pathogenic fungi (EPFs) and the symptoms of APW larva infected by different isolates. ***A.*** Lecanicillium *sp. (Malungon, Sarangani);* ***B.*** Peroconia *sp. Buenavista, (Quinapondan, E. Samar);* ***C.*** Metarhizium anisopliae *(Davao Research Center);* ***D.*** Metarhizium anisopliae *(Albay Research Center);* ***E.*** Metarhizium anisopliae *(Cabacungan, Dulag, Leyte;* ***F.*** Metarhizium anisopliae *(Sta. Cruz, Jaro, Leyte);* ***G.*** Metarhizium anisopliae *(Guinapoliran, Balankayan, E. Samar);* ***1.*** *colony;* ***2.*** *condial structure;* ***3.*** *symptoms of infected APW larva;*

(Table 3). In general, the different geographical isolates exhibited different pathogenicity against *R. ferrugineus* larvae at five days PI.

At ten (10) days PI, the mortality of larvae treated with *M. anisopliae* isolates (all geographical strains) reached 100%. Mortality was not observed in the control group for the duration of the screening.

CONCLUSIONS AND RECOMMENDATIONS

Three genera of enthomopathogenic fungi; *Lecanicillium*, *Peroconia* and *M. anisopliae* were isolated from the five (5) different Provinces surveyed. Based on laboratory bioassays, two isolates of *M. anisopliae* from Davao Research Center (DRC) and Cabacungan, Dulag, Leyte were found to be most virulent to APW larvae achieving 71% and 57% larval mortality within 5 days post-inoculation, respectively. The two *M. anisopliae* isolates are now considered as potential BCA's for *R. ferrugineus*.

Stringent laboratory and field screening of the isolates would have to be conducted. Moreover, the development of efficient mycoinsecticide formulation and feasible delivery systems are still to be investigated for optimum results.

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Coconuts Saturated Fat is Not Related to Heart Diseases

Otniel Sintoro*

For decades, the diet heart hypothesis has guided nutrition recommendations and policy. Recent research have cast doubt on the notion and spurred heated debate aboutthe supposed link between saturated fat consumption and heart disease. Recent evidence suggests that dietary advice should focus on dietary patterns rather than a single food or vitamin. Furthermore, categorizing foods solely as saturated, polyunsaturated, or monounsaturated fats ignores the many other nutrients and health advantages available. Coconut is a saturated fat, therefore it's on the list of foods to avoid if you want to lower your risk of heart disease. In her study, Susan Hewling, Department of Nutrition and Dietetics, Central Michigan University, found that various saturated fats, whether medium-chain or long-chain, behave differently in the body and have different health effects.

The use of coconut oil is addressed, and the American Heart Association recommends that people avoid using it. However, research on the possible advantages of the additional nutrients offered by coconut, as well as discussion of the specific qualities of lauric acid, the type of saturated fat provided by coconut compared to other saturated fatty acids (SFAs) (Sacks et al., 2017), are omitted from the debate. Large observational studies reveal that different SFAs with different physical, chemical, and metabolic structures have different metabolic and health effects, especially when it comes to blood lipids, glucose-insulin homeostasis, insulin resistance, and diabetes (Zhu et al., 2018 & Micha & Mozaffarian, 2010).

The issue stems from decades of dispute about total fat, particularly saturated fat, and its significance in weight control and illness prevention guidelines. The argument has centered on the amount of saturated fat that should. be included in a healthy diet (Boateng et al., 2016). The current research disputing the link between HDL-C and CVD is a separate but related controversy. The discussion centers on whether HDL-C should be a target for intervention and whether recommendations should be concentrated on a specific HDL-C target, which is beyond the scope of this paper. However, because HDL-C concentration is an independent, inverse predictor of the probability of having a cardiovascular event, further robust biomarkers and genetic differences should be studied (Barter & Genest, 2019).

Despite the ongoing debate, it is critical to recognize that dietary fats are essential nutrients that play a critical role in critical physiological functions such as energy storage, supplying essential fatty acids, absorbing and transporting fat-soluble vitamins, protecting and insulating vital organs, providing flavor and satiety in food, providing cell membrane structure, and serving as a precursor to steroid hormones. However, an excess of fat in the diet is linked to increased body weight for a variety of reasons, including its caloric density, which is around 9 kcal/g compared to 4 kcal/g for carbs and proteins (Hewlings, 2019). Furthermore, numerous studies have linked high-fat diets, particularly saturated fat diets, to a variety of lifestyle disorders, including obesity, heart disease, and cancer (Keys et al., 1957, Hu et al., 1999 & Li et al., 2015).

The food source of saturated fat has not been clearly established in the literature or in the recommendations, and not all foods classed as saturated fats have the same fatty acid profiles. The endocarp and coconut water exhibit antioxidant activity, while the fiber has antibacterial, antiparasitic, and anti-inflammatory effects, according to a recent systematic study (Lima et al., 2015). Coconut's use in a number of products has grown in popularity as a result of its many bioactive ingredients and stated health advantages. The coconut crop is claimed to promote the three pillars of society, economy, and environment through sustainable agriculture (Nair, 2018). Despite the numerous advantages of coconut, recommendations for increased consumption remain divisive. This contentious suggestion is linked to the controversy over saturated fat guidelines, as well as the high saturated fat content of coconut oil (about 92%), of which 62-70% is medium-chain triglyceride (MCT) (Krishna et al., 2010, Fernando et al., 2015 & Bach & Babayan, 1982).

Extra virgin coconut oil, in particular, contains a number of health-promoting properties. Many of its health benefits have been overlooked due to its fatty acid composition. Saturated fatty acids make up the majority of it. An increased risk of cardiovascular disease and other major lifestyle illnesses has been related to a high-saturated-fat diet. As a result, previous public health messaging focused on encouraging individuals to consume fewer saturated fats, such as those contained in coconuts. However, the link between saturated fat consumption and cardiovascular disease has recently been questioned.

When it comes to evaluating whether or not reducing saturated fat intake improves lipid profiles and, potentially, CVD risk, it's evident that what's replaced with the saturated fat is crucial to understanding the outcomes. It indicates that replacing fat with vegetable fats is more helpful than replacing fat with simple carbohydrates. This is unsurprising given the harmful health effects of eating too much simple carbs. While diet-disease links cannot be firmly established based on a single meal or food group, it is evident that identifying food sources of nutrients is critical when examining such relationships. There is substantial evidence to advocate differentiating food sources of saturated fats in order to define the specific nutrients of each source and their health implications. This would be analogous to how different forms of polyunsaturated fats are recognized for their distinct qualities and health effects, such as omega 3 and omega 6 polyunsaturated fats.

When comparing the nutrient makeup of the coconut to other saturated fat sources, such as beef, using the same technique with other types and sources of saturated fatty acids is justified. Beef is high in long-chain saturated fatty acids, whereas coconut is high in medium-chain saturated fatty acids. When opposed to longer chain fatty acids, medium-chain fatty acids are absorbed differently and have been linked to a variety of health benefits, including improved cognitive performance and a better lipid profile. Coconuts may thus provide a healthy amount of saturated fats while simultaneously delivering phenols and :ntioxidants in the context of a dietary pattern that has been linked to health advantages, such as the Mediterranean diet. While the research regarding the link between saturated fat intake and heart disease is ambiguous and hence does not fully justify reversing the recommendation to avoid saturated fats, a change is probably warranted. More research into the relationship between different forms of saturated fat and disease is needed. When developing revisions and corresponding policy, future suggestions and guidelines should take all parts of the research into account.

When opposed to longer chain fatty acids, the medium-chain fatty acids found in coconut are absorbed differently and have been linked to a variety of health benefits, including improved cognitive performance and a better lipid profile. Coconuts are a good source of saturated fats, however they should not be confused with foods that have longer chain saturated fats. The challenge in addressing the issue of whether consumption of coconut, or any other single food, unfavorably effects lipid profiles or cardiovascular disease risk is that food sources typically contain more than one nutrient and diets contain many foods. Therefore, discovering a relationship between any one food and disease must take into consideration the complex nature of dietary and lifestyle patterns that ultimately influence disease outcomes.

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Feeding the Soil for Climate Resilient Coconut Farms

Winfried Scheewe*

Severe weather events triggered by climate change such as drought are expected to increasingly affect coconut production. As explained in the articles Coconut farms and climate change: what is at stake and what can be done? Also, Coconut palms under climate stress, the principal key to enabling coconut palms to better cope with heat and water stress lies in the soil. In this article, we will discuss several practices which can help to restore, improve and maintain fertile and resilient soils in coconut farms.

In view of the risks of drought and extreme rainfalls, the foremost aim is to enhance the water holding capacity of the soil, so that the coconut palms and intercrops can cope more effectively with dry spells and drought as well as with flooding.

These practices aim not only to improve the soil but should also make the whole farm resilient in the face of climate change and the projected increase of extreme and variable weather. Moreover, all options will also help farmers to improve overall farm productivity under normal conditions.

When we wish to improve the health of the soil in coconut farms, we may consider the insights from soil ecology discussed in the article The Coconut Farm Below Ground – Appreciating Vital Processes in the Soil:

1. Organic matter needs to be recycled.
2. Soil needs to be covered to protect the organisms (and the processes in soil) against heat and rain and to avoid erosion. Therefore, the use of herbicides should be avoided.
3. There should always be a diversity of deep rooting plants.
4. Processes in the soil should not be disturbed by plowing and the use of herbicides as these practices remove the protection against heat and erosion. This leads us to the question: What can we do to increase and maintain a favorable level of soil fertility? Fortunately, farmers have several options to improve and maintain soil fertility in coconut farms. Among them are (a) mulching as a way to recycle organic matter, (b) planting of green manure and cover crops, as well as (c) the planting of hedgerows of nitrogen fixing shrubs.

Mulching

Figure 1. Mulching with palm fronds

Mulching is the most natural way to recycle organic matter. The covering of the soil with fronds, and when suitable, husks or other plant residues, especially around the trunk of the palm trees, helps the soil absorb more rain water. The runoff of water during heavy rains, and by this the risk of soil erosion, is significantly reduced. Mulch also conserves soil moisture as evaporation is reduced and hampers weed growth. The mulch layer also protects the soil organisms which improve the soil's sponge like structure.

As the mulch layer gradually decomposes, the additional humus augments the soil acidity. The pH level improves towards neutral and some nutrients, especially micro-nutrients, become more accessible to the crops. Likewise, the decomposed organic matter also provides energy to nitrogen-fixing bacteria active in the soil. The improving soil structure allows roots to develop better.

We need to consider the height of the mulch layer. If the layer is too thick, rats might be attracted to breed there. Thick layers of decomposing organic material may also invite female rhinoceros beetles to lay their eggs there. It is better to keep the layer at lower height while adding new layers of organic matter from time to time.

Coconut husks are very valuable to cover soil's surface and to protect the root of trees. Many farmers place coconut husks around the stems of intercropped trees. Husks should be laid with the open side down to avoid the impounding of water and breeding of mosquitoes. Slashed weeds and shrubs are usually left on the ground to decompose but they can also be utilized to cover the roots of palms or the soil among intercrops.

In view of the many positive effects of mulching, burning of crop residues and other organic materials should be avoided. Similarly, the use of herbicides would deny the soil the positive effects of the slashed and mulched vegetation.

Green Manure and Cover Crops

Farmers may also consider replacing nonproductive grasses and shrubs with cover crops, which will add more organic matter to the soil and cover it efficiently. The practice of cultivating specific crops just for improving the soil dates back to the Roman Empire more than two millennia ago when Cato the Elder advocated for the use of manure and green manure as fertilizer.

Cover crops are commonly leguminous plants which make atmospheric nitrogen available to the soil. While shading the soil, cover crops also add organic matter to the soil, thereby improving topsoil depth, water-holding capacity, nutrient content, friability, and texture.

Cover crops require no capital outlay after the initial purchase of seed. To enhance organic matter production, farmers may occasionally press the vegetation down with a roller. This stimulates the growth of new leaves and branches. Several cover crops have been tested in coconut farms, such as:

Calapogonium is a vigorous, creeping, and twining hairy herb forming a tangled mass of foliage 30 to 40 cm deep. Stems are succulent, covered with long brown hairs, creeping in lower parts, with roots at nodes which come in contact with the soil and the upper part of stem twining. The leaves are

Figure 2. Tropical Kudzu under coconut palms

trifoliate and the leaflets are hairy on both surfaces. Its flowers are blue with greenish-yellow blotches. Its seed pods are linear, 2.5 to 4 cm long, and are yellowish brown. The pods contain four to eight-seeds and are densely covered with long erect hairs.

Tropical kudzu (*Pueraria phaseoloides*) has been extensively introduced in tropical and subtropical areas to be used as a forage and soil improvement species, and it can be found naturalized throughout the humid-tropics. It is often used as a nitrogen-fixing green manure or grown as a cover crop in coffee, oil palm, citrus, and rubber plantations. Its leaves are similar to those of the calopogonium in shape, though are a bit larger. Tropical kudzu leaves and stems are rich in protein (about 19%) and are palatable to livestock, and so are used widely as animal fodder. It may also be used as a pasture crop when grown with a suitable grass such as Guinea grass (*Panicum maximum*). The very deep and extensive root system not only provides edible tubers, but also helps minimize soil erosion. The plant's rapid growth also helps suppress weeds and protect the soil from rapid run-off water.

Kudzu is a vigorous, perennial climbing plant producing annual stems up to 5mm in diameter and 2 – 10 meters long from a tuberous rootstock. These stems scramble over the ground, where they produce new roots at the nodes, and also twine into the surrounding vegetation for support.

Centrosema pubescens is an evergreen perennial climber that grows at a fast rate. It is suitable for most soils and can even grow in nutritionally poor soil. It is suitable for mildly acidic, neutral, and mildly alkaline soils. It can grow in full shade, semi-shade, or no shade. Centrosema pubescens prefers moist or wet soil and can tolerate drought.

Velvet bean is a vigorous, nitrogen-fixing, bushy or vining annual plant. The vines will climb anything available and can reach 10 m or more in length. The velvet bean is somewhat drought tolerant and is an excellent green manure or cover crop, with the ability to suppress weeds and provide generous amounts of organic matter and nitrogen to the soil.

Arachis pintoi, or false peanut, can also serve as a cover crop. It has high forage quality and is used as ground cover in many fruit orchards. Like camote (sweet potato) it is readily propagated from cuttings.

The above-mentioned plants have been promoted for many years as cover crops. After the cover crop has established itself, it can be slashed and food crops can be planted, or it can be left permanently. One way to increase the production of biomass is to press down the mature foliage with a heavy roller to initiate new sprouts of the cover crop. Care must be taken as some of the cover crops tend to climb on smaller trees and younger palms and could potentially hamper their growth.

Like mulch from plant residues, cover crops help control grass and weeds. Most cover crops can be used to suppress cogon grass and similar weeds. In addition, they have deep roots which bring nutrients from deeper sections to the topsoil and improve the soil's water holding capacity.

Hedgerows of nitrogen fixing shrubs

Several farmers in Mindanao have experiences with planting hedgerows of nitrogen fixing shrubs such as *Flemingia macrophylla*, *Desmodium rensonii*, or *Indigoferra anil* near coconut palms. Scientist in Sri Lanka have frequently explored the planting of *Gliricidia sepium* (kakawate, madre de cacao) and *Leucaena leucocephala* (ipil-ipil) to increase the available organic material (biomass) by using the prunings (twigs and leaves) as mulch for coconut palms.

Figure 3. Flemingia hedgerows under coconut palms

The shrubs can be established in rows parallel to the palms. This practice is an adaptation of the Sloping Agriculture Land Technology (SALT) chiefly developed to protect and improve upland soil. SALT suggests the planting of double hedgerows on slopes about four meters apart. After the shrubs are well established (after about six months), they are regularly slashed (for example before the harvest of coconuts) and the branches are used for mulching. Some farmers have planted dense hedgerows left and right of each row of coconut palms.

Ideally, each hedgerow consists of a double-row of nitrogen-fixing trees spaced forty to fifty-centimeters apart, while the double hedgerow is about two meters apart from the palms in order not to compromise the roots of the palms. Another option is to plant the nitrogen-fixing trees in circles around the palms.

Farmers preferably prune the shrubs at least quarterly at a height of about one meter. The trees regrow faster if about 10 percent of the leaves are left. The cut branches are placed around the trunks of the palms to cover their roots. This method helps to improve the soil within one year and leads to a significant yield increase in the second year.

Nitrogen-fixing shrubs continuously produce organic matter over several years without the need for replanting. These small trees can be considered nutrient pumps. The straight roots absorb nutrients from deeper soil layers, which are released when leaves and branches decompose on the surface. By this, the nutrients are made available to other plants. It should be noted that no or little competition with palms exists due to the vertical roots of the shrubs.

While adding biomass for mulching, the growth of coconut roots is enhanced and the capacity of the soil to absorb and hold water is significantly increased. Compared to cover crops, nitrogen fixing shrubs can be combined with intercrops analog to the SALT system.

How to plant hedgerows? The ideal way is to plant double rows left and right of the palms. It is recommended to space the double hedgerows 50 cm apart. The seeds are planted in shallow furrows and are slightly covered. Depending on the kind of shrub, one kg of seeds can plant up to 100 meters of hedgerow. Costs for seeds are approximately PhP 500/kg. To gain experience, it is advisable to start with a small area, perhaps one fourth of a hectare. Also, different kinds of shrubs may be tested on a small scale. Seeds from the first shrubs can be collected for further propagation.

The above-mentioned practices, which can also be combined in various manners, allow coconut farmers to adapt to the challenges related to climate change so that life, property, and income of individuals can be protected and productivity can be enhanced. When coconut farmers improve soil fertility and increase diversity by planting trees and shrubs, they also help move carbon dioxide (CO2) from the atmosphere–where there is too much of it–into the soil, where it becomes soil carbon and enhances climate resilience. In other words, by protecting coconut palms and other crops against severe weather events, farmers also help to mitigate (or lessen) CO2 in the atmosphere, which causes climate change.

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* *This article is through the courtesy of Manila Bulletin, Philippines*

Experts' Finding
on the Health Benefits of Coconut

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Virgin coconut oil is effective in lowering C-Reactive Protein levels among suspect and probable cases of COVID-19. There were two main indicators used: recovery from COVID-19 symptoms and level of C-Reactive Protein (CRP) in the blood. These two indicators showed that VCO can be used to treat mild COVID-19 cases.

CRP is a protein that is analyzed in the blood as a quantitative measure of inflammation or infection. CRP level less than 5 mg/L indicates recovery from inflammation or infection. The recovery from COVID-19 symptoms was more rapid in the VCO group compared with the Control group: 17% in the VCO group showed improvement compared to only 4% in the Control group. Full relief from COVID-19 was attained by day 18 in the VCO group compared to day 23 in the Control group.

The level of CRP in the VCO group dropped much more rapidly and completely compared to the Control group. By day 14, the CRP level in the VCO group had fallen below the 5 mg/L, and this continued to show a decreasing trend at day 28. In comparison, the CRP level in the Control group fell slowly to 5 mg/L at day 14 and stayed at this level until day 28.

Other beneficial effects of VCO were noted from the blood assay:

- HDL-cholesterol ("good cholesterol") increased
- LDL and triglycerides remain within normal range
- Fasting blood sugar (FBS) decreased

These results show that VCO, indeed, is a healthy oil.

Source: Proceedings of the XLIX Cocotech Conference, 30 August-2 Sept 2021, Jakarta, Indonesia.

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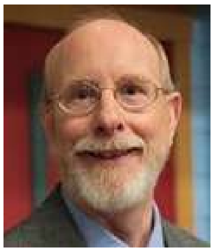
Coconut oil rinsing reduces gingival inflammation. Oil rinsing is a type of traditional procedure that involves swishing edible oil in the mouth and then spitting it out. Virgin and regular coconut oil can be used to reduce plaque related gingivitis. However, the study shows that virgin coconut oil has better taste, odor, and texture in the mouth than regular cooking coconut oil. The advantage of coconut oil or virgin coconut oil as natural oils is that they neither cause any staining as seen in the use of mouthwashes nor there is any after taste or allergic reactions. and are readily available. Such practices cure about 30 systemic diseases and have an effect on the overall well-being of the individuals practicing it.

Source: CORD Journal, Vol. 37 2021

Experts' Finding on the Health Benefits of Coconut



Dr. Bruce Fife

Certified Nutritionist and Doctor of Naturopathic Medicine, and Director, Coconut Research Center, based in USA

If any food could be labeled as brain food it would be coconut oil. According to Fife, coconut oil, converted into ketones, acts as a superfuel to the brain and normalizes brain function, stops the erratic signal transmissions that leads to seizures, and improves cognition and memory. The medium chain triglycerides (MCTs) in coconut oil are converted into ketones, which act as high-potency fuel for the brain. The ketone MCTs provide energy to the brain and stimulate healing and repair. The chemical structure of the MCTs and fatty acids in coconut oil enable them to pass through the blood-brain barrier, which ordinary food or oil cannot break into.

Source: Cocoinfo International, Vol. 19, No. 1, 2012

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Coconut water (*Cocos nucifera* L.) is an ancient tropical beverage whose popularity has been increasing in recent years. This 'naturally canned' beverage is a sweet refreshing drink obtained directly from the inner part of the fruit. It is a beverage that has drawn the attention as a natural functional drink. Coconut water is sterile at source, and is very rich in potassium, and contains sodium, chloride, magnesium and carbohydrates. Therein, making it a healthier alternative to carbonated drinks including isotonic sports drinks. Apart from the lower calories due to lower sugar content, the non-carbonated coconut water is also a great source for replacing the electrolytes lost during sweating when compared to carbonated drinks. Ingestion of carbonated drinksis known to be associated with gastrointestinal discomfort in certain individuals. This "Mother Nature's" gift of coconut water, could be prized as the beverage above all other beverages for its health renewing properties.

Source: Proceedings of the XLVI Cocotech Conference 7-11 July 2014, Bandaranaike Memorial International Conference Hall Colombo, Sri Lanka.

Experts' Finding on the Health Benefits of Coconut

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Coronary artery disease resulting from atherosclerosis is closely linked with lipids which is influenced by dietary fat and oil. Being rich in saturated fatty acids coconut oil has been pointed out as one of the many reasons for high incidence of coronary artery diseases (CAD). There is already recommendations by major organization to avoid coconut oil in order to reduce the CAD risk. In this context we decided to look the impact of coconut oil a cooking medium on the cardiovascular events and risk factors in patients with stable coronary heart disease receiving standard medical care.

Using anthropometric indicators of cardiovascular risk, like body mass index, waist/hip ratio and percentage body fat were statistically comparable between the two groups of using coconut oil and sunflower oil as cooking media over a period of 2 years, the result findings showed that there is no change in the major anthropometric, biochemical, vascular function and in cardiovascular events in patients with coronary artery diseases while using coconut oil. Therefore, as a cooking media, even though rich in saturated fatty acids coconut oil seems to be safe in those receiving standard medical care including statins.

Source: Proceedings of the XLVI Cocotech Conference, 7-11 July 2014, Bandaranaike Memorial International Conference Hall, Colombo, Sir Lanka

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Increased risk for coronary artery diseases is attributed to elevated levels of serum cholesterol, which in turn is due to increased intake of saturated fats. However, a fear complex has been created among the general public that consumption of coconut oil results in elevated cholesterol levels. This "myth" is primarily due to equating coconut oil with saturated fat; without knowing that saturated fat in coconut oil are of the short chain and medium chain fatty acids. It is to be emphasized that the fats that cause heart disease are saturated fats with long chain fatty acids. Nearly 50 % of the fat in coconut oil is Lauric acid (medium chain fatty acid). These medium chain fatty acids directly enter into the cells and are metabolized immediately (Vasudevan et al, 2010). On the other hand, long-chain fatty acids (of other oils) require the help of lipoproteins, which are eventually deposited into various organs, including heart vessels.

Source: Cocoinfo International, Vol. 18, No. 1, 2011.

Bearish Market of Coconut Oil in the Second Half of 2022

Alit Pirmansah[1]

Prices of lauric oils dropped in Rotterdam in two consecutive months of April and May 2022 after recorded a historical price hike in March 2022. Price of palm kernel oil (PKO) plunged by 15% in April and again dropped by 12% in May 2022. At the same time price of coconut oil (CNO) went down by 6% in April 2022 and plunged by 13% in May 2022. Downward trend of lauric oils' price was mainly led by the high price premium of palm kernel oil over coconut oil. The price premium of palm kernel oil over coconut oil in February 2022 was US$295 which was recorded the highest ever. The high price premium had put price pressure on palm kernel oil price which brought about price of the oil to go down and inevitably brought price of coconut oil to weaken since palm kernel oil supply is double of coconut oil. The downtrend of lauric oil prices was also brought by the decline of palm oil prices as Indonesia's palm oil products were back to international market after Indonesian government decided to lift export ban of the oil. It should be noted that Indonesia supplies roughly one third of oils and fats in the global market in recent years. Price of lauric oils is expected to remain weak in the second half of 2022 owing to higher supply and uncertainty in the global market.

High price premium of palm kernel oil was not only put a pressure on the price, but also brought about a shift in demand from palm kernel oil to coconut oil. During the first quarter of 2022, import demand for palm kernel oil from US dropped by 20% as opposed to the same period in 2021. Meanwhile, shipment of coconut oil to the US market jumped by 35% in the same period leading to an increase in import of lauric oils by 8% (table 1). It is worth noting that US demand for lauric oils upsurged in 2021 by 3%. US Census Bureau reported that import quantity of the oils increased from 823,581 tons to 849,808 tons.

The shift in demand of lauric oils at the expense of palm kernel oil was also observed in European market. During period of January-April 2022, imports of coconut oil by European countries leveled up by 5.7% to 313,513 tons. At the same time, import of palm kernel oil dropped by 16% compared the volume a year earlier. In total, shipment of lauric oils to European countries lessened by 4.9% during the

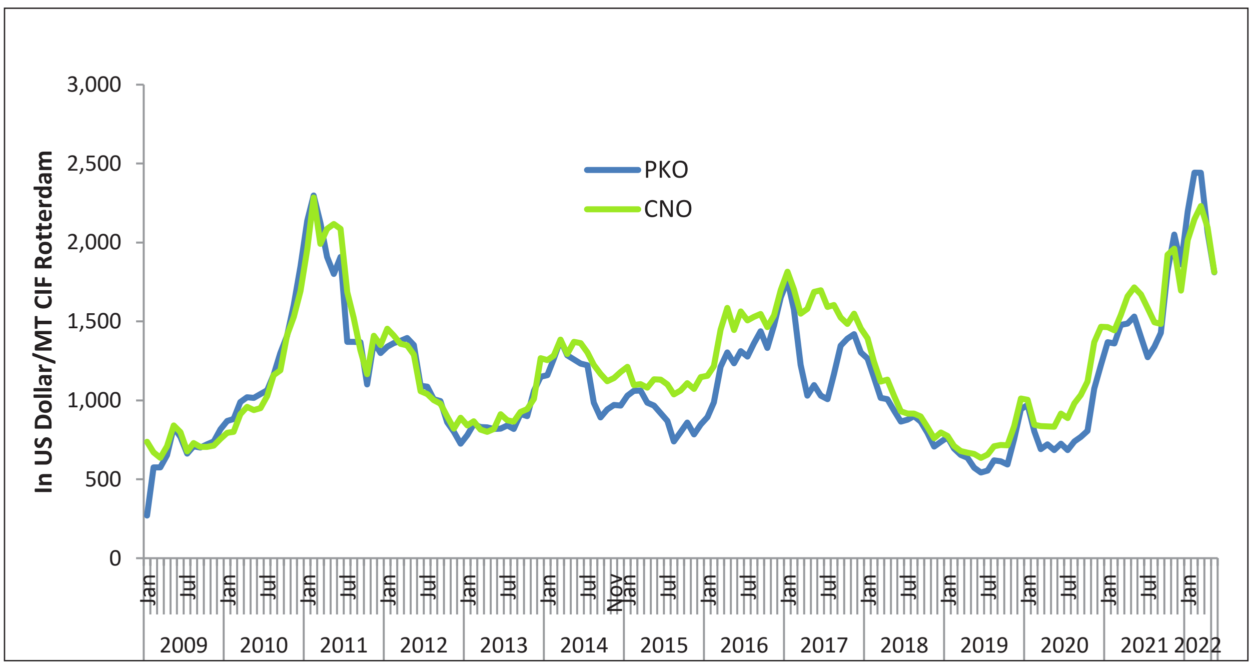

Figure 1. Price Trend of Lauric Oils, January 2009-May 2022 (USD/MT)

Bearish Market of Coconut Oil

Table 1. US Imports of Lauric Oils

		Jan-Dec 2020	Jan-Dec 2021	Change (%)	Jan-Mar 2021	Jan-Mar 2022	Change (%)
CNO	Volume (MT)	445,462	468,095	5	135,466	183,301	35
	Value (USD'000)	530,927	830,561	56	224,512	375,773	67
PKO	Volume (MT)	378,119	381,713	1	134,596	107,295	-20
	Value (USD'000)	318,630	496,713	56	146,026	210,213	44
Lauric Oils	Volume (MT)	823,581	849,808	3	270,062	290,596	8
	Value (USD'000)	849,557	1,327,274	56	370,538	585,986	58

Source: The U.S. Census Bureau, Economic Indicators Division

Table 2. European Union (EU28) Imports of Lauric Oils, January – April 2021/2022

		Jan-Apr 2021	Jan-Apr 2022	Change (%)
CNO	Volume (MT)	296,737	313,513	5.7
	Value (USD'000)	418,193	592,781	41.7
PKO	Volume (MT)	288,553	243,066	-15.8
	Value (USD'000)	329,068	465,139	41.4
Lauric Oils	Volume (MT)	585,290	556,579	-4.9
	Value (USD'000)	747,261	1,057,920	41.6

Source: ITC

Table 3. China Imports of Lauric Oils, January – March 2021/2022

		Jan-Mar 2021	Jan-Mar 2022	Change (%)
CNO	Volume (MT)	33,664	50,977	51.4
	Value (USD'000)	47,814	100,980	111.2
PKO	Volume (MT)	147,920	113,420	-23.3
	Value (USD'000)	167,448	216,797	29.5
Lauric Oils	Volume (MT)	181,584	164,397	-9.5
	Value (USD'000)	215,262	317,777	47.6

Source: ITC

period. Lower demand for lauric oils by European countries was attributed to higher price of the oils and economic uncertainty in the continent caused by Ukraine-Russia war.

A lower demand of lauric oils was also observed in China. ITC data showed that shipments of lauric oils during the first quarter of 2022 reduced to 164,397 tons from 181,584 in 2021 or a decrease of 9.5%. The lower import of the oils was mainly attributed to the drop in import of palm kernel oil. The persistent lockdown enforced by Chinese government and a high price of the oil had led demand of the oil to decline. The high price of palm kernel oil has also led to a shift of demand at the expense of palm kernel oil in Chinese market. During the period, demand for coconut oil upsurged by 51% from 33,664 tons in January-March 2021 to 50,977 tons in January-March 2022. However, the increase could not offset the low demand of palm kernel oil.

On the supply side, global production of lauric oils is expected to continue improving in the second half of 2022 as a result of good weather condition especially in South East Asian countries. Favorable weather condition brings about higher coconut yield in major producing countries such as Philippines, Indonesia, India, Malaysia, Papua New Guinea, Thailand, and Vietnam. As a result, copra production in these countries is projected to increase. Copra production in the Philippines is projected to rise by more than 20% to the level of 1,84 million tons. In Indonesia, production of copra is also expected to go up reaching annual production of 1.37 million tons or an increase of 4.6% compared to previous year's production. Thus, global production of copra is projected to reach 4.9 million tons in 2022 or an increase by 9%. At the same time, production of palm kernel is also projected to go up to 18.74 million tons in 2022 as

Bearish Market of Coconut Oil

Table 4. Copra Production, 2019-2022 (million tons)

	2019	2020	2021	2022p
Philippines	1.82	1.51	1.53	1.84
Indonesia	1.32	1.30	1.31	1.37
Other countries	1.62	1.56	1.65	1.69
World	4.76	4.37	4.49	4.90

Source: Oil World *p: projected figures*

Indonesia and Malaysia is expected to have higher palm kernel production during the year.

Since copra and palm kernel production is projected to level up, production of lauric oils in 2022 is estimated to increase reaching 11.3 million tons or an increase by 5.2% as opposed to the previous year's production. Coconut oil production is expected to reach 3.1 million tons or level up by 12%. At the same time palm kernel oil production is estimated to go up by 3% to reach 8.2 million tons.

The supply of coconut oil is expected to improve, so the global trade of coconut oil is also expected to continue recovering in the coming year amid uncertainty in the global economy. Export of coconut oil from Philippines in 2022 is forecasted to reach 1.05 million tons. This means an increase of 22% as opposed to the export volume a year earlier. Likewise, Indonesia is most likely to experience higher export of coconut oil in 2022. Export of coconut oil from Indonesia is estimated to reach 640 thousand tons during the year. Thus, global supply of the oil is projected to reach 2.28 million tons in 2022.

With an expected increase in supply, coconut oil price will face a price pressure in the second half of 2022. Lessening price premium of palm kernel oil over coconut oil will be an additional pressure on coconut oil price. Therefore, price of coconut oil is expected to remain weak in the second half of 2022 which will be an incentive to boost export of the oil to global market.

[1] Market and Statistics Officer, International Coconut Community

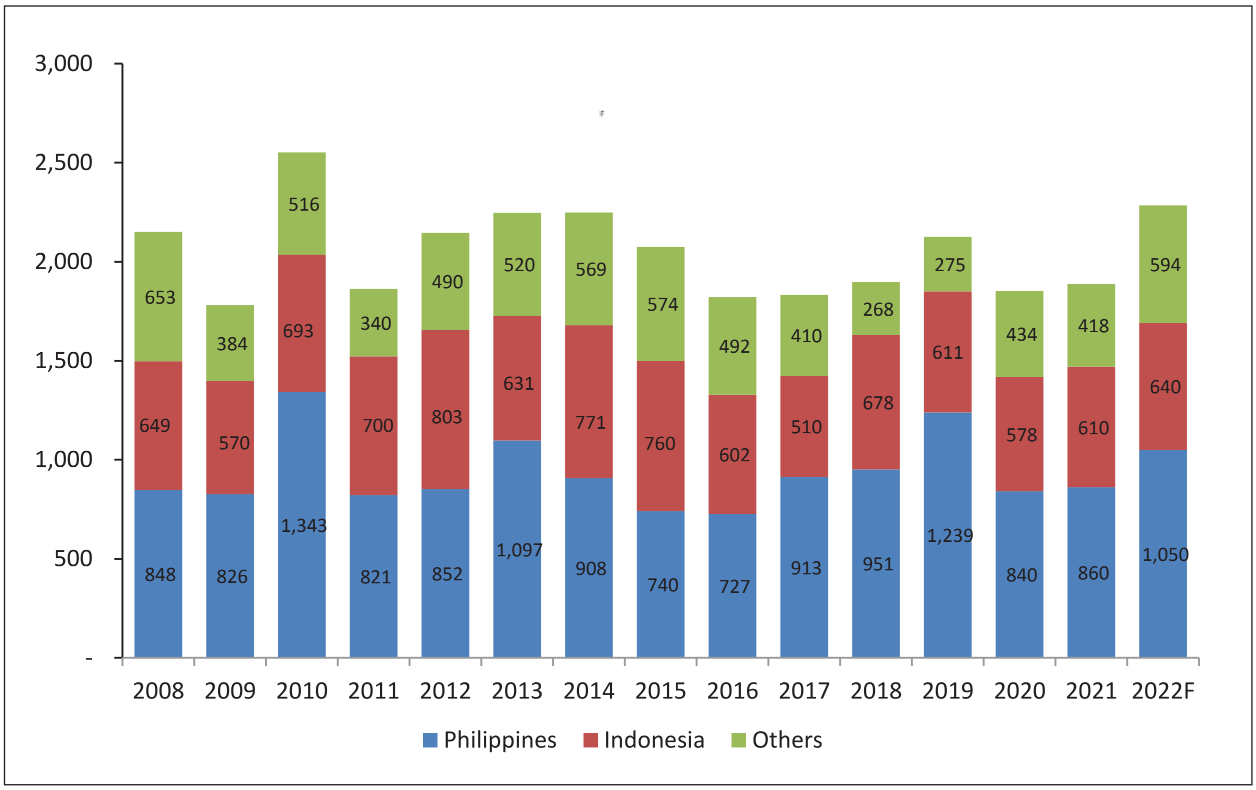

Figure 2. Exports of Coconut Oil from Philippines and Indonesia, 2008-2022

FIRST INTERNATIONAL TISSUE CULTURE WORKSHOP

International Coconut Community under the International Coconut Genetic Resources Network (COGENT) organized the first International Tissue Culture Workshop with the theme "Collaborative Initiatives towards Enhancing Tissue Culture R & D" physically from 16-20 May 2022 in India hosted by the ICAR-Central Plantation Crop Research Institute (CPCRI). This is one of the activities of COGENT's International Thematic Action Group (ITAG 4), who serve as the technical team working on In-vitro Culture and Cryopreservation.

The objective of organizing the workshop is to share expertise and develop skills of researchers working on coconut tissue culture in support of the conservation, germplasm exchange and mass propagation program among member countries of COGENT.

The Tissue culture experts from the different TC laboratory had participated in the workshop, presented their TC research and development, and provided the hand-to-hand skill demonstration to the participants from different eight coconut growing countries and the countries hosting the ICGs from Cote d'Ivoire, India, Indonesia, Malaysia, Papua New Guinea, Philippines, Sri Lanka, and Vietnam. Representatives from each country also presented the progresses and challenges of coconut tissue culture they faced.

The workshop started on 16th May with formal inaugural session in which Dr. Anand Kumar Singh, Deputy Director General, ICAR, India was the chief guest and delivered the inaugural address. In his address he appreciated the activities of ICC and the development happened in the coconut tissue culture and requested all to take maximum benefits of the workshop to implement and adopt in their respective countries. Dr. Rajesh M.K welcomed the delegates and participants. Dr. Jelfina C. Alouw, Executive Director of ICC, presented the overview of COGENT program, followed by address of Mrs. Erlene C. Manohar, COGENT Coordinator about Coconut Conservation Strategy. Dr. Anitha Karun, Director, ICAR-CPCRI delivered the keynote address. The inaugural session concluded with the vote of thanks by Dr. Niral Vittal.

The four-day workshop divided into the following five sessions followed by hand-to-hand demonstrations to the participants. Subject matter experts Dr. Bart Panis, Bioversity International Belgium, Dr. Quang Nguyen, Vietnam International University, Dr. Sundar Kalaipandian, University of Queensland, Dr. Cristy A. Cueto, Philippines Coconut Authority, Dr. Vijitha Vidhanaarachchi, CRI Sri Lanka, Dr. Anitha Karun, Dr. M. K Rajesh and Dr. Shareefa from CPCRI presented and shared the technology development information's with practical demonstrations.

1. Demonstration of Embryo Culture and Exchange Protocols
2. Demonstration of Ex Vitro Plantlet Establishment
3. Demonstration Clonal Propagation Protocols
4. Demonstration of Coconut Cryopreservation Protocols
5. Networking and International Project Develop

After each session there were Q&A sessions and discussion with hand-to-hand practical demonstrations on different aspects. The participants were taken to the different sections of the CPCRI for internal campus visit including the laboratory visits to make them understand the activities of CPCRI. Last day of the workshop i.e on 19th May the participants were divided into five groups for the group activities under the guidance of each resource speaker. The groups were asked to present their research proposals, and participants and resource persons provided input for the alignment of proposals. Mrs. Erlene C. Manohar COGENT Coordinator presented the synthesis of the workshop and action plan.

Certificate of appreciation and participation were distributed to all the resource speakers and participants. The four-day workshop concluded with the closing remarks of Dr. Jelfina C. Alouw, Executive Director. In her remarks she thanked the organizers and sponsors ACIAR, CPCRI and Coconut Development Board of India. She appreciated the resource speakers and the participants for their active participation in the workshop and requested all to adopt the technology and information's what they learned in these four days and try to replicate in their respective countries. She added that this is the first physical program organized by ICC after the pandemic and was very successful due to the active participation of all. Dr. Jelfina thanked and appreciated Dr. Anitha Karun, Director CPCRI and her team for the excellent arrangements for the successful conduct of the program. The symposium was moderated by Mr. Vincent Johnson, COGENT Coordination Support.

On 20th May 2022 a field visit was organized to the team to Mr. A. Narayanan Nair, one of the progressive farmers wherein the multistoried coconut cultivation model was displayed. After that the team were taken to Vittal Agro Products, one of the biggest Desiccated Coconut Powder manufacturers of India. He is processing around 1.5 akh coconuts per day. The team had good interaction with the manufacturer as well as the machine manufacturer. The visit found to be very informative and productive.

2ND INTERNATIONAL TISSUE CULTURE SYMPOSIUM

International Coconut Community through its program of the International Coconut Genetic Resources Network (COGENT) organized the three-day 2nd International Tissue Culture Symposium virtually from 4-6 May 2022. This is one of the activities of COGENT's International Thematic Action Group (ITAG 4), who serve as the technical team working on In-vitro Culture and Cryopreservation.

The objective of organizing the symposium is to establish the status of coconut tissue culture technology, including the information and technical capacity gaps, the needs, challenges, and their application to coconut conservation and to increase coconut production to meet the growing market demand through knowledge and technology sharing, synergies and to help provide support towards achieving more sustainable coconut industry developments. The theme of the symposium was 'Coconut Tissue Culture Aspects and Prospects'.

The Tissue culture experts from the different TC laboratory had participated in the symposium and presented their research and development in this sector.

The symposium started on 4th May with the welcome address by Dr. Jelfina C. Alouw, Executive Director of ICC, followed by address of Ms. Irene Kernot, Research Program Manager for Horticulture ACIAR, and Dr. Fiona Lynn of DFAT Australia. The opening remarks of the symposium delivered by Administrator Benjamin Madrigal and Chair ICC Technical Working Group. Mrs Erlene C. Manohar, COGENT Coordinator presented the Tissue Culture Symposium Rationale, Objectives.

During the three-day virtual symposium, subject matter experts presented the state of the art of coconut tissue culture (TC) in six sessions as follows:

1. The state of the art and challenges of coconut tissue culture globally
2. Coconut germplasm cryopreservation
3. Selection of coconut germplasm for in vitro culture
4. Tissue culture and Coconut Germplasm Exchange
5. Basic studies on embryogenesis technology towards its optimization
6. TC for socioeconomic benefits to coconut producers & processors, and Establishing / Strengthening (Inter)national networks/ linkages for TC

After each session there were Q&A sessions and discussion on different questions raised by the participants. A poster competition was also organized on the third day of the symposium and there were eight entries from both research institutes and private sectors. The best three entries were awarded with Gold, Silver and Bronze supported with ICC digital publications and cash prize and certificate.

A Pre-symposium activity was organized as Roundtable discussions on socioeconomic benefits of Tissue culture Technology to coconut producers & processors in which both private and government sector representatives participated on 27 – April 2022. The output of the roundtable discussion was presented on the last day of the symposium by Dr. Jelfina C. Alouw, Executive Director.

The meeting was attended by Dr. Anita Karun, Director ICAR-CPCRI India as ITAG-4 Leader, other ITAG members as resource speakers, invited participants from government and private sectors and 70 registered participants. There was in depth discussion on almost all the three days of the symposium which was very productive and resulted in several recommendations to be implemented in the coming days. Mrs. Erlene Manohar, COGENT Coordinator presented the Way Forward and Future Plans at the end of the session 6. The symposium concluded with the closing remarks of Dr. Jelfina C. Alouw. The symposium was moderated by Mr. Vincent Johnson, COGENT Coordination Support.

COCONUT FIBER IS USED TO CREATE A UNIQUE GREEN COMPOSITE

Natural fibers such as coconut, sisal, coir, jute, banana, hemp, and bamboo are becoming more popular in the industry due to their high mechanical strength, stiffness, thermal stability, and corrosion resistance. As a cost-effective, cheap, and ecologically acceptable alternative to synthetic fibers, manufacturers are increasingly turning to them.

King Mongkut's University of Technology North Bangkok collaborated with the NUST MISIS Department of Engineering of Technological Equipment to undertake a study on green composites. The leading scientists from Thailand are Dr. Sanjay Mavinkere Rangappa, Senior Research Scientist at KMUTNB, and Prof. Dr. -Ing. habil. Suchart Siengchin, President of KMUTNB.

The superior characteristics of natural fiber composites are mostly due to strong interfacial bonding at the fiber-matrix interface. Natural fibers with hydroxyl groups include lignin and cellulose are usually chemically treated to obtain it. It is possible to improve the degree of interlocking at the fiber-matrix interface using chemical or surface modification, resulting in excellent material resistance to failure, said Sergey Gorbatyuk, Professor of the Department of Engineering of Technological Equipment at NUST MISIS and co-author of the study.

Scientists from NUST MISIS have developed a "green composite" based on coconut fiber reinforced with a phenol-formaldehyde composite in collaboration with colleagues from India and Thailand (based on phenol resin, a synthetic polymer).

The study involved testing tensile, flexural, and impact strength, as well as analyzing the rate of water absorption and biodegradability features of coconut fiber composites with 60% and 40% phenol formaldehyde, followed by compression molding.

According to the researchers, the low quantity of hydrophilic hydroxyl groups and reduced contaminants are responsible for the green composite's superior mechanical capabilities when compared to native coconut fiber.

To improve the technology, the researchers compared two types of fibers: untreated and mercerized, which were treated with a concentrated solution of caustic soda (the most common alkali) and washed with hot and cold water. The mercerized composite samples had a 45–60% higher elastic modulus and a 30–40% higher tensile strength than the untreated sample, owing to the formation of a special rough surface on the fibers as a result of prodding

The excellent results of the processed fiber composites based on coconut shell, according to the authors, confirm that the created composite is a good candidate for domestic and industrial applications in cabin and railway car decoration, highway construction, and commercial interior design as environmental wall and floor coatings.

The technology will be adapted in Russia using flax, hemp, and nettle fibers as raw materials. *(Cision PR Newswire)*

A COCONUT WASTE COMPOSITE THAT IS STRONG ENOUGH TO BE USED FOR ROADS HAS BEEN DEVELOPED

A research group from Russia, India, and Thailand has developed a method for making a reinforcement composite out of waste coconut leaf sheath. The material is suitable for high-demand applications such as road construction, rail and airline interiors, as well as housing, when reinforced with a phenol-formaldehyde composite.

A good interfacial bonding at the interface of fiber and matrix drives the superior qualities of composite made of natural fibers, according to Sergey Gorbatyuk, co-author of the paper and Professor of the Department of Engineering of Technological Equipment at NUST MISIS. Natural fibers with hydroxyl groups containing lignin and cellulose are often chemically treated to obtain it. It is feasible to enhance the degree of interlocking at the fiber-matrix interface by chemical or surface treatment, resulting in high material resistance to failure.

The findings were recently reported in Polymer Composites. *(The Digest)*

INTERNATIONAL COCONUT GENEBANK-SOUTHEAST AND EAST ASIA (ICG-SEA) APPRAISAL

The International Coconut Genetic Resources Network (COGENT) is one of the major programs of ICC since 2019. One of the activities under the COGENT program funded by Australian Centre for International Agricultural Research (ACIAR) and Australian Department of Foreign Affairs and Trade (DFAT) is to undertake appraisals of the International Coconut Genebanks (ICGs) located in five regions i.e., ICG-SEA-Indonesia, ICG-SAME-India, ICG-SP-PNG, ICG-AIO-Ivory Coast, and ICG-LAC-Brazil. The main objective of conducting the ICG appraisal is to assess the collections' overall capacity and needs, including: i) hosting agreement status; ii) management effectiveness; iii) roles, services and use, and linkages with users and other stakeholders; iv) performance targets and work plans; and v) collection status within the global context.

The International Coconut Genebank for Southeast and East Asia (ICG-SEA) is hosted by Government of Indonesia, and is located and managed by Indonesian Palm Crop Research Institute (IPCRI), Manado, and North Sulawesi Assessment Institute for Agricultural Technology (BPTP-SULUT). The technical appraisal of the ICG-SEA was conducted from 28th February to 4th March by the team of experts of Dr. Lalith Parera, Additional Director and breeder from Coconut Research Institute, Sri Lanka, Prof. Alain Rival, Senior Project Manager, CIRAD, Jakarta and Dr. Donata Pandin, former researcher from Balit Palma. The economic analysis conducted by Mrs. Erlene Manohar , COGENT Coordinator and Dr. Celia Medina, Professor (Entomology), Institute of Weed Science, Entomology & Plant Pathology, College of Agriculture and Food Science, University of the Philippines Los Baños from 14-17 March 2022. Besides the experts, Dr. Jelfina C. Alouw, Executive Director, Ms. Mridula Kottekate, Assistant Director and Mr. Klaudio Hosang, Admn & Finance Officer accompanied the team from the ICC Secretariat.

Mrs. Erlene Manohar, COGENT coordinator had Focus Group Discussion with the Balit Palma team and discussed on the activities of the economic analysis of the ICGs and helped the team in preparing the action plan on the activities to be carried in ICG. The main objective of the economic appraisal is to assess the economic value of establishing ICGs and the valuation of the use of the genetic resources for varietal improvement and mass propagation. The key areas to be considered in the action plan was discussed as status of the germplasm collection ICGs (Baseline and Current conditions), total number of existing germplasm collections (Indigenous and Exotic Collections), recommended Germplasm Exchange Protocol, characterization of the vegetative and reproductive performance of each accession (Data Base Management Protocol Adopted), pest and diseases monitoring activities, Good Agricultural Practices (GAP) of the ICG farms, Fund support (Local and External) for Sustainability.

The technical appraisal team had a round table discussion with the Balit Palma team and focussed on the issues related to production, maintenance and plant protection aspects. Dr. Jelfina C.Alouw, Executive Director in her remarks mentioned that ICC-COGENT will facilitate the MoU between Government of Indonesia, FAO Treaty and ICC and shall made some amendments with regard to exchange of germplasm between the ICG regions, to improve genetic diversity and produce some new Hybrids in future. She added that the land issues faced by Balit Palma in the occupancy of the accessions would be discussed with the local North Sulawesi province government. ICC-COGENT shall facilitate the collaborative research and exchange program between the ICG host countries.

The first ICG appraisal of this series has been conducted and completed in September 2019 for the International Coconut Genebank for South Pacific (ICG-SP) in Papua New Guinea (PNG) and the second ICG appraisal was organised for the International Coconut Genebank for Africa and Indian Ocean (ICG-AIO) in January 2021. The coconut accessions conserved in ICGs and NCGs are important materials to use in research and breeding to produce better varieties with desired properties such as tolerant to climate change and biotic stresses, early flowering, high yield, high nutritional value, and beneficial to health. The responsive distribution of coconut diversity is essential for the development of sustainable coconuts globally. *(ICC News)*

DOST-FPRDI TECH: FROM WASTE TO 'SUPER ULING'

Thanks to a technology developed by the Department of Science and Technology's Forest Products Research and Development Institute, the Philippines, what may have been a pile of rubbish waiting to decompose becomes a profitable endeavor for a local coconut farm (DOST-FPRDI).

In 2018, the Thega Coconut Farm (TCF) approached DOST-FPRDI for help converting the farm's tons of coconut shells into charcoal briquettes.

According to Sarahme Corazon B. Esteban of the DOST-Socio-Economics FPRDI's and Marketing Section (SEMS), TCF creates roughly 1,600 kilos to 2,400 kilograms of coconut shells every 45 days from copra production.

Coconut shells are normally left to break down into natural compost if they are not given away for free to local households or sold to tinapa [smoked fish] makers for P3.50 per kg. To transform the garbage into something useful, the company decided to buy four drum kilns, a manual briquettor, a binder-mixer, and a charcoal crusher from DOST-FPRDI.

Charcoal briquettes are a compacted mass of fuel material manufactured from a mixture of carbonized fines and a binder that is molded under pressure.

Because it is tiny and homogeneous in size, it is less dirty and easier to handle than regular charcoal. It also burns more slowly, produces more intense heat per unit volume, and produces nearly no smoke.

TCF's charcoal briquettes are now known as "Super Uling PH", with pricing ranging from P60 to P80 per kilogram.

After a temporary pause in production in July 2019, when a succession of typhoons damaged the farm's primary market, Puerto Galera in Oriental Mindoro, the farm's operation has been steadily recovering.

The Covid-19 epidemic had a negative impact on it in 2020. TCF is currently operating at full capacity, with a monthly production volume of 1.5 to 2 tons.

In Puerto Galera and other tourist destinations, Super Uling charcoal briquettes are already available on online shopping sites and in some physical stores of local food businesses and houses.

The briquettes, as well as other TCF products like coco ropes, coco peat, and coco coir, are sold in kiosks in Ayala Fairview Terraces and Ayala Vertis North. *(Business Mirror)*

NEW TOOL TO FIGHT INVASIVE COCONUT RHINOCEROS BEETLE

Officials in Hawaii are using new technology to tackle the invasive coconut rhinoceros beetle and its spread via green waste transportation. When insects were discovered at Joint Base Pearl Harbor-Hickam eight years ago, the military issued an alert.

Since then, a concerted effort has been made to set massive black traps around Oahu in order to follow the spread. On a regular basis, teams backed by the University of Hawaii's Research Corporation examine them.

Shipping containers, according to state agriculture officials, are being used to fumigate trees and green trash before disposal.

Darcy Oishi, Biological Control Section Chief for the State Department of Agriculture, explained at the Pearl City Urban Garden that they have a pesticide applicator, inject the fumigant into it, it stays in the chamber, and then once the system is finished and it's safe for us to aerate, then the staff remove the treated material, and then dispose of it.

They might utilize the containers to treat large fronds and tree trunks that would otherwise be pulverized, composted, or burnt. This strategy is faster in terms of treating the coconut rhinoceros beetle and killing as many bugs as possible.

According to Oishi, other methods for fighting the beetle include injecting insecticides into trees and composting or burning infected trash.

The ideal situation is that if they can efficiently manage their green garbage, they can manage the insect population. In Kunia and Mililani, they have multiple increasing hotspots. Unfortunately, population growth is occurring in these areas. However, the department's top objective right now is to prevent breakouts outside of these sites so that they may effectively use the tools and methods to reduce core population numbers. *(Hawai'i Public Radio)*

TEMPEH YEAST IS USED TO EXTRACTS COOKING OIL FROM COCONUT

The National Research and Innovation Agency (BRIN), Indonesia, is using tempeh yeast to extract cooking oil and virgin coconut oil (VCO) from coconut, Teuku Bardant, a researcher from BRIN's Chemical Research Center Researcher has informed. The addition of tempeh yeast helps separate oil and water within coconut milk naturally since the protein in coconut milk that helps oil and water to mix is eaten by the yeast.

He explainned that once the amount of protein decreases, its function of preserving the oil and water mix stability declines. As a result, there is no longer anything that maintains the oil and water molecules, and the two separate by themselves.

The process of producing the oil is the wet method, which involves producing milk first. Coconut flesh is grated, processed into milk, and then tempeh yeast is added to the mix, he informed. Next, the oil is heated to a temperature of 70 degrees Celsius to kill the yeast and its spores contained within the oil. The process is repeated two to three times, and is usually known as the pasteurization process, he added.

Bardant pointed out that this oil is better for human health because it has a short and medium chain. The shorter chain makes coconut oil and VCO easier to consume. When people consume such oils, the body tends to use them rather than store them under the skin tissue. Consuming coconut oil also does not lead to people gaining fat as fast as palm oil. He expects people to utilize coconut oil for cooking and palm oil for energy fuel. People will not be too dependent on palm oil because coconut oil can also be used as cooking. *(Antara)*

ICAR - CPCRI OUTREACH TO BELOW POVERTY LINE (BPL) SCHEDULED CASTE FAMILIES

The Scheduled Caste Sub Plan (SCSP) of the Government of India from 15.02.2022 to 19.02.2022, ICAR-CPCRI, in conjunction with the Scheduled Caste Department of Kasaragod, Kerala, held a five-day demonstration and training program on "Scientific Cultivation Techniques of Coconut" for Scheduled Caste beneficiaries at ICAR-CPCRI, Kasaragod.

Dr. K. B. Hebbar, Acting Director of ICAR-CPCRI, inaugurated the program and encouraged the beneficiaries to actively participate in the training and improve their scientific skills in coconut cultivation and processing in order to find better employment opportunities and to use the skills learned during training to establish new coconut gardens in their villages.

During his presidential address, Dr. C. Thamban, ICAR-CPCRI Kasaragod's Head of Social Science, updated the farmers on the SCSP schemes and highlighted several ICAR-initiated activities. CPCRI has been working for the welfare of scheduled cast communities for the past four years. In addition to training, the institute plans to establish a one-hectare demonstration plot for coconut cultivation at the institution's research farm to provide hands-on training by involving beneficiaries in all activities, with the goal of some of them becoming master trainers.

The vote of thanks was proposed by Dr. Rajkumar, Scientist-in-Charge of the SCSP. There were 18 trainees from Scheduled Caste Communities who actively participated. During the technical session, Dr. Subramanian, Principal Scientist, ICAR-CPCRI Kasaragod, briefed the farmers on basic coconut farming skills such as land preparation, pit opening, soil health and nutrient management, and intercrop cultivation methods developed by the institute.

Dr. A. C. Mathew provided a session on various irrigation technologies as well as a live demonstration on how to lay out drip irrigation lines in the field. Dr. Sujithra M. delivered a lecture and hands-on instruction on integrated pest control tactics in coconut, as well as a field demonstration of biological agent treatments and rhinoceros beetle catching and killing using nylon net and pheromone approaches. Dr. Daliyamol informed the farmers about advancements in disease management and conducted field diagnostic visits as well as a disease management technology. Dr. Panjavarnam and Dr. Surekh R., Crop Production Division Scientists, had made field visits.

Dr. Rajkumar acted as Course Coordinator, and the training program's conveners are Dr. Sujithra, Dr. Daliyamol, and Dr. Surekha. During their feedback, the participants acknowledged their contentment but also wanted further practical demonstrations and training on vermicompost production, the usage of bio-control agents, coconut climbing trainings, and finding job prospects for them in CPCRI's farm activities.

Each participant received a training certificate as well as a vegetable seed package containing brinjal, okra, amaranthus, long bean, and gourds obtained from ICAR - IIHR, Bengaluru for production in their fields. *(CPCRI News)*

STRENGTHENING RELATIONSHIP BETWEEN ICC MEMBER COUNTRIES

A virtual coordination meeting between the ICC Secretariat and the Nuts and Oil Crops Directorate, Agriculture and Food Authority, Government of Kenya, was held on 3rd February 2022. This is part of the activities of ICC in Dialogue and Communications with National Liaison Officers (NLOs) of the ICC Member Countries.

The meeting was attended by Madam Rosemary Owino, Acting Director, Nuts and Oil Crops Directorate Agriculture and Food Authority, the NLO of ICC for the government of Kenya, along with Ms. Lily Chebet Kiptoo, Deputy Director, Technical and Advisory Services and Mr. Innocent Masira, Market Development Officer. The ICC Secretariat team was led by Dr. Jelfina C. Alouw, Executive Director, with Ms. Mridula Kottekate, Assistant Director; Mr. Klaudio Hosang, Administrative and Financial Officer; and Mr. Otniel Sintoro, Information and Publication Officer.

In her welcome remarks, Dr. Jelfina congratulated Madam Rosemary on her new task as the Acting Director of the Nuts and Oil Crops Directorate, Government of Kenya, and extended her sincere appreciation to Dr. Florence Kaibi the former NLO, and Ms. Lilly Chebet for her excellent support to ICC. She expressed that ICC has been so blessed with the involvement of Kenya in this community and looking forward to strengthening the relationship for the benefit of coconut farmers, industries, and other stakeholders as well as the country. Dr. Jelfina presented the Global Scenario of Coconut Sector, wherein she described the present status of the coconut sector, coconut market and production, country status, challenges, global export trend value and industries, outlook 2020-2025, ways forward and ICC programs and projects.

In her remarks, Madam Rosemary Owino, Acting Director of the Nuts and Oil Crops Directorate, Government of Kenya, appreciated the collaboration over the year with ICC programs where Kenya as a member country and benefitted optimally. She added there are many more to explore in the future as a part of the Community, especially to increase the production, productivity and value addition of the coconut sector. She is looking forward to meeting physically during the upcoming 50th International COCOTECH Conference at Kuala Lumpur, in October 2022.

Ms. Lily Chebet shared the latest development in the coconut sector in Kenya. Kenya has imported 12.00 coconut seeds from India for the hybridization and tissue culture program. Several SMEs also have come up a lot with production of VCO, and Kenya is looking forward to increasing more processing and value addition of coconut for which ICC's support and the collaboration gain its relevant context. She appreciated the international training course conducted by ICC-CRI in which two of the officers of Kenya trained and their service is well utilized at field level.

Mr. Innocent Masira, who participated in the Statistics workshop organized by ICC last year mentioned that this meeting was very enlightening and encouraging. He looks forward to the upcoming ICC capacity building and technology transfer trainings in 2022, to improve the coconut industry in Kenya.

The meeting was very productive and fruitful. Ms. Mridula Kottekate, Assistant Director, moderated the meeting. *(ICC News)*

News Round-Up

EXPLORE COCONUT'S POTENTIAL FOR CARBON SEQUESTRATION

The carbon sequestration potential of coconut must be explored seriously, says AK Singh, Deputy Director General (Horticultural Sciences), Indian Council of Agricultural Research (ICAR).

Delivering a virtual address at the 106th foundation day of the Kasaragod-based Central Plantation Crops Research Institute (CPCRI), Singh said coconut sequesters 15 tonnes of carbon dioxide per hectare per year. "This is huge compared to other crops that occupy a large area," he said.

He called for adopting high-density multiple cropping system to step up the quantity of carbon dioxide sequestration.

If the UN comes out with a programme on carbon credits, this crop will be one of the biggest beneficiaries in India, he said.

On CPCRI's focus on coconut and arecanut, he said these crops have a significant role in carbon sequestration, and this must be tapped effectively.

Stressing that research institutes should actively adopt new technology tools, Singh said there will be more thrust on technologies in the agricultural sector for greater efficiency in breeding, management and so on.

He said that gene editing had reached unexpected levels in some crops and the Government might take a view on gene editing in the days to come. A committee on this has submitted its report to the Government. "We have to rededicate ourselves to the increased application of new tools," he said.

He urged institutes such as CPCRI to bring at least 15-20 per cent area under natural farming and collect more data on it.

Calling for continuous monitoring of soil mediums at the institute level, he said such information will offer helpful insights when natural farming gains momentum. *(The Hindu Business Line)*

COCONUT VENDORS IN KOVALAM ARE MAKING AN ECO-FRIENDLY SWITCH

If you are wondering how you can contribute to making the world plastic-free, take a cue from these tender coconut vendors in Kovalam Kerala, India. Apart from completely shunning plastic straws, they have replaced them with alternatives like recycled paper straws.

Steering them into this change is Krishna KS, waste management and community outreach officer at Positive Change for Marine Life, an NGO founded by Karl Goodsell based in Australia. Krishna's recent campaign 'Leave No Trace' encourages street vendors with vending zones at tourist destinations to replace single-use plastics with other environment-friendly alternatives.

Krishna says, "Over the past three years, we have been carrying out various activities in the coastal areas to combat waste disposal problems. One such initiative, a community-centric waste collection campaign, was implemented in two wards of Vizhinjam with over 150 families. Plastic collection bags were given to each of the families so that the trash doesn't end up in water bodies. The Leave No Trace campaign was conceptualised based on our recent survey across popular beaches in the district, where we identified the amount of plastic waste piling up," she said.

According to Krishna, during the beach survey, around 12,959 pieces of plastic were collected from the beaches in Kovalam in just 42 weeks. "On assessing the materials collected from the beach, we noticed that plastic straws, thermocol plates, plastic covers and spoons were the major pollutants," he said.

Krishna's team thought the first step is to sensitise tender coconut vendors against the use of single-use plastic straws since they have the most use for it. Presently, around 18 vendors from Kovalam and nine from Vizhinjam are a part of the programme. "Four vendors from Kovalam have started to replace plastic straws with paper ones. Initially, the total number of plastic straws used by these four vendors was 9,660 monthly. The programme helped eliminate around 4,800 straws in just one and a half months," said Krishna. *(The New Indian Express)*

Table 1. WORLD Exports of Coconut Oil, 2014– 2020 (In MT)

COUNTRY	2015	2016	2017	2018	2019	2020[R]
A. APCC Countries	**1,728,076**	**1,548,733**	**1,605,772**	**1,823,859**	**1,837,714**	**1,819,672**
F.S. Micronesia	0	0	87	57	0	0
Fiji	1,794	1,779	1,955	3,261	2,700	2,700
India	7,725	29,215	11,726	6,985	7,632	7,500
Indonesia	760,072	602,318	510,352	675,270	650,000	552,000
Jamaica	3	7	6	2	2	2
Kenya	161	252	55	36	30	30
Kiribati	2,461	2,220	1,359	1,851	1,500	1,500
Malaysia	152,091	115,969	102,735	121,914	135,000	175,000
Marshall Islands	0	1,239	809	2,229	2,000	2,000
Papua New Guinea	18,467	23,866	26,565	22,341	25,000	20,000
Philippines	740,279	726,827	912,632	954,107	980,000	917,000
Samoa	1,020	546	1,098	32	50	50
Solomon Islands	1,163	1,487	5,515	5,670	3,300	3,350
Sri Lanka	22,032	22,679	20,126	19,039	20,000	17,000
Tonga	1,020	900	900	0	0	0
Thailand	15	1,236	1,331	1,266	1,300	1,300
Vanuatu	9,000	654	2,543	1,226	700	740
Vietnam	10,773	17,539	5,978	8,573	8,500	8,500
B. Other Countries	**342,894**	**327,780**	**167,349**	**124,151**	**112,600**	**118,000**
TOTAL	**2,070,970**	**1,876,513**	**1,773,121**	**1,948,010**	**1,950,314**	**1,826,672**

R: Revised figures

Table 2. Prices of Coconut Products and Selected Vegetable Oils, 2020 (US$/MT)

	2020											
Products	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Copra	607	543	519	536	540	585	592	600	632	665	848	920
Coconut Oil	1,062	875	834	840	831	920	886	954	1,034	1,105	1,380	1,459
Copra Meal[2]	257	224	193	231	252	261	231	205	206	209	259	281
Desicc. Coconut[2]	2,153	2,149	2,081	2,150	2,153	2,190	2,190	2,195	2,208	2,222	2,315	2,469
Mattress Fiber[1]	157	154	149	n.q.	136	107	110	111	111	111	109	107
Shell Charcoal[2]	316	327	324	361	371	369	376	381	390	396	418	447
Palm Kernel Oil	955	802	689	721	678	761	704	756	788	801	1,073	1,193
Palm Oil	835	729	635	609	574	652	659	703	741	758	918	979
Soybean Oil[r]	874	800	748	680	684	752	821	867	906	915	974	1,023

1: Sri Lanka (FOB); 2: Philippines (FOB); r: revised

Table 3. World Oil Balance 2018-2020 (1,000 Tons)

Oil/Year	Jan/Dec 2018	Jan/Dec 2019	Jan/Dec 2020
Palm Oil			
Opening Stocks	13.11	15.26	13.61
Production	74.68	76.67	74.02
Imports	51.43	55.39	50.16
Exports	52.21	54.80	50.41
Disappear	71.75	78.91	75.19
Ending Stocks	15.26	13.61	12.19
Soybean Oil			
Opening Stocks	5.75	6.00	5.87
Production	56.91	56.89	58.47
Imports	10.93	11.81	12.77
Exports	11.15	12.03	12.90
Disappear	56.44	56.80	57.55
Ending Stocks	6.00	5.87	6.66
Groundnut Oil			
Opening Stocks	0.34	0.35	0.27
Production	4.17	3.72	3.90
Imports	0.27	0.33	0.35
Exports	0.27	0.33	0.35
Disappear	4.17	3.78	3.88
Ending Stocks	0.35	0.27	0.29
Sunflower Oil			
Opening Stocks	2.01	2.88	3.38
Production	20.04	20.77	21.35
Imports	10.11	11.89	13.16
Exports	10.16	12.09	13.22
Disappear	19.12	20.06	21.28
Ending Stocks	2.88	3.38	3.39
Rapeseed Oil			
Opening Stocks	3.57	3.27	2.99
Production	25.51	24.94	25.14
Imports	4.98	5.34	5.82
Exports	5.01	5.28	5.79
Disappear	25.78	25.29	24.92
Ending Stocks	3.27	2.99	3.24
Cotton Oil			
Opening Stocks	0.43	0.42	0.36
Production	4.68	4.58	4.56
Imports	0.14	0.17	0.15
Exports	0.14	0.16	0.15
Disappear	4.69	4.65	4.56
Ending Stocks	0.42	0.36	0.36

Oil/Year	Jan/Dec 2018	Jan/Dec 2019	Jan/Dec 2020
Palm Kernel Oil			
Opening Stocks	1.01	1.31	1.36
Production	7.81	8.11	7.90
Imports	3.35	3.57	3.42
Exports	3.30	3.63	3.43
Disappear	7.56	8.00	7.92
Ending Stocks	1.31	1.36	1.34
Coconut Oil			
Opening Stocks	0.33	0.52	0.51
Production	2.91	2.91	2.62
Imports	1.92	2.05	1.85
Exports	1.90	2.12	1.81
Disappear	2.73	2.84	2.76
Ending Stocks	0.52	0.51	0.41

Source: APCC and Oil World *F: forecast figures*

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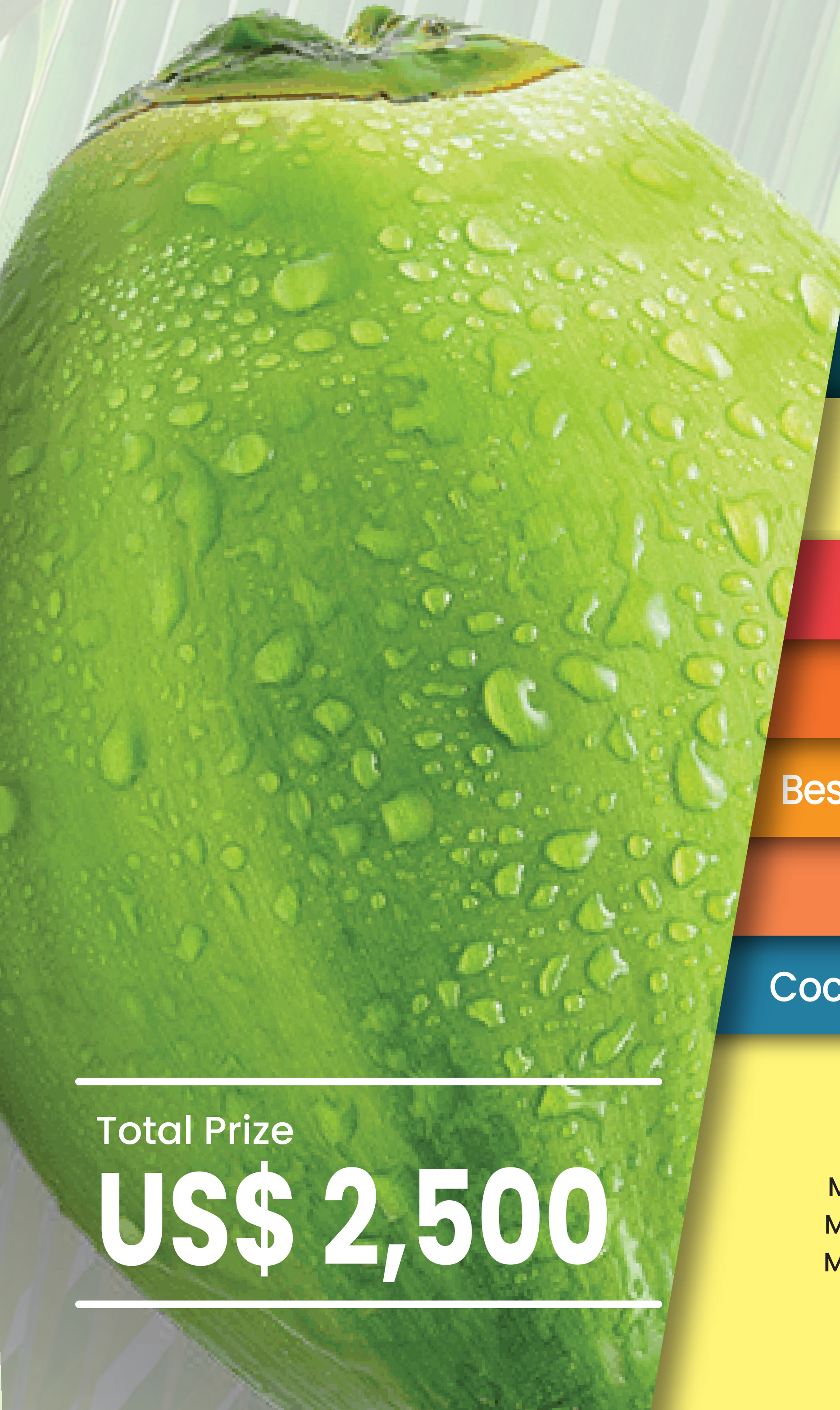

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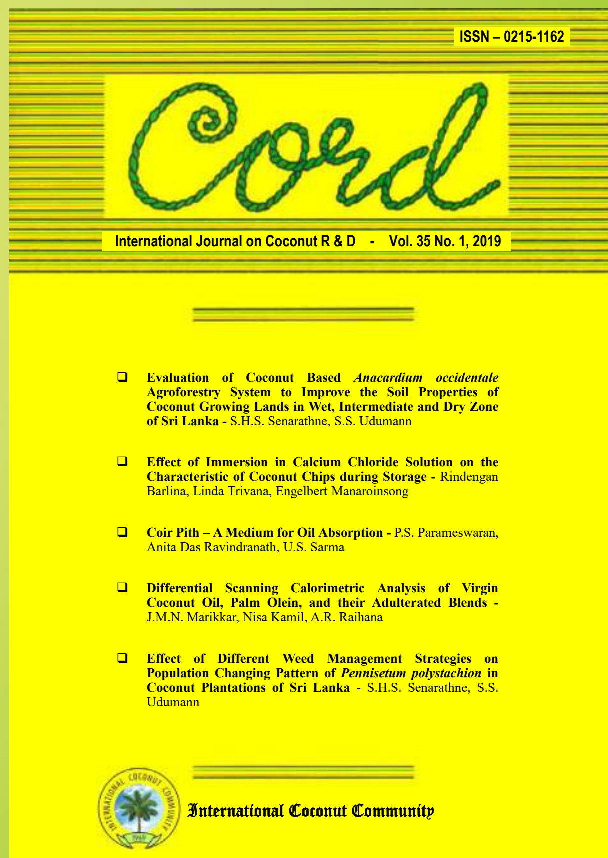

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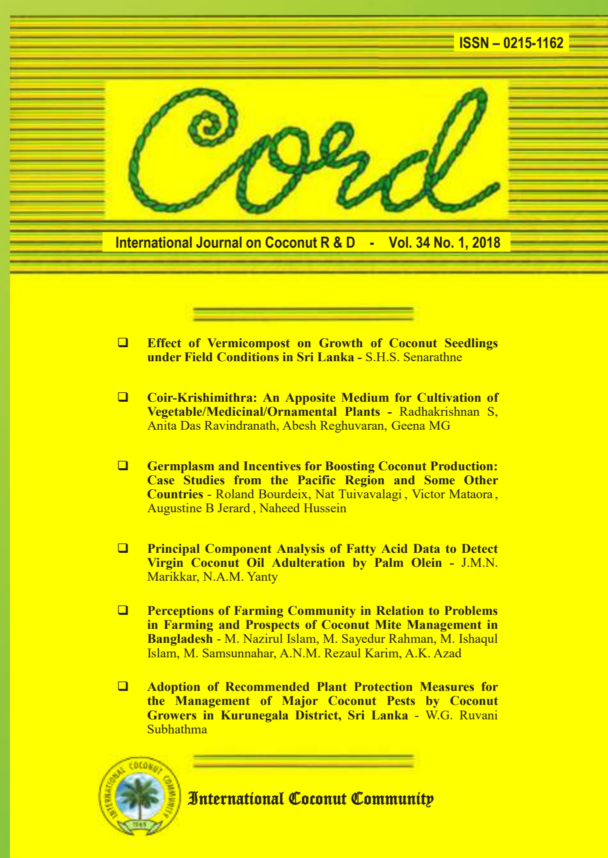

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