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"DEVELOPMENT OF POWDERED ROBUSTA COFFEE (*COFFEA CANEPHORA*) PERICARP"

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Abstract : The coffee growers from the upland municipalities of the province of Ilocos Sur in the Philippines are being recognized for developing market-driven Robusta coffee products. Along with the production of marketable Robusta coffee products is the yield of heavy waste disposal of coffee pericarps without proper treatment. This study aimed to develop powdered Robusta coffee (Coffea canephora) pericarp by experimenting in collaboration with the associations of coffee growers and processors from the upland municipalities of Ilocos Sur, Philippines including Quirino, Gregorio del Pilar, San Emilio, Sigay, and Suyo. Furthermore, this study determined the level of acceptability, nutritional value, and shelf life of powdered Robusta coffee pericarp. Fifteen coffee growers used scoresheets to evaluate the sensory attributes of the research product. The weighted mean of evaluators' scores was calculated to determine the level of acceptability of the research product in terms of aroma, texture, and color. A sample of the research product underwent laboratory testing at SGS Philippines to determine its nutritional value. To determine its shelf life, a real-time stability test was performed by the researcher. The results of this study confirmed that powdered Robusta coffee pericarp offers sensory qualities that could be used to create novel food and beverage products. The nutritional analysis has several nutritional claims including carbohydrates, fiber, calories, sugar, protein, and fat. Moreover, Robusta coffee pericarp can be stored at room temperature for five weeks in a sealable pouch bag.

***IndexTerms* - Robusta coffee, coffee pericarp, acceptability, nutritional value, shelf life**

I. INTRODUCTION

The trend of coffee shops and cafes in urban communities and in developing communities in the Philippines indicates great potential for coffee farming and coffee processing industries. Traditionally, attention has been concentrated on the beverage itself, but current waste valorization and sustainability initiatives have generated curiosity about the possible use of coffee by-products such as coffee pericarp in food and beverage production.

In coffee processing, the main by-product being discarded is the coffee husk or pericarp which is composed of dried skin, pulp, and parchment. By dry weight, it makes up around 12% of the coffee fruit. One ton of fresh coffee fruits yields about 0.18 tons of husks, which can be used to make 150–200 kg of commercial green coffee (Blinová et al., 2017). The pericarp represents a lot of biological material but is frequently thrown away during coffee processing. Nowadays, coffee by-products, specifically coffee pericarps, go out for heavy waste disposal without proper treatment, since they are often considered unusable or of negligible value. This manifests that developing a product by maximizing coffee pericarps will serve significance in coffee farming and coffee processing industries.

Several studies have tested the nutrition compounds present in coffee pericarp. Proximate analyses performed on dried coffee pulp or pericarp revealed that it contains a total digestible nutrients (TDN) value of 63.8%, 18% crude protein (CP), and 33.6% crude fiber (CF) (Núñez et al., 2015). Research findings indicate that the inclusion of coffee husk or coffee pericarps in food formulations has a positive impact on human health. Coffee husk, according to Janissen and Huynh (2018), is high in polyphenols, caffeine, tannins, pectin, and carbohydrates, mostly mono and disaccharides.

According to Hernández et al. (2023), coffee husk powder that has been ground into flour may be utilized as a source of beneficial compounds in food items. It is abundant in crude fiber (13.94 g/100 g d.s.), ash (7.86 g/100 g d.s.), and proteins (8.3 g/100 g d.s.). Excellent qualities were the flour's ability to retain oil and water (2.41 g/g ds and 1.37 g/g d.s., respectively), to swell (9.72 g/g d.s.), and to dissolve (44.7%). These records show that the underutilization of coffee pericarp represents a lost opportunity for waste reduction and the creation of innovative food additives or components.

There are numerous varieties of coffee, and each has distinct flavors and qualities of its own. One of the most widely used varieties is Robusta coffee. Robusta or Coffea canephora as it is officially named, is a highly prized coffee variety that is used to make various espresso and instant coffee blends because of its strong caffeine concentration and strong flavor. This variety of coffee can produce a rich and distinct flavor based on factors including growth conditions, processing procedures, and roasting processes.

Global production of Robusta yielded 74.2 million bags (60 kg each) in the 2022–2023 coffee year. Asia & Oceania remained the largest producer regions of Robusta coffee with 42.9 bags of coffee production. At an individual country level, Vietnam is the world's largest producer of Robusta coffee with 27.8 million bags production in the coffee year 2022-2023 (International Coffee Organization (ICO), 2023).

In the Philippines, Robusta was the most widely produced coffee bean in 2019 with 69% of the coffee beans production. Espresso and instant mixes are its primary uses (Vi, 2020). This coffee variety is also known as "kapeng manipis".

In recent years, the upland municipalities of the province of Ilocos Sur have been receiving multiple awards in the Philippine Coffee Quality Competition (PCQC) organized by Department of Trade and Industry (DTI), together with the Department of Agriculture (DA), Barista and Coffee Academy of Asia, Inc. (BCAAI), the Agricultural Cooperative Development International (ACDI), Volunteers in Overseas Cooperative Assistance (VOCA), and the Philippine Coffee Guild (PCG). Coffee is now one of the priority industries supported by DTI in Region 1. In the sixth year of PCQC which is held on June 4, 2023, the best coffee growers from the municipalities of Sigay and Gregorio del Pilar, Ilocos Sur bagged ten (10) out of twelve (12) top awards for the fine Robusta coffee category (Adriano 2023). It can be recalled that the province of Ilocos Sur started joining the competition in 2018 where a coffee grower from the municipality of Quirino placed first, and third in 2019. In the same category, a coffee grower from the municipality of Sigay claimed the top spot twice in 2021 and 2022 (Villanueva, 2023). This signifies that big market opportunities await Ilocos Sur's Robusta Coffee or Coffea Canephora.

According to the Philippine Statistic Office- Region 1, Ilocos Sur became the region's top coffee producer in 2021, accounting for 44.10 percent of the total output with 68.51 metric tons. Upland municipalities of Ilocos Sur have developed coffee farms capable of supplying commercially viable Robusta coffee products. The coffee processing centers in the upland municipalities of Ilocos Sur aid in the production of market-ready coffee powders. This indicates that a significant amount of coffee waste, such as coffee pericarps, is also produced in these municipalities.

II. NEED OF THE STUDY.

The twelfth Sustainable Development Goal of the United Nations, "Responsible Consumption and Production," can be addressed by reducing agricultural byproducts like Robusta coffee pericarps and turning them into a valuable food product. Additionally, it is consistent with the 12.3 target, which aims to reduce food losses along production and supply chains, including post-harvest losses, and halve per capita global food waste at the retail and consumer levels by 2030 (The Global Goals, 2023). To reduce coffee waste, the coffee industry requires management strategies. This comprises waste reduction and environmental impact reduction measures. There may also be a chance for the community to benefit economically from this.

The community must be informed about strategies to reduce coffee waste and turn it into worthwhile products that can be marketed commercially in addition to the financial benefits of mass coffee production. Utilizing coffee waste for product development can also make the most of the government-provided machinery; its utility will extend beyond only manufacturing the things it is accustomed to generating. Opportunities to create new, strongly community-rooted products may also arise from this.

The potential of innovating a product by utilizing Robusta coffee pericarp has motivated the researcher to explore means to maximize coffee by-products and machinery available in the locality. The researcher aspires to pave the way for more marketing opportunities for local coffee growers and manufacturers.

III. RESEARCH METHODOLOGY

This chapter presents the materials, methods, research design and treatments, experimental procedure, data gathering instrument, and statistical analysis used in the study.

3.1Population and Sample

In the selection of participants who participated in the sensory evaluation of powdered Robusta coffee pericarp, purposive sampling was observed. Participants are fifteen (15) members of the different associations of coffee growers and coffee processors in the upland municipalities of Gregorio del Pilar, Quirino, San Emilio, Sigay, and Suyo. These associations include Tirad Pass Food Processors Association (TPFPA); Quirino, Ilocos Sur Farmers Multi-Purpose Cooperative (QISFMPC); San Emilio Coffee Producers, Inc. (SECOPI); Sigay Coffee Growers Agrarian Reform Cooperative (SCGARC); and BBL (Botigue Bangcag Longboy) Coffee Growers Association (BBLCGA).

Four hundred fifty grams (450 g) of powdered Robusta coffee pericarp sample was brought to SGS Philippines located at 2229 Chino Roces Avenue, 1231, Makati, Metro Manila to test its nutritional value. The same amount of sample was stored in a sealable stand-up pouch bag for the stability test that would determine the shelf life of the research product.

3.2 Data and Sources of Data

Powdered Robusta coffee (Coffea canephora) pericarp was prepared and replicated in adherence to the established protocols of coffee manufacturers; ensuring data integrity; and considering sample variability and measurement accuracy. Clear records and documentation of the entire process were kept for transparency and reproducibility.

To measure the level of acceptability of the samples, scoresheets were used. These were utilized in the sensory evaluation which allowed participants to rate the samples to their level of liking or satisfaction. Scoresheets were crafted by the researcher and validated by food experts.

Since the municipalities of Quirino, San Emilio, Gregorio del Pilar, Sigay, and Suyo are home to coffee growers, information regarding the acceptability of powdered Robusta coffee pericarp was obtained from these locations. Since they are directly involved in the manufacturing of coffee, participants from these locations are aware of consumer preferences.

The scoresheet was validated by three food experts. The calculated S-CVI (scale-level content validity index) based on the I-CVI (item-level content validity index) has an average of 1. The S-CVI/UA (scale-level content validity index based on the universal agreement method) obtained a similar value which is 1. These results indicate that the scale of the scoresheet has achieved a satisfactory level of content validity.

The acceptable content validity index of content validation with three to five experts should be 1. Content validity is the degree to which a measuring tool accurately captures the construct being assessed, and it is regarded as crucial evidence to back up the reliability of a measurement tool like a study instrument (Polit & Beck, 2006 & Polit et al., 2007).

A sample which is four hundred fifty grams (450 g) of the target product was brought to SGS Philippines for analytical testing of its nutritional content, including but not limited to fiber, calories, carbohydrates, fats, and sugar. Reports on the nutritional data were presented in tables.

The shelf life of powdered Robusta coffee pericarp was analyzed by conducting a real-time stability test. Conducting this test requires a product to be observed and kept under suggested storage circumstances until it deviates from the specification. Testing needs to be done at time intervals that exceed the intended shelf life and continue for some time after the product falls below specifications (Magari, 2020).

3.3 Theoretical framework

"Development Of Powdered Robusta Coffee (Coffea canephora) Pericarp" is built upon existing theories and concepts.

A key theoretical concept that underpinned this study is the idea of sustainable agriculture which was introduced by the United States Department of Agriculture. Sustainable agriculture supports comprehensive, data-driven, science-based, and creative problem-solving techniques that facilitate the development of more sustainable agricultural and food systems, including through sustainable productivity growth (U.S. DEPARTMENT OF AGRICULTURE, 2023). From that point, this concept can explore opportunities to minimize waste and increase the value of pericarp or by-products of coffee production.

A system of regeneration known as the "circular economy" for food tries to maximize resource utilization to reduce waste. Its goal is to minimize waste and maximize product life across the supply chain in a closed loop. Recycled organic waste, such as crop leftovers, animal manure, and food scraps, prevents pollution, lessens waste accumulation, and maintains essential nutrients (TraceX, 2023).

The theoretical foundation of this study is rooted in the concepts of Roger's diffusion of innovations which is known as the process by which an idea or product develops popularity and diffuses or spreads through a particular population or social system over time. This happens when someone believes that a product is novel or innovative (LaMorte, 2022). "An idea, practice, or object perceived as new by an individual or another unit of adoption" is what is referred to as an innovation. The five characteristics of an innovation that impact its uptake are trialability, observability of the innovation's development, complexity to implement, compatibility with the organization's workflows and knowledge, and relative advantage over current technologies (Roger as cited by Weil, 2018).

The chemical makeup of the end product of this study including processing, quality assurance, and contamination of the materials needed can all be thoroughly explained using analytical chemistry techniques. Food and drink products' characteristics and control variations are monitored during processing using analytical chemistry. Additionally, by examining raw materials, it is frequently able to forecast how they will behave when processed, allowing circumstances to be changed to yield the required qualities (Marlin, 1980). Analytical techniques can reliably detect allergens and even low levels of harmful materials on products.

Analytical chemistry is a valuable tool that is integrated into improving the properties and authentication of the research product. This is commonly used in studies concerning organic foods and protected designations of origin. It can also be used to produce novel products and conduct systematic analyses of contaminants or additives in food produced for export to other countries or domestic consumption. As a result, food producers, consumers, and policymakers must develop tools that are precise, sensitive, accurate, and selective to quickly control a wide range of food parameters (Coelho et al., 2016). Application of this concept in the development of robusta coffee powder can lead to the production of novelty products.

This study also incorporated the principles of food rheology of Reiner and Bingham. Food rheology is described as the study of deformation and flow in the raw materials, intermediate products, and final products used in the food industry. A food system's rheological characteristic depends on its components or the ingredients of the system. Rheological data is needed in the different areas of the food industry such as determining ingredient functionality in product development; intermediate and final product quality control; and predicting final product performance and consumer acceptance (Adebowale, 2012).

One theoretical perspective that was applied in this study is the philosophy of sensory science (Martens, 1999). The measurement, interpretation, and comprehension of human reactions to product attributes as perceived by the senses- such as sight, smell, taste, touch, and hearing- are all part of the multidisciplinary area of sensory science. A philosophy of sensory science is largely dependent on the theoretical and empirical work of numerous experts. In a world that is changing quickly, one common goal is to raise awareness of how humans react to food.

Experiments involving sensory evaluation primarily use three types of testing. One way to find out if there is a difference between samples is to apply "discriminative tests". To determine which sensory aspects of a product are significant and to provide details on the degree or strength of those aspects, "descriptive tests" are utilized. Based on the sensory qualities of a product sample, "hedonic" or "effective" tests are performed to gauge how much a panelist enjoys it (Howes, 2015).

Sensory analysis is an interdisciplinary science that measures the sensory qualities and acceptability of food products using a variety of materials, including the variance in individual sensory response experimental design and human panelists' sensory perception related to limitations of determination of attributes. Any food study must include a sensory evaluation component since no single device can fully capture or replace the human psychological and emotional reaction. Additionally, the significance of sound experimental design cannot be overstated in studies using senses (Singh-Ackbarali and Maharaj, 2014).

Sensory evaluation analysis included inspection of the quality attributes of the product such as appearance, flavor, aroma, texture, and sound. The first quality that humans notice in an object is its appearance, which is crucial for identifying and choosing the food. This is the way that color, shape, size, gloss, dullness, and transparency are perceived visually in food. Flavor is a sensory phenomenon that is represented by the terms taste, mouthfeel, and odor. Taste perception comes in four flavors: sweet, salty, sour, and bitter. Aroma is a volatile substance that can be detected by the olfactory tissues in the nasal cavity. Smell evaluates a food's aroma, which is significant for appreciating flavor. It is useful for identifying food that is fresh, rotten, or occasionally toxic. Texture is perceived by a combination of senses which is the most important aspect of food. Food's texture, density, softness, chewiness, and the size and arrangement of its constituent parts are all included. Meanwhile, sound is perceived by hearing when food is being prepared and consumed (Sharif et al., 2017).

3.4Statistical tools and econometric models

Ratings of the evaluators during the sensory evaluation were analyzed by calculating the mean to determine the level of acceptability of the research product across aroma, texture, and color attributes..

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IV. RESULTS AND DISCUSSION

4.1 Level of Acceptability of Powdered Robusta Coffee Pericarp

Table 4.1: Level of Acceptability of Powdered Robusta Coffee (Coffea canephora) Pericarp in Terms of Aroma, Texture, and Color

Criteria	Weighted Mean	Description	Interpretation
Aroma	8.20	LE	product has an extremely pleasant quality
Texture	7.93	LVM	product is a medium-fine grind
Color	7.20	LM	product is moderately dark brown
General Weighted Mean	**7.78**	**LVM**	

Legends: LE- Like Extremely LVM- Like Very Much
LM- Like Moderately

Indicators in Evaluating the Aroma

Statistical Limit	Description	Interpretation
8.12 - 9.00	like extremely	product has an extremely pleasant quality
7.23 - 8.11	like very much	product has a very pleasant quality
6.34 - 7.22	like moderately	product has a moderately pleasant quality
5.45 - 6.33	like slightly	product has a slightly pleasant quality
4.56 - 5.44	neither like nor dislike	product has a neutral quality
3.67 - 4.55	dislike slightly	product has slightly unpleasant quality
2.78 - 3.66	dislike moderately	product has moderately unpleasant quality
1.89 - 2.77	dislike very much	product has a very unpleasant quality
1.00 - 1.88	dislike extremely	product has extremely unpleasant quality

Indicators in Evaluating the Texture

Statistical Limit	Description	Interpretation
8.12 - 9.00	like extremely	product is a fine grind
7.23 - 8.11	like very much	product is a medium-fine grind
6.34 - 7.22	like moderately	product is a medium grind
5.45 - 6.33	like slightly	product is a medium-coarse grind
4.56 - 5.44	neither like nor dislike	product is a coarse grind
3.67 - 4.55	dislike slightly	product is a coarse grind with few lumps
2.78 - 3.66	dislike moderately	product has a sandy texture with lots of lumps
1.89 - 2.77	dislike very much	product is granulated
1.00 - 1.88	dislike extremely	product is unground nor granulated

Indicators in Evaluating the Color

Statistical Limit	Description	Interpretation
8.12 - 9.00	like extremely	product is dark brown with consistent color distribution
7.23 - 8.11	like very much	product is a dark brown with inconsistent color distribution
6.34 - 7.22	like moderately	product is moderately dark brown
5.45 - 6.33	like slightly	product is slightly dark brown
4.56 - 5.44	neither like nor dislike	product is a mixture of slightly dark brown and light brown
3.67 - 4.55	dislike slightly	product is slightly light brown
2.78 - 3.66	dislike moderately	product is medium brown
1.89 - 2.77	dislike very much	product is very light brown
1.00 - 1.88	dislike extremely	product takes the color of raw or burnt coffee husks

Indicators for the Overall Acceptability

Statistical Limit	Description
8.12 - 9.00	like extremely
7.23 - 8.11	like very much
6.34 - 7.22	like moderately
5.45 - 6.33	like slightly
4.56 - 5.44	neither like nor dislike
3.67 - 4.55	dislike slightly
2.78 - 3.66	dislike moderately
1.89 - 2.77	dislike very much
1.00 - 1.88	dislike extremely

The data on the level of acceptability of powdered Robusta coffee (Coffea canephora) pericarp in terms of aroma, texture, and color is shown in Table 1. In this study, aroma refers to the smell characteristic or fragrance associated with powdered Robusta coffee pericarp. It can be gleaned from the table that aroma has a weighted mean of 8.20, indicating that the powdered Robusta coffee pericarp was liked extremely by evaluators for its extremely pleasant quality. The result on the level of acceptability of powdered Robusta coffee (Coffea Canephora) pericarp in terms of aroma surpassed the 2.8 rating value of coffee husk or cascara-based beverage in the study of Jarić et al. (2021) that was also evaluated with 9-point Hedonic scale. In terms of aroma profile, there is a similarity between the two research products. The product produced by the previous study which is a coffee husk or cascara-based beverage was associated with fruity, sweet, citrus, and roasted nuts, meanwhile, cherries that are used in the development of powdered Robusta coffee pericarp underwent fermentation to achieve a powdered product with a strong, delicate, and fruity aroma.

The level of acceptance of powdered Robusta coffee pericarp in terms of aroma is consistent with what has been discovered by Ridwan and Novison (2018) that the most significant roasting parameter that can improve the aroma of roasted coffee is temperature. In the preparation of the sample used in this study, the roasting temperature for coffee beans was set to a lower temperature since dried coffee pericarps have a lighter density compared to coffee beans. Adjustment was made to the roasting temperature to achieve the delicate and fruity aroma. If the roasting temperature for coffee beans was adapted to roasting coffee pericarp, they can smell burnt which is an unfavorable factor that can affect the sensory quality acceptance of the product.

Table 1 likewise presents the level of acceptability of powdered Robusta coffee (Coffea canephora) pericarp in terms of texture. Texture is the physical characteristic of powdered Robusta coffee pericarp that affects its structure and consistency. The table shows that the evaluation of the sample in terms of texture has a weighted mean of 7.93. The result points out that the product was liked very much by the evaluators for its medium-fine grind texture. The result is attributed to the usage of sieving material with a 0.045 mm opening size in preparing the sample. The ratings of evaluators on the texture of the sample attest that the finer the pericarp grounds are, the higher the level of acceptance it will receive. The evaluated sample is about to receive the highest possible rating for texture since the sample almost takes the finest grind texture.

The findings on the level of acceptability of powdered Robusta coffee (Coffea canephora) pericarp in terms of texture are also consistent with a study by Rizkaprilisa et al. (2023) that investigated the acceptability and possible application of Robusta coffee silver skin in bread. The physical characteristic of the bread was more yellowed by silver skin, but its texture did not change. In this study, silver skin flakes are visible in the powdered Robusta coffee pericarp with their yellowish color, but the texture of the research product was not significantly affected based on the favorable average ratings of evaluators.

The level of acceptability of powdered Robusta coffee (Coffea canephora) pericarp in terms of color was also presented in Table 1. In this study, color is perceived as the visual structure of powdered Robusta coffee pericarp that affects its visual appeal or presentation. The table shows that the evaluation of the sample in terms of color has a weighted mean of 7.20, indicating that the sample was liked by evaluators moderately. The result also denotes that the evaluators described the product as moderately dark brown.

The assessment of the color of powdered Robusta coffee (Coffea canephora) pericarp supports the findings of Guglielmetti et al. (2019), which emphasized the feasibility of using coffee husk and silver skin together as a natural colorant. However, the current finding is inconsistent with earlier findings that showed appearance or color to be the most valued or highly rated parameter of the coffee husk product.

Having alterations in the roasting temperature leads to variations in the color of powdered coffee pericarp. The lower the temperature to be observed in roasting, the lighter the color of the powdered pericarp will be achieved. The higher the temperature to be observed in roasting, the darker color of the powdered pericarp will be achieved. The sample used in the evaluation was roasted for 15 minutes with a temperature ranging from 100°C to 120 °C. The color of the evaluated sample is relatively like the color of some commercially available medium-roast instant coffees.

As to the overall acceptability of powdered Robusta coffee (Coffea canephora) pericarp, data show that it has a general weighted mean of 7.78. This signifies that the overall quality of the product was liked very much by the evaluators. This result has not confirmed the previous study of Poláková et al.,(2023) on the sensory acceptability and qualitative characteristics of several botanical coffee co-products denoting that none of the samples of cascara or coffee husk and silverskin from Coffea arabica and Coffea canephora are well accepted by evaluators. It is plausible that a few limitations could have affected the difference in the results obtained such as geographical composition, post-harvest processing, and even technological processing of the specified items.

4.2 Nutritional Value of Powdered Robusta Coffee Pericarp

Table 4.2: Nutritional Analysis of Powdered Robusta Coffee (Coffea canephora) Pericarp

Name of Analysis	Value	Methodology
Ash	6.88 g/100 g	Gravimetric Method (QLY-LAB-1153 REV1)
Crude Protein (N x 6.25)	8.71 g/100 g	Kjeldahl Method (QLY-LAB-1201 REV2)
Moisture	2.22 g/100 g	Gravimetric Method (QLY-LAB-1202 REV 4)
Crude Fat	0.68 g/100 g	Acid Hydrolysis and Gravimetric Method (QLY-LAB-11147 REV2)
Total Dietary Fiber	60.84 g/100 g	Enzymatic-Gravimetric Method (QLY-LAB-1208 REV 1)
Calories from Carbohydrates	326.04 kcal/ 100 g	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)
Calories from Fat	6.12 kcal/ 100 g	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)
Calories from Protein	34.84 kcal/100 g	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)
Total Calories	367.00 kcal/100 g	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)
Total Carbohydrates	81.51 g/100 g	By Computation from Proximate Analysis (Philippine Food Composition Tables 2019)
Total Sugar	11.57 g/100 g	High Performance Liquid Chromatography- Refractive Index Detector (QLY-LAB-1148 REV0)

The nutritional value of powdered Robusta coffee (Coffee canephora) pericarp tested in different parameters and methodologies is presented in Table 2. The values of tested substances are expressed in grams and kilocalories. Other chemical substances such as ash and moisture were tested to identify the nutritional value of the research product.

The ash content of the sample tested in this study, which was quantified by the Gravimetric Method (QLY-LAB-1153 REV1), has a value of 6.88 g/100 g. This result is close to the finding of Romauli et al. (2023) indicating that Robusta cascara has an ash value of 5.48% and the finding of Machado et al. (2023) denoting that coffee husk has 7.86% dw ash. Meanwhile, the Gravimetric Method (QLY-LAB-1202 REV 4) conducted in this study revealed that the moisture content of powdered Robusta coffee pericarp has a value of 2.22 g/100 g.

As Abdullah et al. (2020) reported, maintaining a dry powder's moisture level below 5% is necessary in the food industry to extend product shelf life. Controlling a powder's moisture level is essential to producing a stable product with extended shelf life. The recently discovered moisture content of powdered Robusta coffee pericarp appears to be a component that may contribute to the product's longer shelf life. The result however does not appear to corroborate with what had been discovered by Romauli et al. (2023) indicating that cascara powder of dehydrated Robusta coffee pulp or pericarp has 8.66% moisture content and the literature study of Bondesson (2015) pointing out that coffee husk has 13.0% moisture content. These varied results findings that methods of processing coffee husk powder can affect the product’s moisture content.

According to Ismail (2017), one crucial quality trait for food ingredients is the amount of ash in the food, which may be found by proximate analysis in nutritional evaluation. The initial stage in preparing a sample for a particular elemental analysis is also called ashing. On the other hand, Vera Zambrano et al. (2019) reported that food items' moisture content significantly impacts storage quality, which lowers post-harvest loss and is crucial for farmers. One of the main causes of food deterioration is microbial development which is correlated with moisture. Food items' moisture content significantly impacts dehydration or drying. This issue can be solved by lowering the moisture content that encourages microbial growth. Anggarani et al. (2019) added that products with lower water content have higher stability and better quality which can be further enhanced through storage. In contrast, the potential of mineral content increases with ash levels.

The table shows that the nutrient with the highest value in powdered Robusta pericarp is carbohydrates with a value of 81.51 g/100 g. Holesh (2023) asserted that carbohydrates are macronutrients needed by the body for several functions. They help with fermentation, serve as an energy source, and have a role in the metabolism of triglycerides and cholesterol as well as blood sugar and insulin. The value of carbohydrates in the sample is quantified by Proximate Analysis (Philippine Food Composition Tables 2019) or by deducting the total value of ash, crude protein, moisture, and crude fat from the load of the sample which is 100 g.

The new finding about the carbohydrate content of powdered Robusta coffee pericarp validated the study result of Blinová et al. (2017) emphasizing that coffee husk residue is primarily composed of 58–85% carbohydrates and is a possible functional element in the food industry. This result also reaffirmed the investigation of Muzaifa et al. (2021) denoting that coffee pericarp or husk, primarily composed of pulp, parchment, and outer peel has 35–85% carbohydrates.

As demonstrated in Table 2, Total Dietary Fiber, which was measured using the Enzymatic-Gravimetric Method (QLY-LAB-1208 REV 1), is another nutrient with a significant content. Its value is 60.84 g/100 g. Marengo & Gunnars (2023) identified dietary fiber as a type of carbohydrate that is non-digestible. Fermentable fiber not only feeds gut bacteria but also produces short-chain fatty acids that support the wall of the colon. Furthermore, viscous, soluble fiber may lessen blood sugar rise after high-carb meals, cut cholesterol, and reduce starvation.

The total dietary fiber content measured in powdered Robusta coffee pericarp bears a resemblance to the nutritional value comparison of dried coffee pulp published by Romauli et al. (2023). It was reported that dehydrated coffee pulp contained 40.84% insoluble dietary fiber, 9.46% soluble dietary fiber, and 5.63% crude fiber. The report on the total dietary fiber content of powdered Robusta pericarp found a higher value compared to the analysis of Machado et al. (2023), which found that coffee husk contains 39.04% dw of total dietary fiber. The result of the study proposed the idea of consuming high-fiber foods and supplements to protect people's health from the risks of diabetes, obesity, hypertension, cardiovascular disease, and gastrointestinal disorders.

A High-Performance Liquid Chromatography-Refractive Index Detector (QLY-LAB-1148 REV0) was used to measure the sample's total sugar content. The data indicates that the Robusta coffee pericarp powder has a sugar level of 11.57 g/100 g. The value does not seem to confirm the claim of Bondesson's (2015) claim that coffee husk contains 22.8% sugar. However, Pérez et al. (2023) reported in their research that fructose, glucose, and sucrose are the principal free sugars found in coffee fruits. The pericarp and the seeds become more sugar rich as the fruit ripens; sucrose can make up 73% of the total sugar in a seed. These findings support Abdulhameed's (2018) study, which found that coffee husks include lipids, polyphenols like tannins, and carbohydrates like fermentable sugars.

The sample's crude fat content is 0.68 g/100 g. Acid Hydrolysis and Gravimetric Method (QLY-LAB-11147 REV2) were used to quantify the outcome. According to Sarmila (2023), crude fat is the total amount of fat present in a sample of food or feed. One of crude fat's main purposes in the body is energy production. With more than twice as much energy per gram as proteins and carbohydrates, fat is a very concentrated energy source. Higher values of coffee husk fat content were determined by earlier studies. Romauli et al., (2023) comparative analysis found that cascara powder, a dehydrated coffee pulp or pericarp from different kinds of coffee has a fat content of 4.24%. Meanwhile, Machado et al., (2023) analysis on the bioactive and chemical composition of coffee byproducts found that coffee husk has 1.06% dw fat.

Additionally, the chart demonstrates that the powdered Robusta coffee pericarp- the sole studied characteristic whose value is stated in kilocalories- is a respectable supply of calories. The Robusta coffee pericarp powder has a total calory value of 367.00 kcal/100 g. Proximate Analysis (Philippine Food Composition Tables 2019) was used to test the outcome. Based on the table, powdered Robusta coffee pericarp's calory from carbohydrates has a value of 326.04 kcal/100 g; calory from fat has a value of 6.12 kcal/100 g; and calory from protein has a value of 34.84 kcal/100 g respectively. The values of total carbohydrates, crude fat, and crude protein lead to the determination of the values of these nutrients.

One gram of carbs has 4 calories, one gram of fat has 9 calories, and one gram of protein has 4 calories. These are the calorie counts of the three main meal components. Human health requires calories, but it's crucial to eat the right amount of them. According to the US government, an average lady requires 2,200 kcal per day, whereas an average man needs 2,700 kcal. Daily calorie requirements vary among individuals. Because everyone has a different metabolism, some people use energy at different rates than others, and some people lead more active lives than others (Bubnis, 2017).

4.3 Shelf Life of Powdered Robusta Coffee Pericarp

Table 4.3: Shelf Life of Powdered Robusta Coffee (Coffea canephora) Pericarp

Interval	Sensory Parameters		
Weeks from the Manufacturing Date	**Aroma**	**Texture**	**Color**
one week	has the distinct aroma of freshly roasted coffee with a fruity smell	it is soft, medium-fine, dry, and not lumpy	moderately dark brown with a few visible silver skins
two weeks	no changes	no changes	no changes
three weeks	no changes	no changes	no changes
four weeks	no changes	no changes	no changes
five weeks	no changes	no changes	no changes
six weeks	the delicate aroma and fruity smell started to fade	no changes	no changes
seven weeks	has a mild aroma	no changes	no changes
eight weeks	has a mild aroma and smells flavorless	a few small lumps started to form	no changes

The analysis of the shelf life of powdered Robusta coffee pericarp is shown in Table 3. The analysis of the shelf life of powdered Robusta coffee pericarp was carried out by conducting a real-time stability test, a shelf-life assessment method proposed by Magari (2020). The real-time stability test requires the product to be observed and kept under suggested storage circumstances until it fails the specifications.

Table 3 presents the observations recorded during the stability testing of the sample. The powdered Robusta coffee pericarp used for the real-time stability test was packed in a sealable stand-up pouch bag and stored at room temperature. Observation of aroma, texture, and color attributes started a week after the manufacturing of the sample. Eight (8) series of observations were conducted with seven - (7) day intervals for each observation.

Observation conducted revealed that the sample didn't show deterioration in its quality such as a noticeable foul odor, discoloration, and clumping within the 5-week observation. The storage conditions were able to retain the distinct aroma of freshly roasted coffee with a fruity smell; the soft, medium-fine, dry, and not lumpy texture; and the moderately dark brown color with a few visible silver skins. Within the 5 weeks of storage, the sample remained consistent with its sensory attributes across aroma, texture, and color.

On the sixth week of the stability test, the delicate aroma and fruity smell started deteriorating, however, there were no changes observed across the sample's texture and color. The same observations were recorded in the seventh week. An additional change was observed on the eighth week of the stability test. The sample had a mild aroma and smelled flavorless; a few small lumps also started to form. There were no changes observed in the color of the sample within the eight weeks of storage.

The procedure that was observed in storing powdered Robusta coffee products shed additional insight into the findings of Turck et al.'s (2022) study, which recommended keeping coffee in tightly sealed containers between 15 and 20°C and 50 and 65% relatively humid. The idea of monitoring the required specifications such as the sensory attributes was also considered in analyzing the product's shelf life. Additionally, the new finding corroborated the research of Hernández et al. (2023), which proposed that coffee husk flour should be stored in a low-humidity environment to minimize spoiling reactions and avoid caking, in addition to being sealed in airtight packaging to prevent gas exchange. In packaging the powdered Robusta coffee pericarp, sealable pouch bags were used to prevent gas exchange and avoid contamination.

The packaging method observed in testing the shelf life of powdered Robusta coffee pericarp proceed very much in the same way as what had been studied by Benkovi (2018) suggesting that triplex packing is more appropriate since triplex bag material is absorbing less moisture. In this study, similar packaging material was used in storing the sample while testing its shelf life.

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