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Issue	**Ensuring the Safety and Quality of Copra**
Background	The Philippines is considered as the world's second largest producer of coconut products with 3.6 million hectares of land planted with coconut trees and 3.14 million metric tons produced in 2021 [1, 2]. Coconut and coconut by-products are among the country's top export commodities with copra, copra cake or meal, and coconut oil as primary export coconut commodities. In 2019, copra oil cake export reported a volume of 304,600 MT and a value of 60.8 M USD [3]. Despite the increase in export earnings, copra price in the country sharply declined in the past 5 years mainly due to: drop in global coconut price, oversupply of palm oil in the world market, and reduced quality of copra [4-7]. Importing countries, such as the European Union (EU), imposed stringent requirements on feed materials due to possible aflatoxin contamination [4]. On August 1, 2003, the EU, through its Directive 2002/32/EC, reduced the allowable aflatoxin content in feed materials, such as copra meal, from 200 parts per billion (ppb) to 20 ppb [8, 9]. As a result, the Philippines suspended its export of copra meal to the EU unless aflatoxin levels were ensured to be below the requirement [10]. At the domestic level, although all sizes and qualities of coconuts are mostly accepted, some buyers reject overmature and cracked nuts. Price discounts are also imposed on copra that do not meet the moisture and quality requirements. The Copra Moisture Discount Table stipulated in the Philippine Coconut Authority (PCA) Administrative Order No. 02 Series of 2003 is used to identify the corresponding percent discount for a particular percent moisture content [11, 12]. In most cases, copra produced locally is of inferior quality, i.e., high free fatty acid, aflatoxin and moisture content, bad color, and odor. The oil derived therefrom is also of poor quality and needs additional refining to meet international standards. Poor quality is subject to an automatic

	price deduction of 10 to 15% in the world market, thus resulting in annual losses [13].
General Description	**Copra, copra cake and coconut oil** One of the main products derived from coconut is copra. It is produced by drying the fresh coconut meat obtained from the matured coconuts. The drying process may be done using traditional methods, i.e., sun-drying, or the use of mechanical dryers, such as kiln, flatbed and channel dryers [14]. Its derivative, coconut oil, is extracted by expeller process or solvent extraction methods. The by-product of the extraction process, i.e., copra cake or meal, is used as feed ingredients for ruminants [14, 15].
Hazard Presence in Food	**Aflatoxin** Aflatoxins are amongst the most poisonous mycotoxins. Mycotoxins are toxic secondary metabolites, which are produced by yellow-green molds or fungi, specifically *Aspergillus flavus* and *Aspergillus parasiticus* species. Aflatoxins are high temperature-resistant and chemically stable compounds that can withstand food or feed processing [16, 17]. In copra production, if there is inadequate drying, improper handling or faulty storage, fungal growth and subsequent aflatoxin production may occur. [18]. In the case of the Philippines, high temperature and high relative humidity climate*, i.e., 80-90% in wet season and 50-70% in dry season*, further exacerbates the problem of aflatoxin contamination [16]. **Polycyclic Aromatic Hydrocarbons** Direct drying or smoking of foods causes the production of polycyclic aromatic hydrocarbons (PAH). These carcinogenic and mutagenic compounds are produced during combustion and pyrolysis of organic molecules [19]. PAHs may be adsorbed by foods directly from the smoke during processing or produced in the food itself due to the action of heat [20].

Among the principal sources of major exposure of humans to PAHs is through consumption of edible oils. This is because edible oils require the drying of vegetable seeds before oil extraction, the resulting combustion fumes may be high in PAHs, which would eventually reach the commercial oil [21, 22]. In coconut oil production, direct contamination with smoke during the copra drying process causes the formation of PAHs [23].

Quality Issues in Food

In local and international markets, moisture content and appearance are considered as the bases for determining copra quality [24].

Copra is graded and classified based on moisture content, oil content, free fatty acid (FFA), aflatoxin content, etc. Table 1 shows how copra is classified based on the several quality parameters.

Table 1. Classification based on characteristic quality of Copra [25]

Parameters	Grade 1	Grade 2	Grade 3
Moisture Content (%)	6-7.9	8-10.9	11-13.9
Oil (%, min.)	62	60	58
Free fatty acid (as oleic, % max.)	0.5	4.0	5.0
Color of meat	Clean, white to pale yellow	Brown to dark brown	Brown to dark brown
Extraneous matter (% max.)	0.25	0.75	1.0
Aflatoxin level (ppb, max.)	5	20	20
ARM (% max.)	0	10	20
Inferior copra (% max.)	0	10	20
Other specifications	Free from smoke and other contaminants		

Good quality copra is described as well dried and clean; reasonably free from any visible extraneous matters, molds and insects, and other contaminants; and reasonably free from rancid or objectionable odor. From good quality copra, extracted crude coconut oil is characterized as clear, with low FFA, and has a good aroma [15].

Inferior quality copra, on the other hand, is described as smoky, burnt, sooty, moldy, rubbery, and has high moisture [24, 25]. The resulting crude coconut oil is distinguished as dark and turbid oil, with high FFA, phosphatides, gums and has an unpleasant aroma [15].

According to PCA Administrative Order No. 02 Series of 2003, resecada (bodega) copra with a moisture content of 6.0% is traded with the base price while copra with 6.1 to 13.9% moisture content is subjected to price adjustments through discounts or deductions. Copra with moisture content of 14% and above are considered as rejected [12].

Issues on quality are commonly due to the poor production and handling practices such as sun-drying copra at highway shoulder roads while split coconuts are not immediately dried and are usually left exposed to substances such as dust and rain [11]. Photos of the extent of drying and defects in copra can be seen Figures 1 and 2.

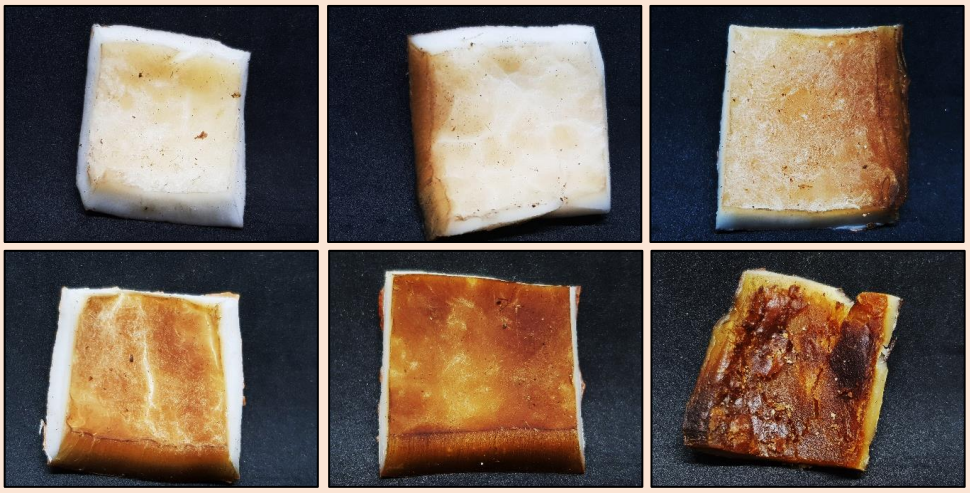

Figure 1. Images of copra from undried to overdried (from upper left to lower right)

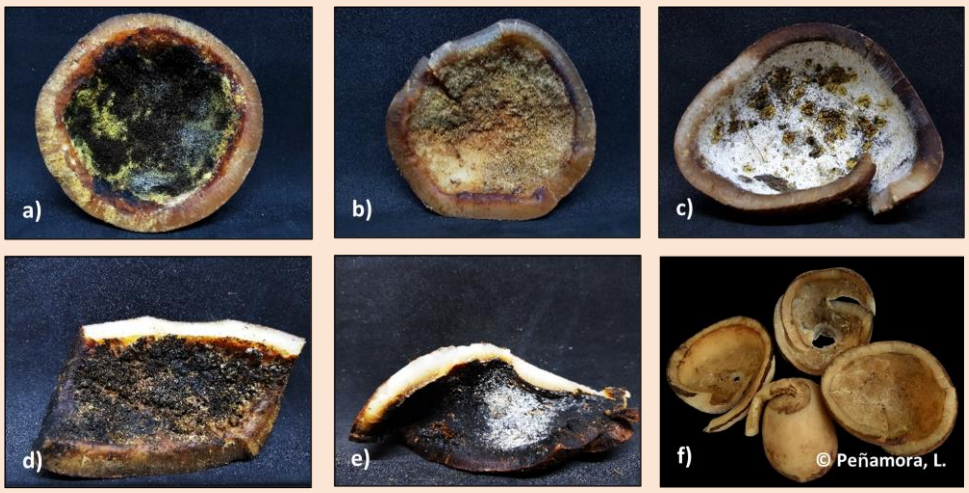

Figure 2. Copra defects: a-c) *Aspergillus* contamination, d) penetrating mold, e) sooty molds, and f) rubbery copra

Adverse Health Effect in Human

Aflatoxin contamination

Among the widely known types of aflatoxins (B1, B2, G1 and G2), aflatoxin B_1 is the most toxic and potent carcinogen for both humans and animals. Meanwhile, its metabolite form, aflatoxin M_1 may occur in meat, milk, and other dairy products because of the consumption of aflatoxin B_1- contaminated feed by farm animals [8, 16].

Ingestion of large doses of these toxins can cause both acute and chronic toxicities. The toxins particularly cause acute poisoning to the liver (e.g., aflatoxicosis, hepatitis, and liver fibrosis), and may cause damage to the kidney, immune system or the circulatory system [8, 16].

Aflatoxins have also been found to be genotoxic. The toxins can induce DNA damage, gene mutation, chromosomal defects, and cell transformation in mammalian cells in vitro [8, 16]. Several animal studies were carried out to determine its carcinogenicity and genotoxicity[26-31].

In 2001 and 2003, the EU, through its regulation (Regulation 466/2001) and directive (Directive 2002/32), established and set the maximum levels of aflatoxin contaminants in milk and other dairy products, and copra meal to 0.05 ppb and 20 ppb, respectively [9, 32].

Exposure to PAHs

Dietary source is the major exposure route for humans. In a study by Rengajaran et al. (2015), food consumption was found to be the cause of more than 70% of PAH exposure in non-smokers. [33, 34]. Due to its high solubility and lipophilic nature, PAHs are easily absorbed in fats and bind to cell membranes causing structural changes and interference with normal functions occur in cells. It accumulates in tissues and organs, such as the liver and small intestines, affecting the normal organ process [35, 36].

PAHs can cause immunosuppressive, carcinogenic, and mutagenic effects to human health. Its toxicity to humans depends on the length and mode of exposure. Skin and eye irritation, nausea, vomiting, and inflammation are some of the short-term side effects, whereas long-term side effects due to chronic exposure include skin, lung, bladder, and gastrointestinal cancers, as well as kidney and liver malignancies. Genetic mutations, cell damage, and cardiopulmonary-related issues were also some of the severe effects reported [37-39].

Among the major PAHs, benzo[a]pyrene (BaP) is considered as the most easily solubilized by lipids, which makes it the most carcinogenic [35]. In 2005, the EU, through its Commission Regulation No. 208/2005, set the maximum level for BaP in oils and fats to 2 ppb [40].

Mitigating Measures

To produce safe and good quality copra, the following measures are recommended for the on-farm and off-farm production and handling of copra [13, 14, 18, 41]:

Harvesting

1. Harvest mature coconuts which are approximately 10 months old or when the husks start to change color from green to brown (*i.e.,* color break). Mature coconuts are easier to dry, and the resulting copra will be hard enough to avoid mold and insect infestation. An interval of 45 days between harvesting mature coconuts should be followed.
2. In case of immature coconuts (segundas or terceras), season the coconut for two (2) to three (3) weeks after harvesting. Seasoning of immature coconuts lessens the production of 'copra goma' or soft and rubbery copra, thus, reducing the susceptibility of copra to deterioration.

3. Avoid placing newly harvested coconuts in direct contact with the soil to lessen the possibility of pest infestation and subsequent germination.

Husking and splitting

1. Husking and splitting of coconuts should be done in a clean and dry area or cemented floor while using clean tools, equipment, and materials to avoid microbial contamination.
2. If splitting cannot be carried out immediately after husking, the husked coconuts should be covered with husks, leaves or fronds to prevent cracking due to direct sun exposure. Cracks or openings serve as entry points for insects and other organisms that can initiate meat spoilage.
3. Newly split coconuts should be placed in a clean and dry pavement or in a relatively drier area using appropriate underlays to protect from direct contact with soil. Clean suitable containers or baskets may also be used to contain split nuts.
4. Coconuts that show visible signs and symptoms of insect infestation or microbial contamination should be sorted out and discarded. Proper disposal of discarded coconuts is done by placing them in a compost pit away from the production, drying and storage areas.

Drying

1. For solar drying of copra, splitting operation should be done within four (4) hours and should be done early in the morning. Freshly split coconut should be dried immediately in a clean pavement with appropriate underlays. Fungal or microbial growth will set in on the meat surface when drying is delayed.
2. Copra should be dried uniformly to 6% moisture content.
3. If direct smoke copra dryer or 'tapahan' is used for drying, dry combustible farm waste materials should be used as fuel. The fuel feeding should be regulated to prevent overheating, which will likely affect the quality of the meat.
4. In 'tapahan', maintain the drying temperature at 35°C to 50°C for the first 16 hours, after which, sustain the temperature at 50°C until the final moisture content of 6% is reached. Through this method, occurrence of case hardening in copra caused by trapping of moisture inside the copra tissues due to high drying temperature is prevented.
5. For efficient drying of copra, follow the recommended standard operating procedure (RSOP) of copra dryers.
6. Hot air dryers produce high quality grade copra. Hot air dryers prevent direct exposure of fresh coconut meat to fire since these

utilize heat exchangers to transfer the heat energy from the firing chamber to the drying chamber. These dryers produce dried copra that is white, clean, and free of smoke, molds, and dirt.

7. Mixing dried copra with wet or undried copra or any foreign matter should be avoided.

Packing/bagging, storing and transport

1. Prior to packing or bagging for storage, allow copra to cool off. Sort out copra that show visible defects (e.g., goma).
2. Immediately after drying, dried copra should be placed in clean and suitable containers and moved to a suitable storage or processing area.
3. When storing loose or unsacked copra, the product should be stored in a clean, dry and well-ventilated bodega. For bagged copra, uniform piling inside the warehouse should be observed to allow good ventilation.
4. To avoid copra moisture accumulation during storing and transport, copra should be properly stacked in pallets inside the transport vehicle and covered with tarpaulin sheets.
5. The storage structure should be made of durable materials and able to withstand strong winds, rain and earthquakes. It should be situated in areas where there is no flooding. The design of the warehouse should:
   a) prevent re-wetting of copra;
   b) prevent entry of insects, birds and rodents; and
   c) provide good ventilation to the stored copra.
6. Observe the first-in- first-out (FIFO) principle. Newly delivered copra should not be mixed with those previously stored. Copra with more than 12% MC should be re-dried immediately.
7. Maintain the MC of copra at 6 % to 7 % at all times to prevent the growth of *A. flavus* and *A. parasiticus*.
8. Maintain cleanliness of the storage facility to prevent insect and rodent infestation.
9. Measure the temperature of the stored copra regularly. A temperature rise may indicate microbial growth and/or insect infestation.
10. Copra should be visually checked for evidence of mold growth. Infected portions should be separated, and may be subjected to aflatoxin analysis, if possible.

	Record keeping and documentation 1. All activities in the production, harvesting and postharvest operations including the environmental conditions during each activity should be documented. 2. For identification and traceability, the date of collection or delivery of copra in bulk or in bags from different origins should be handled separately and kept separated, until the final processing and packaging. **General recommendation** 1. All personnel involved in copra production should be regularly trained for proper personal hygienic and sanitary practices that must be implemented at all stages of production.
Researchers/ Editors	Researcher: Jan Vincent DR. Tecson Editors: Vivencio R. Mamaril, PhD Mary Grace R. Mandigma Bureau of Agriculture and Fisheries Standards
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