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Characterization of Fiddlehead Fern (Diplazium Esculentum) and Cinnamon Bark (Cinnamomum Cassia) Tea

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ABSTRACT

This research work aims to develop a tea from fern (*D. esculentum*) and cinnamon (*C. cassia*) using a 3x3 factorial design, with fern levels at 2g, 4g, and 6g, and cinnamon levels at 1g, 2g, and 3g. Nine treatments were analyzed for physicochemical properties, including pH (6.18-6.57), total soluble solids (0.83-1.31), water activity (0.661-0.697), moisture content (7.45-13.96%), and color parameters $L*$ (46.73-56.98), $a*$ (13.15-31.54), and $b*$ (44.79-58.26). Both the powder and infused tea were evaluated for total phenolic content, antioxidant activity, and microbial properties. Production costs were calculated, resulting in a product price of ₱507.1 per pack. Sensory evaluation assessed color, aroma, flavor, and aftertaste to determine the most acceptable formulation.

Results of the sensory evaluation revealed that the most acceptable formulation is treatment 3, which has a sensory response of 7.88, equivalent to moderately on the 9-point hedonic scale. pH values were found at 6.18, TSS at 0.96 ˚Bix, having 0.69 water activity and a moisture content of 8.95 %, respectively, are within the acceptable range for tea. Most acceptable formulations have a total phenolic of 44.5 mg GAE/g for infused tea and 38.5 mg GAE/g for the powder while having antioxidant properties of IC50 215.9 µg/L for infused tea and 383.4 µg/g for the powder. This finding recommends that the parameters for making this tea were the combination of 2 grams of fern and 3 grams of cinnamon in 200 mL of water at 70-85°C temperature, infused for 10 minutes.

Keywords: Tea, D. esculentum (*Diplazium esculentum*), C. Cassia (*Cinnamomum cassia*), Physicochemical Analysis, Antioxidant Analysis

INTRODUCTION

Nature and Importance of the Study

Antioxidants protect cells from oxidative stress, a process linked to cell damage and various health issues caused by free radicals. These unstable molecules are produced in response to environmental factors like pollution, UV radiation, and normal metabolic processes. When free radicals accumulate unchecked, they can trigger inflammation and harm tissues (Kıran et al., 2023). Antioxidants act as the body's defense against oxidative stress by neutralizing free radicals and preventing cellular damage. They achieve this through different mechanisms, such as donating electrons to stabilize free radicals and modulating the immune system response (Lobo et al., 2010). Notably, antioxidants are essential for the survival of all living organisms.

Alternatively, tea is known for its various health benefits, which is why it is famous as a staple beverage worldwide. Initially, it is an infusion that was prepared by steeping fermented leaves and twigs of a plant, *Camellia sinensis*, in water or other solvents (Faisal & Nada, 2019). Tea is recognized for its richness in biologically active compounds, particularly total phenolic compounds, which contribute significantly to its health-promoting properties. The levels of phenolic compounds in tea can vary depending on the tea type and processing methods employed. Among the most consumed types globally, black tea ranks as the most prevalent, followed by green tea, oolong tea, and white tea. The study highlighted that the total phenolic content of tea can influence its antioxidant capacity and potential health benefits (Klepacka et al., 2021).

In contrast, herbal teas are distinct as they are not derived from the Camellia plant but rather from dried herbs, spices, flowers, fruits, seeds, roots, or leaves of other plants, notably. Unlike traditional teas, herbal teas generally do not contain caffeine (Loomis et al., 2016). Tea contains antioxidants that can help protect the body against oxidative stress and damage caused by free radicals and has been shown to help manage diabetes and obesity by improving insulin sensitivity and reducing inflammation (Das et al., 2022). Further, tea has been associated with improved mental health, including reduced stress and anxiety levels (Xing et al., 2019).

Meanwhile, various types of ferns have existed, notably here in the Philippines. "Pako" (*Diplazium esculentum*) or fiddlehead fern is the most common edible fern worldwide (Delos Angeles & Buot 2012). Fern possesses significant antioxidant properties as highlighted in various journals. Studies have shown that the plant extract exhibits antioxidant activity through various methods. Additionally, the methanolic extract of D. esculentum fronds displayed promising antioxidant activity with IC50 values of 3.8, 4.6, 0.59, and 2.24 mg/mL for DPPH (Raina et al., 2023). On the other hand, Cinnamon Cassia (*C. cassia*) is a type of cinnamon that has been studied for its potential health benefits, including its antioxidant, anti-inflammatory, antilipemic, antidiabetic, and antimicrobial properties (Kawatar & Rajagopala, 2015). A study by Al et al. (2023) shows that cinnamon had the highest calcium content of 1414.82 mg/100g among the spices ginger, clove, saffron, and cardamon. Nevertheless, the primary utilization of cinnamon lies within the aroma attributed to its captivating fragrance. This scent can be integrated into a diverse range of foods, perfumes, and medicinal items (Huang et al., 2007).

Given the mentioned circumstance, the study aims to formulate a tea from fern (*Diplazium esculentum)* and Cinnamon Cassia (*C. cassia*) and will determine its antioxidants properties, physicochemical analysis, sensory analysis, microbial properties, and production cost.

Objectives of the Study

This study aimed to explore the potential of fern and cinnamon for tea production.

Specifically, the study aimed to:

1. determine the moisture content, water activity, and color of fern-cinnamon powder;
2. determine the pH, and total soluble solids (TSS) of fern-cinnamon tea;
3. evaluate the sensory acceptability of fern-cinnamon tea in terms of taste, aroma, color, aftertaste, and general acceptability;
4. appraise the antioxidant, DPPH scavenging activity, and total phenolic content of the most acceptable fern-cinnamon tea (powder & infusion);
5. assess the microbial property of the most acceptable formulation of fern-cinnamon tea in terms of total plate count, yeast, and molds; and
6. determine the production cost of the most acceptable formulation of fern-cinnamon tea.

Scope and Limitations of the Study

The scope of this study focused on the creation of tea utilizing fern and cinnamon as the main components. The study covered all treatments which undergo physicochemical and sensory analyses. The most acceptable formulation was then subjected to total phenolic content assessment, antioxidant properties, and microbial analysis. However, it is important to note that the study is confined solely to these aspects and does not extend beyond the formulation and evaluation of these tea bags.

Time and Place of the Study

The study was conducted from November 2023 to February 2024 at the College of Human Ecology Integrated Laboratory Building. Other tests were conducted at the Soil and Plant Analysis Laboratory at the College of Agriculture and Natural Products Research and Development Center, Central Mindanao University, Musuan, Maramag, Bukidnon.

REVIEW OF RELATED LITERATURE

Antioxidant Properties in Teas

The antioxidant properties of tea and herbal tea have been extensively studied for their potential health benefits. Green tea, in particular, has been found to possess high antioxidant capacity and total phenolic content. This could be attributed to the minimized oxidation degree of young leaves and the bud due to inactivated enzymes during the steaming process. The antioxidant properties of tea are known to vary greatly depending on factors such as cultivar type, place of production, planting condition, harvesting time, leaf grade, and the manufacturing process (Zhao et al., 2019). Studies have shown that herbal teas formulated based on the concepts of traditional medicine have favorable antioxidant properties and are pleasing to consumers (Tipduangta et al., 2019). The antioxidant activity of herbal teas has been evaluated using various methods, including DPPH free radical-scavenging activity, which involves measuring the tea's ability to scavenge free radicals. The results of such studies have indicated that herbal teas can exhibit strong antioxidant activities, with some varieties showing better antioxidant and cytotoxic activities than green tea (Kumari & Kumar, 2022). The antioxidant capacities and total phenolic contents of teas have been found to differ greatly, with green tea generally possessing the highest antioxidant capacity and total phenolic content.

Tea Culture

Tea holds a profound significance in numerous countries, serving as more than just a beverage; it stands as an age-old tradition, distinct and intrinsic to each cultural heritage. According to FAO (2021), global tea production rose to around 6.5 million tons from 6.3 million in 2020. Recovery in black tea production, particularly in major countries like India and Sri Lanka, contributed to this increase. China remained the largest producer, with 3.1 million tons, up from 2.9 million in 2020. India, the second-largest producer, rebounded to 1.33 million tons in 2021 from 1.26 million in 2020. Japan alone consumption of green tea is about 100,000 tons per annum, out of which 90,000 tons are produced domestically, and there are 3 major types of commercially producedgreen tea, black and oolong tea (Ali et al., 2013). Tea is the second most widely consumed beverage globally after water and is cultivated in about 30 countries worldwide.

While its origins lie in Southeastern China, tea cultivation has now spread worldwide to numerous tropical and subtropical regions (Wambulwa et al., 2021). Derived from the leaves, leaf nodes, and internodes of the *Camellia sinensis* plant, tea is prepared by steeping these components in hot water, creating an aromatic and flavorful beverage. This process involves curing the leaves using hot water, resulting in the extraction of various compounds (Xiao et al., 2008). Originally, tea was produced from the apical shoot of the *Camellia sinensis*, consisting of one bud and two or three leaves (Hatibaruah et al., 2012). Tea is famous for its various health benefits to humans; notably, the antioxidant, reported anti-tumour , anti-carcinogenic (Katiyar & Mukhtar, 1996), and various chemical components like polysaccharides (Monobe et al., 2008), volatile acids (Wei et al., 2010), vitamins (Xiong et al., 2012). Nowadays, various types of tea are found in the market, from flowers and leaves to herbs, as everything can be made into tea (Dubrin, 2012).

Tea Composition

The composition of tea varies based on its raw materials. A study by Eneighe et al. (2020) indicated that green tea powder has a moisture content ranging from 3.5% to 5.6%, with a water activity ranging from 0.16 to 0.28. Physicochemical analysis of commercially available black tea and green tea showed that the moisture content ranges from 2.46% to 7.47%, and protein content ranges from 0.87% to 1.14%. A study using the EPR spectroscopy method found that green tea had the highest total antioxidant capacity (TEAC) value of 495 ± 157 µmol/g, followed by black tea at 335 ± 34 µmol/g, and earl grey tea at 248 ± 59 µmol/g. Such variances can impact the teas' nutritional content and sensory qualities, contributing to the distinct characteristics and potential health benefits associated with each tea type.

Moreover, tea contains bioactive compounds that contribute to its antioxidant properties. Cleverdon et al. (2018) determined the levels of healthy compounds called polyphenols in green and black tea using specific methods recommended by the International Organization for Standardization (ISO) 14502-1. They assessed the ability of these teas to combat harmful molecules called free radicals, which can damage our bodies, and found that green tea had higher polyphenol levels than black tea. Specifically, the concentration of polyphenols in green tea ranged from 14.32% to 21.02% of gallic acid equivalents (GAE), whereas black tea had a lower polyphenol content ranging from 8.42% to 17.62% GAE. This suggests that green tea might offer more health benefits due to its higher polyphenol levels.

Herbal Tea

Herbal tea is a blend of various plant leaves, seeds, and/or roots. It's important to note that herbal teas are not derived from the typical tea plant but rather from what is referred to as 'tisanes.' Numerous types of tisanes, commonly known as herbal teas, have been historically valued for their medicinal properties. People consume these herbal teas for various purposes, including relaxation, soothing digestive issues, boosting energy, and fortifying the immune system. Some well-known examples of herbal teas include chamomile, ginger, ginseng, peppermint, and cinnamon (Ravikumar, 2015).

Herbal teas comprise several beneficial compounds, including polyphenols, flavonoids, terpenoids, volatile oils, alkaloids, organic acids, and polysaccharides (Ye et al., 2015), contributing positively to human health. According to the World Health Organization (WHO, 2019), global mortality patterns have shifted, with noncommunicable diseases now causing more deaths than infectious diseases. Among these noncommunicable diseases, heart disease, dementia, and diabetes have become the most common causes of death. This has led to research on safer and more natural food consumption. Herbal tea aligns with this trend by offering a variety of teas with potential health benefits.

Fern

Ferns are well-known as a common vegetable in Asian countries. In the Philippines, "Pako" or Fiddlehead fern (*D. esculentum)* is considered an edible fern abundant throughout the country. The morphology of ferns is easily identifiable. They are classified as non-flowering vascular plants within the class known as Polypodiopsida. These plants possess roots, stems, and leaves that exhibit a higher level of sophistication than other plant kingdom members. The world of ferns encompasses a fascinating array of species, with an estimated number of extinct fern species hovering around 10,500, although some projections extend as far as 15,000. The variation in these estimates arises because certain fern groups remain insufficiently examined, and new species continue to be discovered, particularly within tropical regions that remain relatively unexplored (Walker et al., 2022).

Fern Composition

Fiddlehead fern (*D. esculentum*) is a highly popular vegetable in Asian countries such as India, Malaysia, Sri Lanka, and the Philippines. In the Philippines, this fern is prepared in various ways, from being blanched and served as a salad with fermented fish "bagoong" or shrimp paste "alamang," to being cooked in coconut milk-based stews with pork or prepared in adobo style. The nutritional composition of fern makes it particularly attractive to consumers.

A study conducted by Tongco et al. (2014a) analyzed fresh fern samples using standard AOAC methods and found that ferns contain different components. Fresh fern samples exhibited 91.82% moisture content, representing the amount of water present in them. Additionally, they contained 1.42% ash, which signifies the inorganic minerals left behind after burning off organic matter. The fresh plant samples comprised 0.28% crude fat, indicating the fat content, and 0.87% crude protein, essential for various biological processes. Furthermore, the fresh samples contained 0.72% crude fiber, aiding digestion. However, their composition changed significantly when the plant samples were dried using an oven. The dried samples now showed 17.39% ash, indicating a higher concentration of inorganic minerals due to the removal of water content. Moreover, the dried samples had 3.40% crude fat, 10.67% crude protein, and 9.06% crude fiber, showing a concentration of these nutrients due to the drying process. The study also analyzed phenolic and flavonoid compounds. The total phenolic content was 125.6 ± 13.4 mg gallic acid equivalents (GAE)/100g of air-dried sample for the ethanolic extract and 11.7 ± 0.9 mg GAE/100g for the water extract. The total flavonoid content was listed as 110.8 ± 11.2 mg quercetin equivalents (QE) per 100 g of air-dried sample for the ethanolic extract and 16.2 ± 0.7 mg QE/100 g for the water extract. Researchers noted the presence of cardiac glycosides in the fern, which can be toxic and affect the heart, causing cardiac arrhythmias and potentially fatal outcomes (Roberts et al., 2016). However, cardiac glycosides were undetected when water was used in the study (Tongco et al., 2014b).

Furthermore, according to the Philippines Food and Nutrition Research Institute (FNRI), ferns contain minerals. Unprocessed ferns are reported to contain 15 mg of calcium, 64 mg of phosphorus, 1.3 mg of iron, 434 mg of potassium, 6 mg of sodium, and 0.60 mg of zinc. As per FNRI, Boiled ferns contain 6 mg of calcium, 34 mg of phosphorus, 1.0 mg of iron, and 6 mg of sodium.

Cinnamon

Cinnamon plays a significant and diverse role as a spice, valued for culinary purposes and in traditional and contemporary medicinal practices globally. The cinnamon genus encompasses approximately 250 recognized species, with trees distributed across various regions worldwide (Sangal, 2011). Cinnamon has been esteemed as a spice for millennia, with evidence of its use dating back to 3000 BC by ancient Egyptians. Numerous species possess aromatic and flavor-enhancing qualities within the Cinnamomum genus of the Lauraceae family. The most used type of cinnamon in commerce is derived from the dried inner bark of the Cinnamomum verum tree (also known as *C. zeylanicum Blume*), native to Sri Lanka and the Malabar Coast of India. This cinnamon typically exhibits a pale tan color and a mildly sweet flavor profile. In contrast, cassia, another spice related to cinnamon, is generally considered of lower quality and originates from Myanmar (Burma). Cassia cinnamon sources include Chinese cassia (*C. cassia)*, also known as *C. aromatica*) from China and Vietnam, Indonesian cassia *(C. burmanii)* from Sumatra and Java, and Indian cassia (*C. tamala*) from northeastern India and Myanmar. The biology and morphology of the cinnamon tree, reveal it to be a tropical evergreen that can reach heights of up to 7 meters in its natural habitat but is typically cultivated as a bush to maintain a height of less than 3 meters. Regular trimming encourages new shoot growth for bark and quill extraction. The tree boasts thick, rough bark and sturdy branches. Cinnamon leaves are oblong and ovate, ranging from 7 to 18 centimeters long. When cooked or fried, the leaves emit a delightful fragrance and slightly hot and bitter taste. The tree produces greenish flowers arranged in panicles, notable for their distinct aroma, and bears purple berries about 1 centimeter long, each containing a single seed. Cinnamon trees thrive in hot, humid tropical climates at low altitudes and are typically ready for harvesting around three years after planting. Well-drained soil is essential, as waterlogged soil can result in bitter-tasting bark. By about three years of age, the tree usually develops eight to ten side branches suitable for harvesting high-quality cinnamon bark. The spice is primarily obtained by drying the inner bark, marketed as quills or powder. In some cases, dried leaves are also used in spice blends. Cinnamon presents a reddish-brown color and emits a sweet, warm, spicy, and woody fragrance. Its flavor profile is characterized by warmth, spiciness, and aromatic qualities. The essential oil derived from cinnamon possesses a sweet, aromatic, spicy, slightly woody, and clove-like aroma (Thomas & Kuruvilla, 2012).

Cinnamon Composition

Cinnamon is widely utilized for its diverse health benefits, ranging from medicinal applications to its use in the food industry. Numerous studies have highlighted its potential therapeutic properties. In vitro and animal studies suggest that cinnamon exhibits anti-inflammatory (Meades et al., 2010), antimicrobial (Du et al., 2009), antibacterial (Nuryastuti et al., 2009), antitumor (Jayaprakasha & Rao, 2011), cardiovascular (Lee et al., 2011), cholesterol-lowering (Mandal et al., 2011), and immunomodulatory effects (Wang et al., 2011). Cinnamon contains cinnamaldehyde, a key compound known for its ability to mask off-flavors and contribute to sensory characteristics. This compound also possesses potent antioxidant properties, surpassing other herbs (Pagliari et al., 2023).A study by Yang et al. (2012) demonstrated that cinnamon bark extracts are rich in antioxidant compounds, ranging from 6.313 to 9.534 grams per 100 grams of dry weight, compared to 0.151 to 2.018 grams per 100 grams of dry weight in supercritical fluid extracts. The study also identified more effective methods for extracting these natural antioxidant substances from cinnamon cassia. Mineral analysis of cinnamon cassia revealed various mineral contents per gram, including 7.0 mg of iron, 2.6 mg of zinc, 83.8 mg of calcium, 0.4 mg of chromium, 20.1 mg of manganese, 85.5 mg of magnesium, 0.0 mg of sodium, 134.7 mg of potassium, and 42.4 mg of phosphorus. Further analysis showed that cinnamon contains 2.4% ash, 3.5% crude protein, 4% crude fat, 33.0% crude fiber, 5.1% moisture, and 52.0% carbohydrates. Notably, it is richest in carbohydrates and potassium, containing the least ash and no sodium (Gul & Safdar, 2009).

MATERIALS AND METHODS

Materials

Procurement of Raw Materials

The fern was locally sourced from Central Mindanao University from a known seller. The food-grade tea bags were bought commercially online from a supplier. Cinnamon barks were bought online also from a food-grade supplier. Other materials such as distilled water, cups, and containers used during the research were bought in Valencia City, Bukidnon.

Methods

General Experimental Approach

The tea bag preparation involves putting dried fern and cinnamon into the bags. The resulting tea can be categorized as either powder or infused. The dried tea powder undergoes physicochemical analysis (water activity, color analysis, moisture content) for all treatments. On the other hand, infused tea was subjected to physicochemical (pH and TSS) and sensory evaluation for all treatments and was statistically analyzed to come up with the most acceptable formulation. The most acceptable formulation then undergoes determination of, total phenolic content, antioxidant properties, and microbial analysis, as well as product cost analysis as shown in Figure 1.

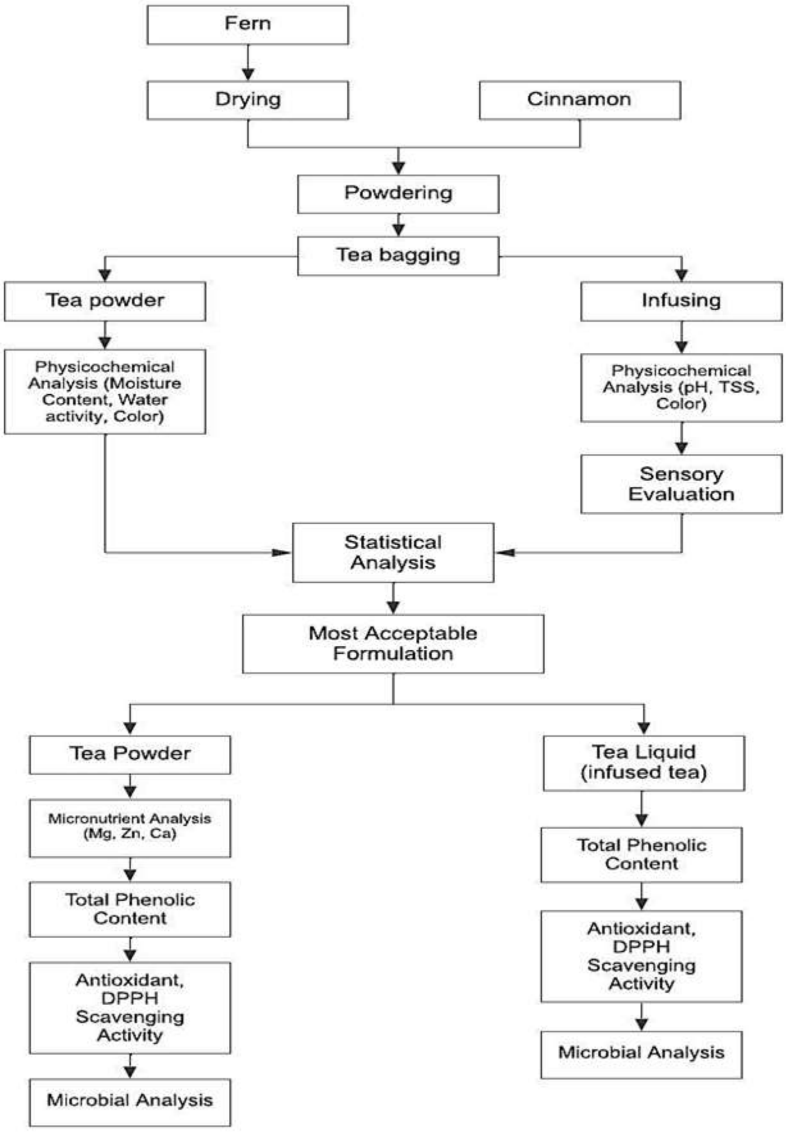

Figure 1. Flow chart for making fern-cinnamon tea

Experimental Design

The study utilized a 3x3 factorial design to investigate the main and interaction effects between the dependent and independent variables. The independent variables used were the weight of fiddlehead fern and cinnamon in grams (Table 1).

TREATMENTS	FERN (g)	CINNAMON (g)	Infusing Water (mL)
1	2	1	200

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2	2	2	200
3	2	3	200
4	4	1	200
5	4	2	200
6	4	3	200
7	6	1	200
8	6	2	200
9	6	3	200

Table 1. 3x3 factorial design matrix with levels of medium component

Preparation of Tea bags

To prepare tea bags, fern fronds and pinnule are dried at 60°C for 3 hours and powdered to fit into the tea bags. Dried cinnamon is commercially bought and powdered before being mixed with the fern according to table 1. This mixture is then put into 6x8 cm teabags, as described by Adnan et al. (2017). The tea bags are then steeped in 200mL of water at a temperature of 70-85°C for 10 minutes, using a modified method originally described by Piljac-Žegarac et al. (2013).

Physicochemical Analysis (Powder)

Moisture Content

The method of Cheng et al. (2022) was followed to determine the moisture content of tea samples. Each treatment of the samples were placed on a drying plate and heated to 120°C for an hour using a (Radwag MAX2.A, Poland) moisture analyzer. The weight difference between the initial and final weight after drying was recorded. The moisture content, expressed on a wet basis, was calculated by dividing the change in weight by the initial weight.

Water activity

The water activity (Aw) of the samples was measured at room temperature by using a water activity meter (NADE HD-6 four-sensor Smart). 3 grams of sample was transferred to a sample holder and run for 10 minutes. The data was recorded three times to ensure accuracy (Ayhan Topuz et al. 2014).

Color

A handheld digital colorimeter was used to analyze the powder's color. Before starting the procedure, the instrument was calibrated using a white calibration plate. The tea was carefully minced and placed on the measuring plate to ensure complete coverage, which helped to prevent measurement errors. The instrument's probe was positioned over the tea sample to obtain the most precise readings. The color measurements were performed three times to ensure reliability, and the average values of $L*$ (which represents brightness), $a*$ (indicating the green-red axis), and $b*$ (referring to the blue-yellow axis) were recorded. This method allows for a thorough assessment of the color properties of the tea samples, following the approach described by Xie et al. (2014).

Physicochemical Analysis (Infused tea)

pH Measurements

The pH levels of the tea samples were measured using a pen-type pH meter (HANNAH HI 5221). Prior to measurement, the pH meter was calibrated according to the manual. Each pH reading was taken three times, and the results were recorded as the average value.

Total Soluble Solids

The dissolved solids that are present in the samples were determined using a digital refractometer (ATAGO N4) The same method outlined by Tan et al. (2023) was followed. The instruments were calibrated using distilled water before taking the measurements. A small amount of tea sample was placed on the prism until it formed an even layer without any gas bubbles. After a 30-second wait under appropriate lighting, the sample reading was taken. The instrument was rinsed with distilled water after each measurement. The results were expressed as the concentration of °Brix, and the average was calculated from three readings.

Sensory Evaluation

The sensory evaluation was conducted in the Sensory Evaluation Laboratory Room at the College of Human Ecology, Central Mindanao University, Musuan, Maramag, Bukidnon. The product was evaluated using descriptive and acceptability scores employing 25 semi-trained panelists composed of Junior and Senior BS Food Technology students who are tea and coffee lover. Each panel was given written instructions and was asked to evaluate the product in terms of color, aroma, flavor, aftertaste and general acceptability using a 9-point hedonic scale.

Antioxidant, DPPH Scavenging Activity

Samples were sent to a third-party laboratory for the analysis of antioxidant properties, specifically focusing on the most accepted formulation. The analysis was conducted using standard methods in accordance with USDA and FDA guidelines to ensure accuracy and reliability of the results.

Total Phenolic Compound

Samples were sent to a third-party laboratory for the analysis of total phenolic content, focusing on the most accepted formulation. The analysis followed standard methods recommended by the USDA and FDA to ensure consistency and reliability of the results. The data obtained from this analysis will be instrumental in understanding the formulation's phenolic composition and its potential health-promoting properties.

Microbial Analysis

Samples were sent to a third-party laboratory for the microbial analysis for total plate count, yeast and molds for the most accepted formulation. The analysis followed standard methods recommended by the USDA and FDA to ensure consistency and reliability of the results. The data obtained from this analysis will be instrumental in understanding the formulation's microbial properties and its safety for consumption.

Product Cost Analysis

Production costs for creating fern-cinnamon tea were conducted by thoroughly documenting all estimated direct and indirect expenses associated with production. This will encompass potential markups and overhead costs, ensuring a thorough understanding of the financial aspects involved in the tea's development.

Ethical Consideration

The research underwent an ethical review process. The proposal was submitted to the Institutional Ethics Review Committee (IERC) to ensure it adhered to ethical standards. Additionally, the handling of samples strictly adheres to established food safety protocols. Furthermore, individuals participating in the sensory evaluation received an invitation letter along with a consent form before they took part in the evaluation, this is the method for green tea by Setiawan et al. (2021)

Statistical Analysis

All the data that was collected and was analyzed using the Analysis of Variance or ANOVA at 95% level of significance and Tukey's Honest Significance Difference Test (Tukey's HSD Test)

RESULTS AND DISCUSSION

Physicochemical Properties of Fern Cinnamon Tea

The physicochemical properties of food and beverages play a crucial role in determining their quality, stability,

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and sensory attributes. These properties encompass a range of characteristics that impact the structure, behavior, and composition of these products. Physicochemical properties include factors like pH, total soluble solids, water activity, moisture content, color. Changes in these properties during processing, storage, and enrichment can significantly influence the final product (Igual & Martínez-Monzó, 2022). Fern Cinnamon tea was analyzed for pH, TSS, moisture content, water activity and color. The physicochemical properties of fern cinnamon tea are presented in Table 1.

Table 2. Physicochemical properties of fern-cinnamon tea

TRT	pH	TSS	*Aw*	MOISTURE CONTENT (%)
1	6.35 ± .00^{cd}	0.83 ± .006^{f}	.661 ± .002^{f}	7.45 ± .08^{f}
2	6.27 ± .01^{e}	0.92 ± .006^{e}	.675 ± .002^{e}	7.81 ± .03^{f}
3	6.18 ± .01^{f}	0.96 ± .006^{cd}	.679 ± .001de	8.95 ± .16^{e}
4	6.44 ± .00^{b}	0.95 ± .006de	.676 ± .002^{e}	10.39 ± .14^{d}
5	6.35 ± .01^{cd}	0.98 ± .011^{c}	.683 ± .003^{cd}	10.91 ± .45^{cd}
6	6.29 ± .01de	1.11 ± .010^{b}	.688 ± .002^{bc}	11.32 ± .30^{c}
7	6.57 ± .01^{a}	0.98 ± .015^{c}	.685 ± .002^{c}	12.92 ± .55^{b}
8	6.42 ± .00^{bc}	1.11 ± .015^{b}	.692 ± . 002^{ab}	13.35 ± .20^{ab}
9	6.37 ± .07^{bc}	1.31 ± .011^{a}	.697± .000^{a}	13.96 ± .05^{a}

Values with the same superscripts in the column are not significantly different a ($p \leq 0.05$)

The data used are mean of three replicates.

pH

The pH of teas plays a crucial role in determining the acidity or alkalinity of the beverage, which has significant implications for taste, health properties, and potential effects on the body. Different types of teas have varying pH levels, influencing factors such as flavor profile, freshness, and health benefits. Understanding and controlling the pH of teas are essential for preventing the growth of harmful bacteria like Salmonella and E. *coli*, maintaining the freshness, taste, and appearance of foods and beverages, and ensuring that the acidity levels align with personal preferences and health goals (Del Rio et al., 2010). Table 2 shows that the pH of fern cinnamon tea ranges from 6.18 (T3) being the lowest and 6.57 (T7) being the highest. Statistical analysis revealed that the amount of fern, cinnamon, and the interaction of factors (fern-cinnamon) significantly affected ($p \leq 0.05$ "Appendix Table 21") the pH of the fern-cinnamon tea. It can be observed that as the fern levels increase, the pH levels also increase (Figure 2), while levels of cinnamon increase, the pH decreases (Figure 3). The interaction between fern and cinnamon tea to the pH indicates that the increase in fern levels is the driving factor on the increase of pH in the tea regardless of increasing the cinnamon levels (Figure 4). This is possible because fern powder has a near-neutral pH level of 6 (Valmorida et al., 2023), and the pH of cinnamon tea has a pH ranging between 6 and 10, making it an slightly acidic spice (Bernardo et al., 2015). This suggests that fern cinnamon tea may also have an alkaline pH, which contributes to the pH of the tea ranging from 6.18-6.57. The pH of tea can also affect the taste, color, and aroma of the tea (Tan et al., 2023). Standard teas like green teas have a pH value ranging between 7 and 10, making them more alkaline than acidic (Smith, 2021).

According to Lunkes and Hashizume (2014), teas can have varying pH levels depending on the type and preparation method, pH of tea can influence its taste and how it interacts with other substances. Black tea, known for its bold flavor, typically falls within a pH range of 4.99 to 5.55, making it less acidic compared to coffee. In contrast, green tea exhibits a more neutral to slightly alkaline pH, ranging from 7.0 to 10.0, which contributes to its perceived mild and refreshing taste. Oolong tea occupies a middle ground with a pH range of 5.9 to 8.2, sharing black and green teas characteristics. White tea, known for its delicate flavor, also tends towards a more neutral to alkaline pH range of 6.9 to 9.7. Herbal teas, derived from various plants and botanicals, generally maintain a pH around 6.0 to 7.0, placing them within a relatively neutral range. This suggests that the pH fern-cinnamon tea is within the range of the acceptable pH on teas.

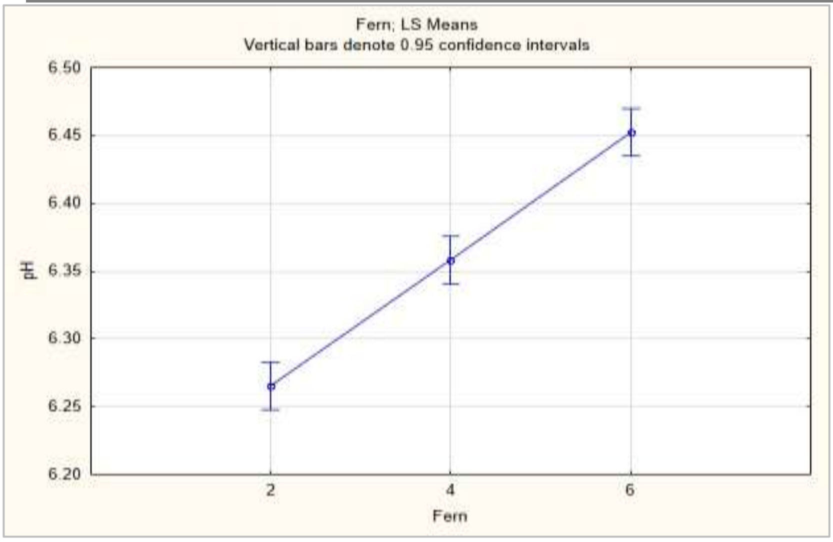

Figure 2. Interaction between levels of fern and pH

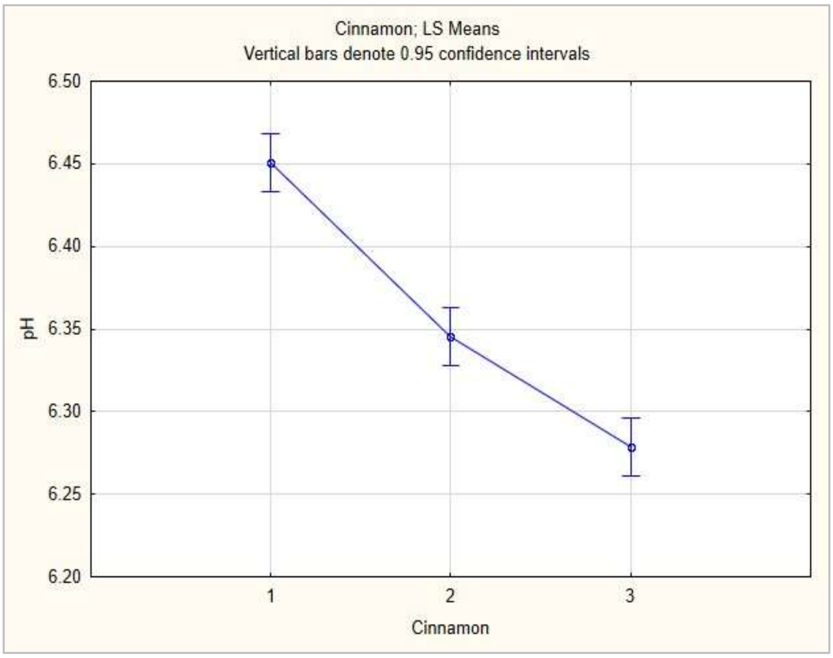

Figure 3. Interaction between levels of cinnamon and pH

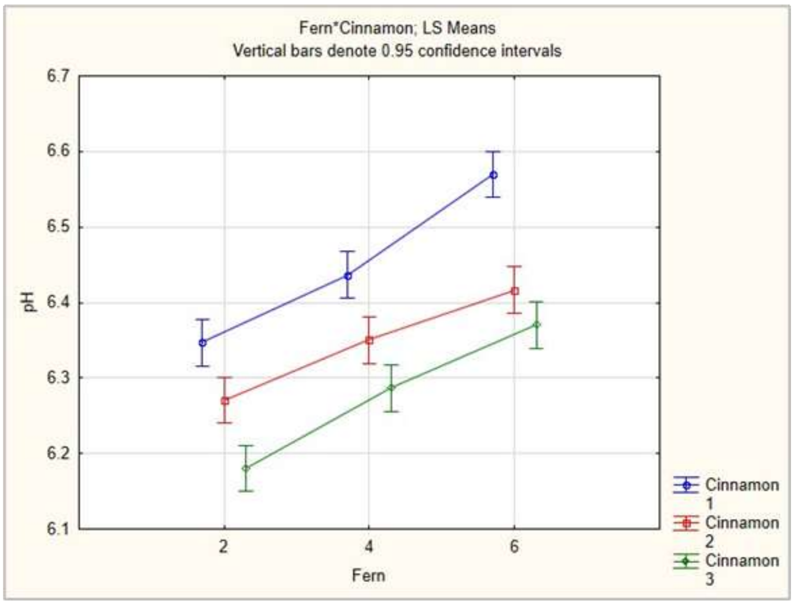

Figure 4. Interaction between Fern-Cinnamon and pH

Total Soluble Solids (TSS)

The TSS value is a percentage of brix that indicates the concentration of sugars and other organic compounds in a sample. It is calculated by comparing how light travels through the sample versus through a vacuum. This measurement primarily reflects the amount of sugar in the sample (Bexiga et al., 2017). Table 2 shows that the Total Soluble Solids (TSS) value of the fern-cinnamon tea increases as the amounts of fern and cinnamon increase. This trend is also visible in the graph in Figure 5, where the TSS values are shown to be rising. The statistical analysis indicated that the individual amounts of fern, cinnamon, interaction of fern-cinnamon and their intercept are significantly different from each other ($p \leq 0.05$, see "Appendix Table 20"). Treatment 1 has the lowest TSS value at 0.83, while Treatment 9 has the highest value at 1.31. Additionally, Treatments 2, 3, 4, 5, 6, 7, and 8 do not significantly differ from each other due to the similarity in the ratios of fern-cinnamon powder used. This finding could be attributed to the presence of various bioactive compounds in fern such as fructans, a type of polysaccharide known for its sweet taste, which may influence the TSS of the product. Similarly, specific components of cinnamon, including cinnamaldehyde, cinnamic acid, and cinnamate found in its essential oil, might contribute to variations in the TSS value (Rao & Gan, 2014).

Moreover, according to Tan et al. (2023b), the total soluble solids (TSS) levels in green tea infusions brewed using different brands and types of water exhibited significant variation. The highest TSS value observed was 1.33°Brix for tea brewed with mineral water, whereas the lowest was 0.97°Brix for tea brewed with tap water. However, it is worth noting that a TSS value of less than 1 degree Brix, indicates very low levels of dissolved solids in the liquid solution (Samarasinghe et al., 2020). This variation in TSS/Brix levels is an important indicator of sweetness and overall quality in food products, reflecting differences in composition and quality, as noted by Raheel et al. (2015). In the context of cinnamon tea, the TSS value primarily stems from sugars like glucose, fructose, and sucrose, alongside other compounds such as organic acids, proteins, and polyphenols (Choi et al., 2022).

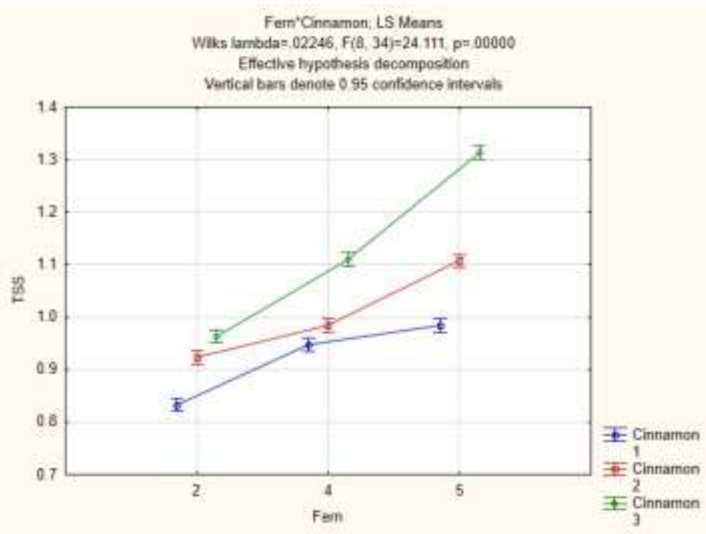

Figure 5. Interaction of Fern-Cinnamon TSS

Water Activity

Foods with elevated levels of water activity create conditions conducive to the growth of bacteria, yeasts, and molds. Managing water activity is essential for ensuring food safety and maintaining quality, as it directly impacts microbial proliferation, rates of deterioration, and various chemical and physical characteristics of food items (Syamaladevi et al., 2016). Aw is a more reliable indicator of the potential for microbial growth and spoilage than moisture content alone, as it considers the availability of free water for microbial growth. Table 2 shows that the water activity of fern cinnamon tea ranges from .661 to .697. Figure 6 illustrates that increasing the amount of fern and cinnamon in the composition leads to an increase in water activity. However, the results showed that the fern, cinnamon, and fern-cinnamon intercept results are statistically different to each other at ($p \leq 0.05$ "Appendix Table 21"). This difference can be attributed to the inherent water-holding capacity of ferns, as they typically grow near riverbeds and have a higher natural water content compared to cinnamon bark, which is drier (Chettri et al., 2018). The observed variation in Aw values between fern and cinnamon highlights the moisture characteristics of these materials and their impact on Aw when incorporated into tea formulations. Nevertheless, according to a related beverage study by Aung Moon et al. (2022), products like green tea and black tea powder have water activity values around 0.5 Aw, indicating lower water availability and reduced microbial growth potential. This suggests that the water activity values for the fern-cinnamon tea are within range of the known tea products.

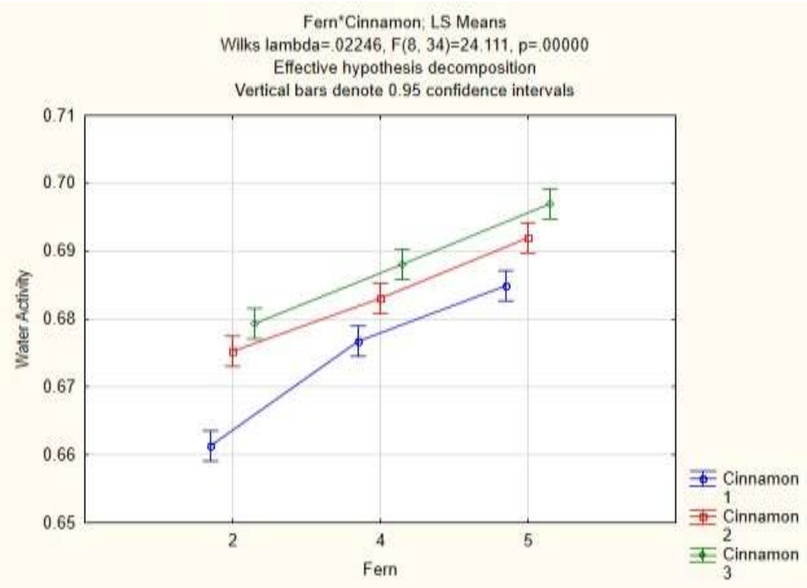

Figure 6. Interaction between Fern-Cinnamon to Aw

Moisture Content

Excessive moisture content in tea powder can lead to issues such as clumping, caking, and microbial growth, which can affect the quality, safety, and shelf life of the product (You et al., 2018). In addition, insufficient moisture content can result in a loss of flavor, aroma, and overall quality of the tea powder. Therefore, maintaining the appropriate moisture content in tea powder is crucial to ensure its quality, taste, and shelf stability (Zou et al., 2022). Table 2 shows that the moisture content of the fern-cinnamon powder mixture ranges from 7.45% (T1) being the lowest to 13.96% (T9) being the highest. The statistical analysis revealed that the moisture content of fern-cinnamon tea is significantly influenced by the amount of fern powder and cinnamon powder ($p \leq 0.05$, "Appendix Table 22"). However, the intercept of the fern-cinnamon powder mixture did not show significant differences ($p \leq 0.05$, "Appendix Table 24"). Noting that treatments 1,2 and 3 have small levels of fern and cinnamon might be the reason why it is noticeably lower than all other treatments that have reached 10% and above moisture content. A study by Wickramasinghe et al. (2020) documented that for long storage of herbal tea, maintaining a moisture content between 6.1% and 9.2% is recommended to preserve quality and prevent microbial growth. However, for short-term storage, a moisture content below 15% is considered satisfactory. The moisture content of the fern-cinnamon powder could be attributed to the fern and cinnamon itself since the characteristics of dried cinnamon bark typically contain a moisture content ranging from 11% to 15% (Balasubramanian et al., 2012). Another study aligns with the moisture characteristics of fiddlehead ferns, which have a high moisture content ranging from 81.68% to 89.83% in fresh fronds, as reported by Trail et al. (2021). Furthermore, the high moisture content of fern leaves per 100g ranges from 75% to 95% (Sareen et al., 2020). With this, it might contribute to the overall moisture dynamics observed in the tea product.

Figure 7 demonstrates an increase in moisture content with higher levels of fern powder in the tea formulation. The observed increase in moisture content as fern powder levels increase highlights the water-retentive properties of ferns and their impact on the overall moisture balance of the tea mixture. This information is essential for formulating teas with desired moisture levels and understanding the hydration dynamics of herbal ingredients like fern powder. Figure 8 indicates that increasing levels of cinnamon also lead to increased moisture content in the fern-cinnamon powder mixture. This could be attributed to the combined influence of higher levels of fern powder in the mixture, as suggested by Praseptiangga et al. (2019). Regarding tea leaves, the optimal moisture content after drying is around 3.5%, which helps establish aroma and enhances chlorophyll bonding with proteins while reducing astringency (Eneighe et al., 2020b). Figure 9 indicates that all treatments fall within the acceptable moisture content range for tea and herbal tea, making them safe for consumption. This finding underscores the importance of moisture control in tea processing to ensure product quality and shelf stability.

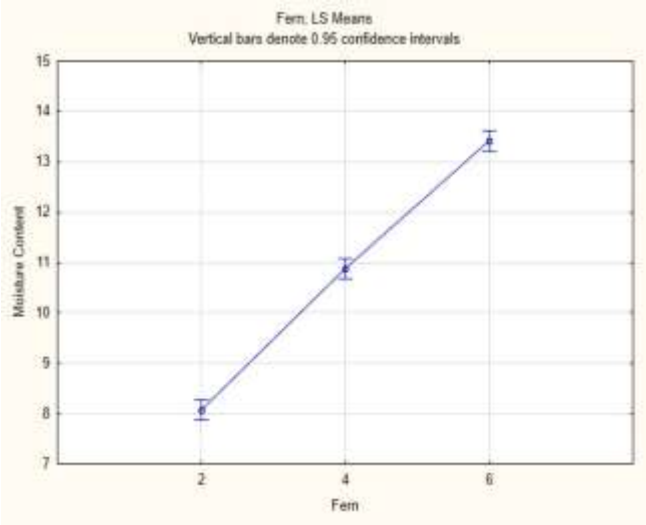

Figure 7. Interaction between fern and Moisture Content %

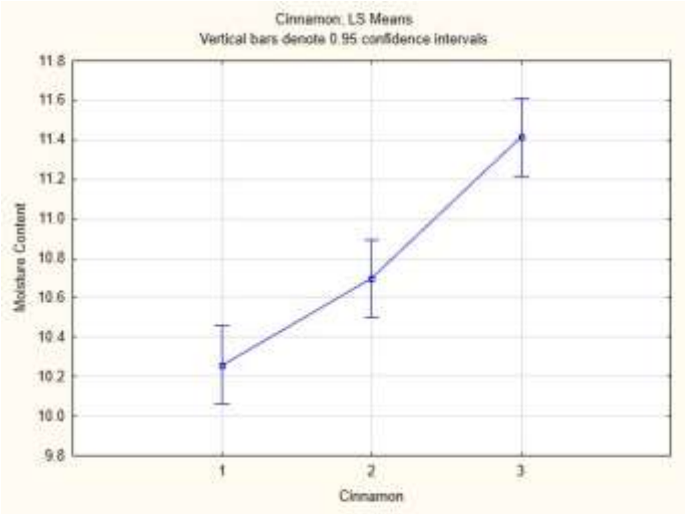

Figure 8. Interaction between Cinnamon and Moisture Content %

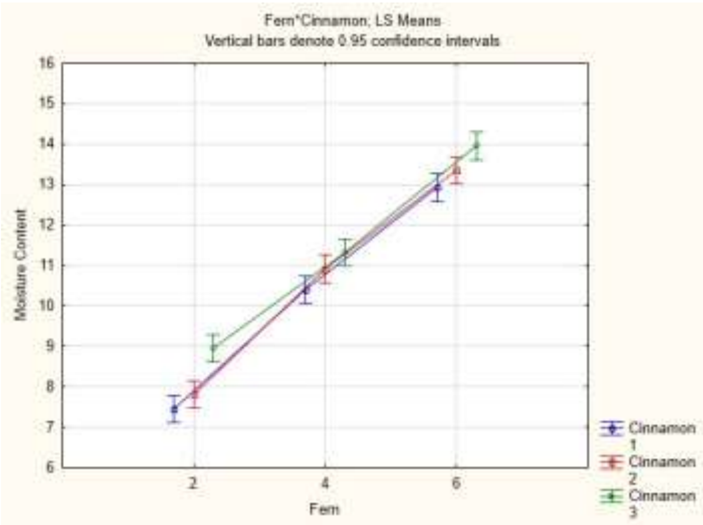

Figure 9. Interaction between Fern-Cinnamon and Moisture Content %

Color *L* a* b** (Fern-Cinnamon Powder)

The color of tea is essential for consumer acceptance and is one of the primary qualities evaluated when purchasing tea. Tea color varies based on its type, with black and green teas being the most popular varieties. Additionally, tea color can be affected by factors such as raw material quality, processing methods, and the presence of plant material or other elements in the final product (de Godoy et al., 2013).

*L**

In LAB color space, the *L** axis measures the lightness of a color on a scale from 0 to 100, where 0 represents pure black (no light) and 100 represents pure white (full light). This axis focuses solely on the perception of lightness, irrespective of specific hues. The data from Table 4 for fern-cinnamon tea powder shows *L** values ranging from 46.73 (T6) to 56.98 (T7). Statistical analysis in Table 4 indicates that these L* values are significantly different from each other ($p \leq 0.05$, see "Appendix Table 23"). Notably, Treatments 2, 3, and 7 have similar *L** values but differ from other treatments according to Table 4. Additionally, the significance of the *L** value in color analysis can be influenced by the presence of darker color pigments in substances like fern powder, such as chlorophyll, which imparts a greenish color (Sundue et al., 2011). Because chlorophyll adds a green tint to fern powder, especially in darker areas, the *L** value representing lightness may be less distinct or significant.

*a**

In LAB color space, the *a** axis represents the position of a color between green (negative values) and red (positive values). Negative values along the *a** axis indicate greenness, with stronger negative values indicating more intense green tones. Positive values indicate redness, with stronger positive values indicating more intense red tones. Table 4 shows *a** values ranging from 13.15 (T9) to 31.54 (T3). Statistical analysis in Table 4 indicates significant differences in *a** values ($p \leq 0.05$, see "Appendix Table 24"). Treatments 1, 2, and 3 are not significantly different from each other, and the same applies to Treatments 4-5 and 8-9. However, Treatments 6 and 7 display differences in *a** values. The results suggest that the *a** values lean towards redness or brownness. This shift towards red or brown hues can be attributed due to the cinnamon present in the mixture. Cinnamaldehyde, the main pigment responsible for cinnamon's characteristic color and which also imparts cinnamon's distinct flavor and aroma, has a yellowish to brownish color. This pigment contributes to the warm, reddish-brown tone observed in ground cinnamon powder (Knauth et al., 2018).

*b**

The *b ** value is particularly useful in describing and comparing objects color characteristics, as it quantifies the perceived yellowness or blueness of a color. Positive *b ** values indicate a shift toward the blue end of the spectrum, while negative *b ** values indicate a shift toward the yellow end. Table 4 *b** values from 44.79 (T9) to 58.26 (T3) as it is seen in the results of the statistical analysis presented in table 4 it indicates that *b** is significantly affected by ($p \leq 0.05$, "Appendix Table 25"). This indicates that the color of fern-cinnamon powder tends towards a bluish hue, likely due to an increase in the *b** values, resulting in a bluer appearance. The notable variations in color treatments may be attributed to chlorophyll, a photosynthetic pigment that imparts green color to plants (Sheen et al., 2018). Additionally, *D. esculentum* appears yellowish green because of flavonoids (Koniyo et al., 2021).

Table 3. Color Measurement of Fern-Cinnamon Tea Powder

Treatment	*L**	*a**	*b**
1	$54.40 \pm .242^{c}$	$30.52 \pm .184^{a}$	$56.77 \pm .202^{b}$
2	$56.27 \pm .486^{a,b}$	$31.26 \pm .486^{a}$	$57.34 \pm .421^{b}$
3	$55.12 \pm .503^{a,b}$	$31.54 \pm .401^{a}$	$58.26 \pm .490^{a}$
4	$48.52 \pm .140^{d}$	$28.90 \pm .633^{b}$	$49.99 \pm .198^{c}$
5	$48.28 \pm .605^{d}$	$28.47 \pm .217^{b}$	$49.14 \pm .170^{c}$
6	$46.73 \pm .150^{e}$	$27.12 \pm .452^{c}$	$47.77 \pm .087^{d}$
7	$56.98 \pm .473^{a}$	$15.41 \pm .040^{d}$	$46.85 \pm .495^{e}$

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8	55.63± .119^{b}	13.66 ± .424^{e}	45.78 ± .150^{f}
9	54.34± .151^{c}	13.15 ± .400^{e}	44.79 ± .205^{g}

Values with the same superscripts in the column are not significantly different at ($p \leq 0.05$)

The data used are mean of three replicates.

Sensory Evaluation of Fern-Cinnamon Tea

Color

The color of tea is a critical quality attribute that strongly influences consumer acceptance, often being the initial characteristic consumers evaluate when choosing a product. The visual appearance of tea is typically the first sensory aspect perceived, and consumers hold specific expectations regarding its optical qualities. Tea color significantly impacts consumer taste perceptions and overall sensory experience, as consumers correlate specific colors with flavors and aromas (de Godoy et al., 2013b). The significant effects of ferns indicate that ferns have higher sensory acceptability at a higher level (Figure 12). This is because of the color compounds of fern, particularly chlorophyll. The significant effects of cinnamon indicate that a higher level of cinnamon has higher sensory acceptability (Figure 12). Statistical analysis revealed that the amount of fern and the interaction of factors fern and cinnamon significantly affected ($p \leq 0.05$ "Appendix Table 26") the color acceptability of fern-cinnamon tea. This is because the color compounds of fern, particularly the cinnamaldehyde, have a yellowish to brownish color, and it is this pigment that contributes to the warm, reddish-brown hue of ground cinnamon powder (Knauth et al., 2018). Figure 13 shows that the deep saffron color from treatment 3 and the straw color from treatment 4 are noticeable colors (Appendix Table 15).

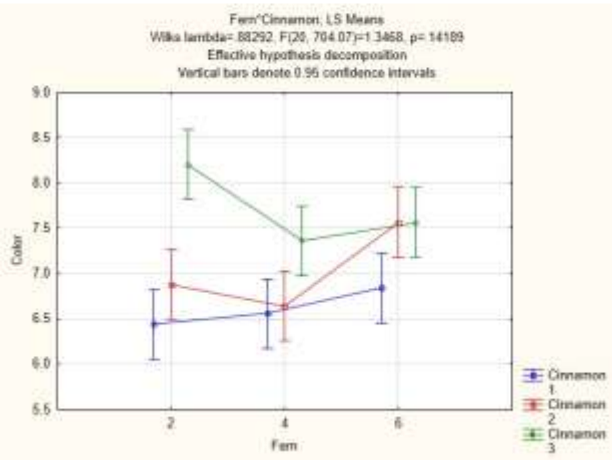

Figure 10. Effects of the interaction of factors on the color acceptability of Fern-Cinnamon Tea

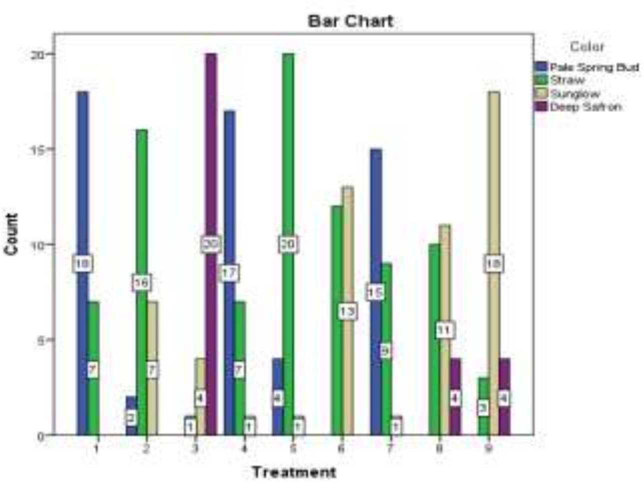

Figure 11. Color of different treatments of Fern-Cinnamon Tea from Sensory Evaluation

Aroma

The fragrance of tea is a crucial quality trait that significantly influences consumer acceptance, typically being the primary characteristic consumers evaluate when purchasing the product. Tea aroma varies based on its type, with black and green teas being the most popular varieties. Tea aroma can be classified into different categories, including vegetal, fruity, floral, marine, spicy, woody, undergrowth, buttery/milky, mineral, and burnt notes (Feng et al., 2019). Statistical analysis revealed that the amount of fern and the interaction of factors (fern-cinnamon) significantly affected ($p \leq 0.05$ "Appendix Table 27") the aroma acceptability of fern-cinnamon tea. This is possible because fern species are noted for their distinct aromas reminiscent of lemon, hay, and a forest bathing scent. These unique fragrances not only characterize specific fern varieties but also enable differentiation between different types of ferns based on their aromatic profile that the aroma of ferns contributes to the overall sensory experience, evoking the refreshing and natural essence associated with forest environments (Gabriela et al., 2024). As shown in Figure 14, as the cinnamon level increases, the sensory acceptability of aroma increases. This is because cinnamon is renowned for its potent aroma, primarily derived from its essential oil containing cinnamaldehyde and other compounds such as eugenol. The fragrance of cinnamon is often characterized as warm, spicy, subtly sweet, and captivating. The natural essential oil of cinnamon is remarkably esteemed for its enchanting effect (Zhang et al., 2022). Treatments 8 and 9 indicate the highest value count of the perceivable aroma (Figure 15) (Appendix Table 16).

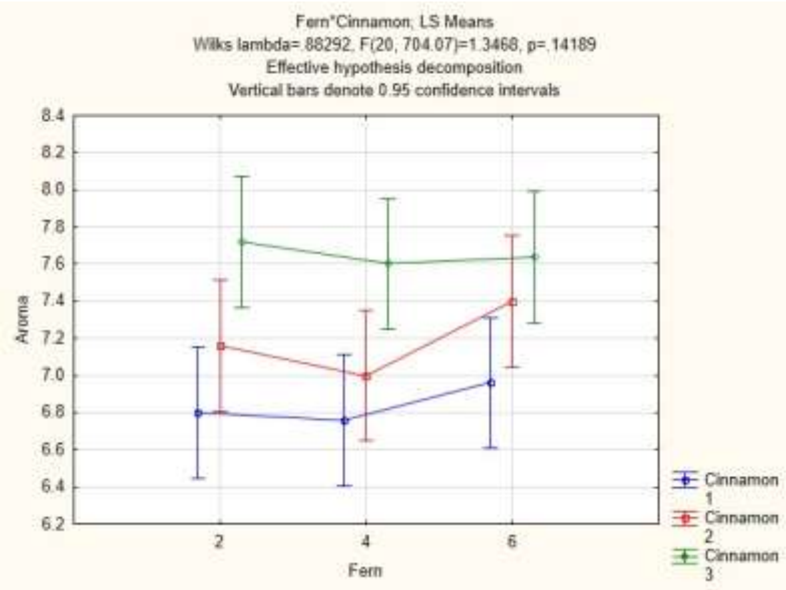

Figure 12. Effects of the interaction of factors on the aroma acceptability of Fern-Cinnamon Tea.

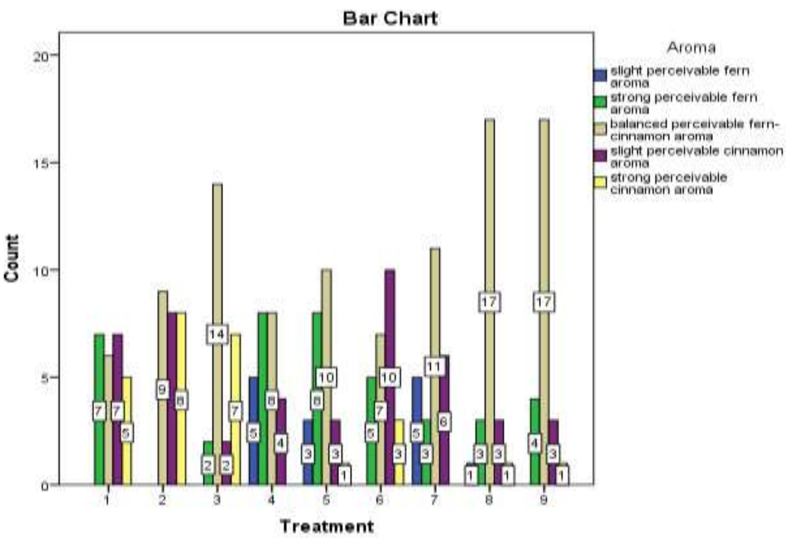

Figure 13. Aroma of different treatments of Fern-Cinnamon Tea from Sensory Evaluation

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Flavor

The taste of tea is a sophisticated and intricate characteristic shaped by several factors, including tea type, processing techniques, and brewing conditions. Scientific studies highlight tea's delightful taste and diverse health benefits, exploring how processing steps like withering, fixing, rolling, and fermentation impact the aroma quality of green, oolong, and black tea varieties. Tea flavor encompasses a range of attributes such as astringency, bitterness, umami, sweet aftertaste, floral notes, and green fruity undertones. The chemical composition of tea, including phenolic and volatile compounds, significantly influences its flavor profile (Zhai et al., 2022). Statistical analysis revealed that the amount of fern, and the interaction of factors (fern-cinnamon) significantly affected ($p \leq 0.05$ "Appendix Table 28") the flavor acceptability of fern-cinnamon tea. The significant effects of fern indicate that at higher level of fern has higher sensory acceptability (Figure 16). This is possibly because ferns have a unique flavor described as refined, slightly bitter, and slightly astringent, reminiscent of asparagus. This distinct taste combines earthy, vegetal notes with a delicate bitterness, creating a refreshing flavor profile (Gabriela Pereira Lima et al., 2024b). The significant effects of cinnamon indicate that at higher level of cinnamon has higher sensory acceptability (Figure 16) (Appendix Table 17). Cinnamon contains a range of chemical constituents that impart its characteristic taste and aroma. Among these compounds, cinnamaldehyde is prominent which is responsible for the unique spicy and sweet flavor associated with cinnamon (Knauth et, al. 2018b).

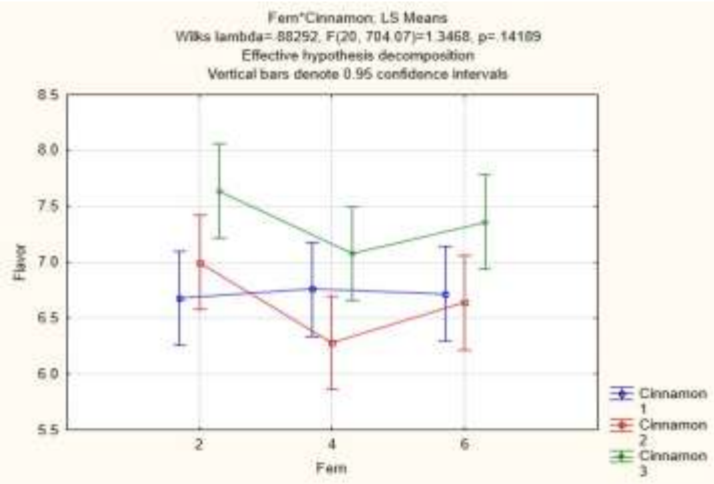

Figure 14. Effects of the interaction of factors on the aroma acceptability of Fern-Cinnamon Tea.

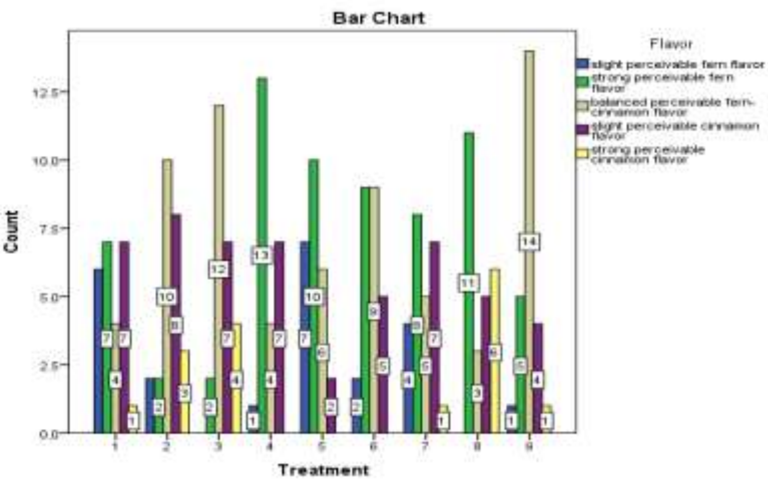

Figure 15. Flavor of different treatments of Fern-Cinnamon Tea from Sensory Evaluation

Aftertaste

The term "aftertaste" refers to the lingering flavors that persist in the mouth after consuming tea. This aspect of the tea-drinking experience is essential for assessing tea quality and complexity, although it is often

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underestimated. The aftertaste is influenced by the tea's mineral content and the degree of oxidation the leaves undergo, leading to distinct aftertastes for different tea types (Chong et al., 2022). Statistical analysis revealed that the amount of fern, and the interaction of factors (fern-cinnamon) significantly affected ($p \leq 0.05$ "Appendix table 29") the aftertaste acceptability of fern-cinnamon tea. Based on the results on the sensory evaluation it indicates at figure 18 that there are higher numbers of panelists evaluated that the fern-cinnamon tea has no bitter aftertaste (Appendix Table 18) this is possible because cinnamon is warm and sweet, with a hint of spice due to its presence of cinnamaldehyde, the compound responsible for cinnamon's flavor and aroma. However, this aftertaste is not typically described as bitter (Muhoza et al., 2021).

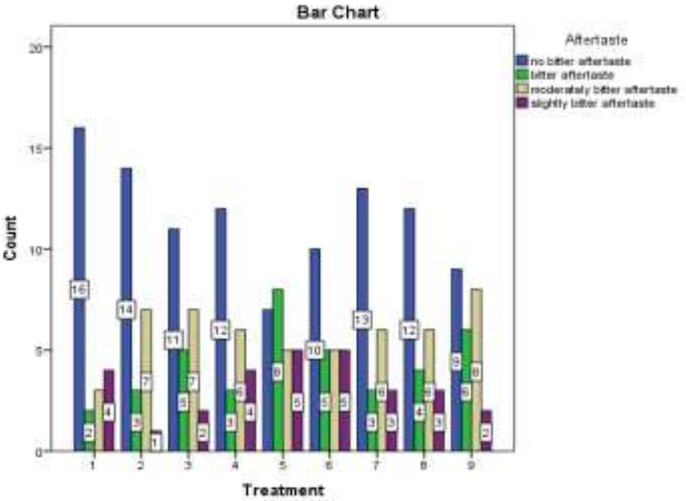

Figure 16. Aftertaste of different treatments of Fern-Cinnamon Tea from Sensory Evaluation

General Acceptability

Consumer reception of food products is affected by sensory qualities, food settings, cognitive factors, and palatability. Individuals often choose foods that provide them with the greatest enjoyment, and the sensory features of food are deemed a crucial factor in determining acceptability. Additionally, social approval significantly impacts consumer food preferences, as prevailing attitudes can influence eating intentions and consumption choices (Świąder et al.; 2021). Statistical analysis revealed that the amount of fern, cinnamon, and the interaction of factors fern and cinnamon levels significantly affected ($p \leq 0.05$ "Appendix 30") the general acceptability of fern-cinnamon tea. The results at figure 19 show that the general acceptability rating of fern-cinnamon tea ranged from lowest at 6.44 Treatment 1 to 8.20 Treatment 3 being the highest. Using the 9-point hedonic scale ranging from 1 (Dislike Extremely) to 9 (Extremely Like), with each number corresponding to a specific level of liking or disliking towards food items. The scale includes ratings such as 2 (Dislike Very Much), 3 (Dislike Moderately), 4 (Dislike Slightly), 5 (Neither like nor dislike), 6 (Like Slightly), 7 (Like Moderately), 8 (Like Very Much), and 9 (Extremely Like), representing varying degrees of preference and neutrality based on sensory attributes and personal taste experiences. The results indicate at table 5 shows that treatment 3 has the highest general acceptability across all treatments indicating that it is the most acceptable formulation.

Table 4. Sensory Evaluation Data

Treatment	Color	Aroma	Flavor	Aftertaste^{ns}	Gen. Acceptability
1	6.44 ± 0.961^{d}	$6.80 \pm .764^{b}$	6.68 ± 0.557^{bc}	7.20 ± 1.04	6.64 ± 0.638^{bc}
2	6.88 ± 1.333^{bcd}	7.16 ± 0.987^{ab}	7.00 ± 1.155^{abc}	7.12 ± 1.333	7.20 ± 1.080^{abc}
3	8.20 ± 0.866^{a}	7.72 ± 0.843^{a}	7.64 ± 0.995^{a}	7.52 ± 1.085	7.88 ± 0.781^{a}
4	6.56 ± 0.917^{cd}	6.76 ± 0.831^{b}	6.76 ± 0.723^{abc}	7.60 ± 1.041	6.84 ± 0.850^{bc}
5	6.64 ± 0.810^{cd}	7.00 ± 0.764^{ab}	6.28 ± 1.308^{c}	6.76 ± 1.052	6.48 ± 1.046^{c}
6	7.36 ± 0.907^{abc}	7.60 ± 0.913^{a}	7.08 ± 1.115^{abc}	7.40 ± 1.323	7.12 ± 0.881^{abc}

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7	6.84 ± 1.068^{bcd}	6.96 ± 0.84^{ab}	6.72 ± 1.275^{abc}	7.48 ± 1.194	6.92 ± 0.954^{bc}
8	7.56 ± 0.917^{ab}	7.40 ± 0.957^{ab}	6.64 ± 0.907^{bc}	7.04 ± 1.306	6.92 ± 0.812^{bc}
9	7.56 ± 0.917^{ab}	7.64 ± 1.114^{a}	7.36 ± 1.319^{ab}	7.24 ± 1.052	7.40 ± 0.866^{bc}

*Values are means ± standard deviation (n=25). Values within a column with same superscript are not significantly different ($p \geq 0.05$). *ns* denotes non-significant.

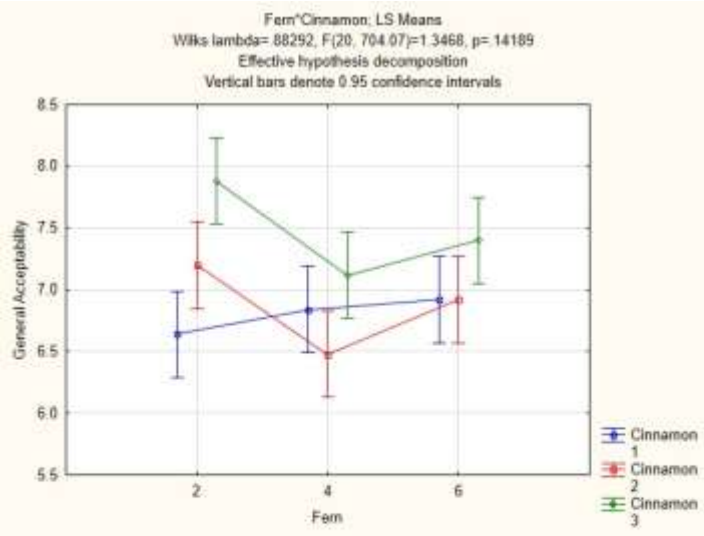

Figure 17. Effects of the interaction of factors on the general acceptability of Fern-Cinnamon Tea

Determining the Most Acceptable Formulation

The determination of the most acceptable treatment involves weighing the results of sensory evaluation, particularly in terms of general acceptability, alongside considering important physicochemical properties such as pH, TSS (Total Soluble Solids), water activity, and moisture content. Among all treatments, Treatment 3 received the highest mean score for general acceptability based on sensory evaluation, indicating it was favored by panelists. However, other treatments also met acceptable levels. Treatment 3 exhibited specific physicochemical properties within the desired range for tea. Its pH value of 6.18 falls within the optimal range for teas, contributing to balanced flavor and stability. The TSS value of 0.96 reflects a suitable concentration of soluble solids. The water activity value of 0.79 suggests favorable moisture conditions for microbial stability and shelf life. Additionally, the moisture content of 8.95% aligns well with quality standards for tea products, ensuring freshness and texture.

This comprehensive approach integrates both physicochemical and sensory properties to determine the most suitable treatment for meeting consumer expectations and maintaining product quality. While Treatment 3 excelled in general acceptability, adherence to key physicochemical criteria underscores its suitability for tea production and consumer satisfaction.

Total Phenolic Content of the Most Acceptable Formulation

Total phenolic content refers to the total amount of phenolic compounds in a substance, which are natural plant compounds that affect the flavor and mouthfeel of tea. These compounds include catechins, theaflavins, tannins, and flavonoids, are compounds that are a type of antioxidant that can help protect the body from damage caused by free radicals (Eruygur et al., 2018). In the context of tea, the total phenolic content is often used as a measure of the tea's antioxidant potential where a study has shown that tea, particularly green tea, is a rich source of phenolic compounds (Fu et al., 2011b). Table 7 shows that the total phenolic content of fern-cinnamon infused tea contains the value of 44.5 mg/GAE and 38.5 mg/GAE for fern-cinnamon powder. It can be observed that the value for infused tea is greater than the powder this is possibly because the total phenolic of tea powder can be influenced by factors such as the type of tea, extraction method, and specific tea samples, on the other hand, infused tea is influenced by the steeping process, temperature, and time (Dutta et. al., 2013). The study documented a total phenolic content (TPC) range of green tea is 80.27 mg GAE/g to 56.63 mg GAE/g of black tea across various tea samples (Qhairul et al., 2013). The study of Dutta et al. (2013) also showed that ceylon a cinnamon tea has 63.43 mg GAE/g which is close to the fern-cinnamon tea, this would suggest that fern-cinnamon tea is in the range for total phenolic content of tea.

Table 5. Total Phenolic Content Data Results

Test Parameters	Fern-Cinnamon Tea (Liquid)	Fern-Cinnamon Powder
Total Phenolic Content, µg/mg	44.5 mg GAE/g	38.5 mg GAE/g

Antioxidant, DPPH Scavenging Activity Analysis for the Most Acceptable Formulation Fern-Cinnamon Tea

Antioxidants in teas, specifically green and black tea, are responsible for their antioxidant activity, with tea flavanols, catechins, and theaflavins being the bioactive phytochemicals responsible for these properties. The antioxidant properties of tea can be affected by the production method, individual technological processes, and the origin of the tea itself (Peluso & Serafini, 2016). The antioxidant properties of foods vary depending on the content of phenolic compounds, vitamins C and E, carotenoids, and flavonoids. Among the phenolic compounds with known antioxidant activity, flavonoids, tannins, chalcones, and coumarins, as well as phenolic acids, are highlighted (Giada, 2013).

Table 6. Results of Antioxidant, DPPH Scavenging Activity

Concentration, µg/mL	Fern-Cinnamon Tea (Liquid)	Fern-Cinnamon Powder
12.5	18.9	8.9
25.0	28.8	14.5
50.0	34.5	20.5
100.0	44.8	34.6
250.0	59.8	40.5
500.0	75.5	57.5
IC_{50}	**215.9**	**383.4**

The IC_{50} value of a compound is a measure of its potency in inhibiting a specific biological or biochemical function, with lower IC50 values indicating higher potency, a lower IC50 value would indicate a stronger antioxidant (Jumina et al., 2019). According to the study of Budaraga and Putra (2021), a compound is said to be a very strong antioxidant if its IC50 value is less than 50 ppm, active if it is worth 50-100 ppm, while if it is 101-250 ppm and weak if it is greater than 250 ppm.

Table 7 presents an analysis showing that the fern-cinnamon tea has a concentration of 215.9 µg/L, which is lower than the concentration of 383.4 µg/g found in the fern-cinnamon powder. This indicates that the tea brewed from the powder is stronger in terms of concentration compared to the prepared tea itself. However, despite this higher concentration in the powder, the infused tea shows weaker antioxidant activity, as evidenced by higher IC50 values. The discrepancy in antioxidant activity between infused tea and tea powder can be attributed to the concentration of antioxidant compounds. Antioxidant compounds are more concentrated in powdered forms of tea, and some of these compounds may be lost or degraded during the brewing process of making tea. For instance, research by Nuryana et al. (2021) reported that green tea powder contains antioxidant concentrations ranging from 15.41 µg /L to 17.32 µg /L, whereas according to Unachukwu et al. (2010), green tea powder contains concentrations ranging from 21.38 to 228.20. These findings contradict the expectation that the infused tea would exhibit higher antioxidant activity compared to the tea powder.

The reason for this discrepancy lies in the concept of extraction efficiency, which refers to how effectively antioxidant compounds are extracted from tea during the brewing process. Factors such as water temperature, steeping duration, and tea concentration influence extraction efficiency. When extraction is more efficient, the infused tea is likely to contain a higher concentration of active compounds compared to tea powder (Cheng et al., 2023). Therefore, despite the lower concentration indicated in Table 7, the brewed tea can still retain potent antioxidant properties if the extraction process is optimized effectively.

Microbial Analysis

Microbial analysis of tea, including total plate count, yeast, and molds, is essential to ensure the safety and quality of tea products. The total plate count measures the total number of viable microorganisms, such as bacteria, yeast, and molds, present in a tea sample, serving as an indicator of overall microbial quality. Different regulations and standards often specify acceptable limits for total plate count in tea. Yeast and molds can grow on tea leaves under specific conditions, and while they are generally not harmful, excessive growth can indicate poor quality or improper storage conditions (Karunaratne et al., 2024). Regulatory guidelines, such as those outlined by the Tea and Herbal Infusions in Europe (THIE's) (2021), recommend limits for total plate count (no more than 10^7 microorganisms per gram) and molds (no more than 10^5 molds per gram) in tea samples. Table 8 indicates that fern-cinnamon infused tea exhibits negative to low counts of total plate count, yeast, and molds. Similarly, the fern-cinnamon powder shows low total plate count (<10 CFU/g) and yeast and mold count of 100 CFU/g. The low microbial values observed in both the tea and powder may be attributed to the potent antibacterial properties of cinnamon.

Cinnamon contains bioactive phytochemicals such as cinnamaldehyde, eugenol, and essential oils, which have been reported to inhibit bacterial growth by damaging cell membranes, altering lipid profiles, and inhibiting bacterial enzymes (Nabavi et al., 2015). These natural compounds contribute to the preservation and microbial safety of tea products, ensuring they meet quality standards and are safe for consumption.

Table 7. Microbial Analysis results for Fern-Cinnamon.

Microbial Analysis	Fern-Cinnamon Tea (Liquid)	Fern-Cinnamon Powder
Total Plate Count cfu/g	0 CFU/g	<10^{EST} CFU/g
Yeast and Molds cfu/g	0 CFU/g	100 CFU/g

(EST) estimated/approximate value

Production Cost Analysis

The production cost of fern-cinnamon tea bags includes both direct and indirect expenses. Each tea bag requires 2 grams of dried fern costing ₱0.15, 3 grams of cinnamon costing ₱2.64, and a tea bag material costing ₱1.28, summing up to a direct cost of ₱4.07 per tea bag. Indirect costs cover labor (₱0.25), electricity (₱0.30), and dehydrator expenses (₱0.15) per tea bag, totaling ₱0.70. Adding 10% for overhead increases the indirect costs by ₱0.07, making it ₱0.77 per tea bag. A 30% markup of ₱0.231 is applied, leading to a total indirect cost of ₱1.001 per tea bag. Combining direct and indirect costs, the total cost per tea bag is ₱5.071, resulting in a total cost of ₱507.10 for a pack of 100 tea bags. In the Philippine market according to various online selling platform, the prices of tea products packaged in 100-piece packs vary based on the type and brand of tea. For instance, Dilmah Infusion Tea Pure Peppermint in foil envelopes, containing 100 tea bags, is priced at ₱899.00. Similarly, other tea options available in the market include Twinings Pure Green Tea, priced at ₱850.00 for 100 tea bags, and Tetley Decaffeinated Tea Bags, offered at ₱500.00 per 100-pack. Additionally, Lipton Tea is priced ₱900 per 100pcs per pack. This indicates that the fern-cinnamon product is within the range of the commercially available tea products. The availability of different tea varieties and price points caters to diverse consumer preferences, with higher prices often associated with premium tea brands and specialty blends (Ong et al., 2021).

Table 8. Production of the most acceptable fern-cinnamon tea

Direct Cost			
Raw Materials	Quantity per teabag	Price	Total price per tea bag
Fern	2g	15.00	0.15c

Cinnamon	3g	264.00	2.64
Tea Bag Materials (100 tea bags)	1	128.00	1.28
Total			**4.07 (per tea bag)**
Indirect Cost			
Labor Cost (per pack)	-	25.00	0.25
Electricity Cost (per pack)	-	30.00	0.3
Dehydrator Cost (per pack)	-	15.00	0.15
Sub-total 1		70.00	0.7
Overhead (10%)		7.00	0.07
Sub-total 2		77.00	0.77
Mark-up (30%)		23.1	0.231
Sub-total 3		**100.1**	**1.001**
Total (Direct Cost and Indirect Cost per tea bag)			**₱5.071**

SUMMARY, CONCLUSION AND RECOMMENDATION

Summary

The study was conducted at the College of Human Ecology Integrated Laboratory Building at Central Mindanao University, Musuan, Maramag, Bukidnon, from January to April 2023. The study focused on the development and evaluation of a fern-cinnamon tea formulation, analyzing its physicochemical, sensory properties, antioxidant properties, and total phenolic content. The pH of the fern-cinnamon tea ranged between 6.18 to 6.57, indicating that its neutral . Total soluble solids (TSS) ranging from (0.83-1.31)˚ brix, water activity, moisture content (7.45-13.96%). The water activity (A_w) of the fern-cinnamon tea powder fell between .661-.697 indicating low moisture availability that could inhibit microbial growth. Moisture content ranged from 7.45% to 13.96%, within acceptable levels for tea powders. Color analysis revealed moderate lightness ($L*$ values between 46.73 and 54.34), a reddish-brown hue ($a*$ values between 13.15 and 31.54), and a bluish tone ($b*$ values between 44.79 and 58.26).

In sensory evaluation, Treatment 3, containing 2g each of fern and 3g of cinnamon, scored highest in taste, aroma, color, aftertaste, and overall acceptability. Moreover, as evidenced in the sensory evaluation of the products, Treatment 3 was found to be the most acceptable sample with a mean score of 7.88. Further analysis of Treatment 3 to mineral content (ongoing), medium antioxidant activity at IC_{50} where fern-cinnamon infused tea have 215.9 and 383.4 for powder, and total phenolic content for the infused fern-cinnamon tea at 44.5 mg GAE/g while the fern-cinnamon powder at 38.5 mg GAE/g. Microbial analysis confirmed low total plate count, yeast, and mold levels in the most acceptable formulation, indicating good microbial quality. The study also assessed the production cost for this formulation which the price if sold for 100pcs per pack the price would be at ₱507.01.

Overall, the findings demonstrate the successful development of a fern-cinnamon tea with desirable physicochemical properties, high sensory acceptability, beneficial nutritional profile, and good microbial quality, highlighting its potential as a functional beverage.

Conclusion

The investigation produced several significant findings that led to the following conclusions:

1. physicochemical properties of the produced fern-cinnamon tea in terms of pH (6.18-6.57), TSS (1 °Brix),

water activity (0.66-0.69), and moisture contents (7.45% -13.96%) are within the acceptable limit. Fern powder in the formulation greatly influenced the color values of product.

2. sensory properties of fern-cinnamon with added fern powder are acceptable to the panel members. In terms of taste, the produced fern-cinnamon has a balanced and pleasant flavor that appeals to a wide range of consumers. The aftertaste is not bitter to taste. Flavor also have been balanced with fern and cinnamon flavor. Appearance is visually appealing with deep saffron color, that is acceptable to the consumer.
3. The most acceptable formulation also exhibited total phenolic content and antioxidant activity and suggesting potential health benefits.
4. Fern-cinnamon passed standard for the microbial count in terms of yeast and mold and is therefore safe for human consumption with a low risk of microbial spoilage.
5. produced fern-cinnamon are priced at ₱507.01 per pack containing 100 teabags , which is lower compared to the existing tea's found commercially.

Recommendation

For further development of the study, the author recommends the following:

1. Future researchers may focus on standardizing the fern-cinnamon tea in terms of infusing time and temperature as well exploring deeply on phytochemical components of the tea.
2. Improving training and increasing the number of panelists could enhance the reliability of sensory analysis outcomes.
3. Toxicity test may also be good for this study to identify the toxicity levels of the infused tea.
4. Identify which phenols are high in the infused tea may be explored to strengthen its claims for antioxidant benefits.
5. Future research may also include Vitamins and Minerals content on the infused and tea powder.

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APPENDICES

Appendix 1. Sensory Evaluation Scoresheet

FERN-CINNAMON TEA
SENSORY SCORESHEET

Judge No. ____________________ Date ____________
Name (Optional): ____________________ Age ____________

Instruction: Kindly evaluate the samples below for their description and acceptability using the scale provided below. Please rinse your mouth before evaluating next samples.

Sample Codes

		____	____	____	____	____	____	____	____	____
Color	Description	____	____	____	____	____	____	____	____	____
	Acceptability	____	____	____	____	____	____	____	____	____
Aroma	Description	____	____	____	____	____	____	____	____	____
	Acceptability	____	____	____	____	____	____	____	____	____
Flavor	Description	____	____	____	____	____	____	____	____	____
	Acceptability	____	____	____	____	____	____	____	____	____
Aftertaste	Description	____	____	____	____	____	____	____	____	____
	Acceptability	____	____	____	____	____	____	____	____	____
General Acceptability		____	____	____	____	____	____	____	____	____

Color

Aroma

1 - slight perceivable fern aroma
2 – strong perceivable fern aroma
3 – balanced perceivable fern-cinnamon aroma
4 – slight perceivable cinnamon aroma
5 – strong perceivable cinnamon aroma

Flavor

1 - slight perceivable fern flavor
2 – strong perceivable fern flavor
3 – balanced perceivable fern-cinnamon flavor
4 – slight perceivable cinnamon flavor
5 – strong perceivable cinnamon flavor

Aftertaste

1 - no bitter aftertaste
2 – bitter aftertaste
3 – moderately bitter aftertaste
4 –slightly bitter aftertaste
5 – verry bitter

Sensory Acceptability

9 – Extremely Like
8 – Like Very Much
7 – Like Moderately
6 – Like Slightly
5 – Neither like nor dislike
4 – Dislike Slightly
3 – Dislike Moderately
2 – Dislike very much
1 – Dislike Extremely

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Appendix 2. Total Phenolic Content, Microbial Analysis, and Antioxidant

Analyses Results.

TESTING & RESEARCH LABORATORY
For Better Future

Making progress through research and development

Client : **LUCAGBO, JULIUS KIM**
Address : Maramag, Bukidnon
Sample : Cinnamon tea liquid (01); Powder (01)

Date Received: March 8, 2024
Date Reported: March 19, 2024

OFFICIAL RESULTS

TEST PARAMETER	Cinnamon tea Liquid	Powder (Fern and Cinnamon)	
Total Phenolic Content, ug/g	44.5	38.5	
Yeast and Molds, cfu/g	-	<10	
Total Plate Count, cfu/g	-	100	
Antioxidant, DPPH Scavenging activity			
Concentration, ug/mL	**Cinnamon tea Liquid**	**Powder (Fern and Cinnamon)**	**Ascorbic Acid**
12.5	18.9	8.9	25.5
25.0	28.8	14.5	38.9
50.0	34.5	20.5	45.5
100.0	44.8	34.5	59.8
250.0	59.8	40.5	72.5
500.0	75.5	57.5	90.8
IC_{50}	**215.9**	**383.4**	**109.4**

NOTE:

1. Results are solely based on the submitted and tested samples. The laboratory cannot guarantee that the submitted samples are representative of the entire batch.
2. Results shall not be reproduced in any form other than in their entirety.
3. Scan the QR code to verify the electronic results of the test.

Reported and approved by:

(Sgd) VENCHIE C. BADONG, RCH, CSSO, MAT
Managing Director
Registered Chemists
PRC License No.: 00009039

wvnreslab@gmail.com
(082) 308 - 0681

Door 1, Junsay Building, Elpidio Quirino Ave.,
Talomo, Davao City, 8000 Davao del Sur

Appendix 3. IERC Approval Letter

Republic of the Philippines
CENTRAL MINDANAO UNIVERSITY
University Town, Musuan, Bukidnon

Office of Research

INSTITUTIONAL ETHICS REVIEW COMMITTEE
(IERC)

APPROVAL LETTER

May 22, 2024

JULIUS KIM T. LUCAGBO
COLLEGE OF HUMAN ECOLOGY

ATTENTION: **JOSE S. VALMORIDA**
ACADEMIC Adviser

This is to inform you that after a thorough review of your protocol and requirements for ethical consideration, you are hereby granted an IERC permit to proceed in the conduct of your study, provided the following minor comment(s) and recommendation(s) is/are followed:

Title of Research:

"CHARACTERIZATION OF FIDDLEHEAD FERN (*Diplazium esculentum*) AND CINNAMON BARK (*Cinnamomum cassia*) TEA"

Category: Undergraduate Thesis

Method: Qualitative Approach

Comment/s and Recommendation/s:

Ensure that the Informed Consent includes the following information: the study objectives and methods, the expected duration of participation, Potential risks with their corresponding mitigation strategies, the advantages for participants, the option for respondents to withdraw from the study, acknowledgment of confidentiality in accordance with the Data Privacy Act, and contact details for the researchers for any participant queries.

This approval is only valid for one year. Please be advised that any changes in your protocol should be reported to the IERC for appropriate notation on your protocol.

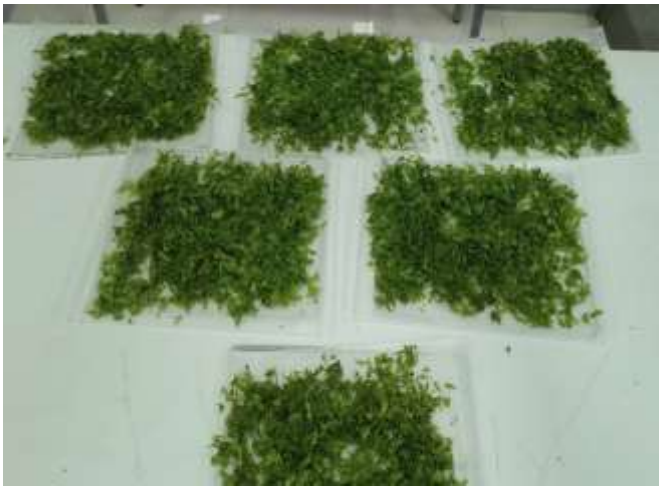
Very truly yours,

MARK LLOYD G. DAPAR
Chairperson, Institutional Ethics Review Committee (IERC)
IERC Control Number: 1129 s. 2024

Email: researchoffice@cmu.edu.ph — The Academic Paradise of the South — Contact Number: 09170B0439

APPENDIX FIGURES

Appendix Figure 1. Fern Preparation and Drying



Appendix Figure 2. Commercial Cinnamon Sticks

Figure 3. Grounded Fern and Cinnamon

Appendix Figure 4. Treatment 1, 2, 3 of Fern-Cinnamon Powder

Appendix Figure 5. Treatment 4, 5, 6 of Fern-Cinnamon Powder

Appendix Figure 6. Treatment 7, 8, 9 of Fern-Cinnamon Powder

Appendix Figure 7. Tea bagging of Fern-Cinnamon Powder

Appendix Figure 8. Infused Fern-Cinnamon Tea

APPENDIX TABLE

Appendix Table 1. ANOVA Table for the physicochemical properties of fern-cinnamon

	VARIABLE	SUM OF SQUARES	df	MEAN OF SQUARE	F	SIG.
pH	Between Groups	.298	8	.037	59.567	.000
	Within Groups	.011	18	.001		
	Total	.310	26			
Water Activity	Between Groups	.003	8	.000	97.701	.000
	Within Groups	.000	18	.000		
	Total	.003	26			
TSS	Between Groups	.471	8	.059	548.466	.000
	Within Groups	.002	18	.000		
	Total	.473	26			
Moisture Content	Between Groups	135.073	8	16.884	213.413	.000
	Within Groups	1.424	18	.079		
	Total	136.497	26			
L	Between Groups	385.754	8	48.219	356.076	.000
	Within Groups	2.438	18	.135		
	Total	388.192	26			
a	Between Groups	1510.343	8	188.793	1190.455	.000
	Within Groups	2.855	18	.159		
	Total	1513.198	26			
b	Between Groups	670.382	8	83.798	891.851	.000
	Within Groups	1.691	18	.094		
	Total	672.073	26			
Wavelength	Between Groups	99.667	8	12.458	.682	.702
	Within Groups	329.000	18	18.278		
	Total	428.667	26			
Absorbance	Between Groups	15.873	8	1.984	13.465	.000
	Within Groups	2.652	18	.147		
	Total	18.526	26			

Appendix Table 2. Tukey test for pH

Treatment	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
3	3	6.1800					
2	3		6.2700				
6	3		6.2867	6.2867			
1	3			6.3467	6.3467		
5	3			6.3500	6.3500		
9	3				6.3700	6.3700	
8	3				6.4167	6.4167	
4	3					6.4367	

7	3						6.5700
Sig.		1.000	.995	.107	.058	.079	1.000
Means for groups in homogeneous subsets are displayed. a. Uses Harmonic Mean Sample Size = 3.000.							

Appendix Table 3. Tukey test for Total Soluble Solids

Treatment	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
1	3	.8333					
2	3		.9233				
4	3		.9467	.9467			
3	3			.9633	.9633		
5	3				.9833		
7	3				.9833		
8	3					1.1067	
6	3					1.1100	
9	3						1.3133
Sig.		1.000	.196	.580	.358	1.000	1.000
Means for groups in homogeneous subsets are displayed. a. Uses Harmonic Mean Sample Size = 3.000.							

Appendix Table 4. Tukey test for Water activity

Treatment	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
1	3	.6613					
2	3		.6753				
4	3		.6767				
3	3		.6793	.6793			
5	3			.6830	.6830		
7	3				.6850		
6	3				.6880	.6880	
8	3					.6920	.6920
9	3						.6970
Sig.		1.000	.226	.318	.069	.226	.069
Means for groups in homogeneous subsets are displayed. a. Uses Harmonic Mean Sample Size = 3.000.							

Appendix Table 5. Tukey test for Moisture Content

Treatment	N	Subset for alpha = 0.05					
		1	2	3	4	5	6
1	3	7.4513					
2	3	7.8147					
3	3		8.9583				

4	3			10.3977			
5	3			10.9173	10.9173		
6	3				11.3213		
7	3					12.9283	
8	3					13.3583	13.3583
9	3						13.9600
Sig.		.802	1.000	.410	.706	.639	.244
Means for groups in homogeneous subsets are displayed. a. Uses Harmonic Mean Sample Size = 3.000.							

Appendix Table 6. Tukey test for *L** values

Treatment	N	Subset for alpha = 0.05				
		1	2	3	4	5
6	3	46.7333				
5	3		48.2833			
4	3		48.5233			
9	3			54.3433		
1	3			54.4000		
8	3				55.6333	
3	3				56.1233	56.1233
2	3				56.2733	56.2733
7	3					56.9833
Sig.		1.000	.995	1.000	.485	.164
Means for groups in homogeneous subsets are displayed. a. Uses Harmonic Mean Sample Size = 3.000						

Appendix Table 7. Tukey test for *a** values

Treatment	N	Subset for alpha = 0.05				
		1	2	3	4	5
9	3	13.1533				
8	3	13.6633				
7	3		15.4133			
6	3			27.3033		
5	3				28.4733	
4	3				28.9033	
1	3					30.5267
2	3					31.2633

3	3					31.5433
Sig.		.809	1.000	1.000	.912	.102
Means for groups in homogeneous subsets are displayed. a. Uses Harmonic Mean Sample Size = 3.000.						

Appendix Table 8. Tukey test for *b** values

Treatment	N	Subset for alpha = 0.05						
		1	2	3	4	5	6	7
9	3	44.7933						
8	3		45.7833					
7	3			46.8533				
6	3				47.7733			
5	3					49.1433		
4	3					49.9933		
1	3						56.7700	
2	3						57.3433	
3	3							58.2600
Sig.		1.000	1.000	1.000	1.000	.062	.395	1.000
Means for groups in homogeneous subsets are displayed. a. Uses Harmonic Mean Sample Size = 3.000.								

Appendix Table 9. ANOVA Table for the Sensory Evaluation of fern-cinnamon

	VARIABLE	SUM OF SQUARES	df	MEAN OF SQUARE	F	SIG.
Color	Between Groups	68.836	8	8.604	9.015	.000
	Within Groups	206.160	216	.954		
	Total	274.996	224			
Aroma	Between Groups	27.760	8	3.470	4.316	.000
	Within Groups	173.680	216	.804		
	Total	201.440	224			
Flavor	Between Groups	33.840	8	4.230	3.696	.000
	Within Groups	247.200	216	1.144		
	Total	281.040	224			
Aftertaste	Between Groups	14.329	8	1.791	1.320	.235
	Within Groups	293.200	216	1.357		
	Total	307.529	224			
General Acceptability	Between Groups	35.236	8	4.404	5.586	.000
	Within Groups	170.320	216	.789		
	Total	205.556	224			

Appendix Table 10. Tukey test for Sensory Evaluation Color Acceptability

Treatment	N	Subset for alpha = 0.05			
		1	2	3	4
1	25	6.44			
4	25	6.56	6.56		
5	25	6.64	6.64		
7	25	6.84	6.84	6.84	
2	25	6.88	6.88	6.88	
6	25		7.36	7.36	7.36
8	25			7.56	7.56
9	25			7.56	7.56
3	25				8.20
Sig.		.808	.096	.190	.065
Means for groups in homogeneous subsets are displayed. a. Uses Harmonic Mean Sample Size = 25.000.					

Appendix Table 11. Tukey test for Sensory Evaluation Aroma Acceptability

Treatment	N	Subset for alpha = 0.05	
		1	2
4	25	6.76	
1	25	6.80	
7	25	6.96	6.96
5	25	7.00	7.00
2	25	7.16	7.16
8	25	7.40	7.40
6	25		7.60
9	25		7.64
3	25		7.72
Sig.		.227	.073
Means for groups in homogeneous subsets are displayed. a. Uses Harmonic Mean Sample Size = 25.000.			

Appendix Table 12. Tukey test for Sensory Evaluation Flavor Acceptability

Treatment	N	Subset for alpha = 0.05		
		1	2	3
5	25	6.28		
8	25	6.64	6.64	
1	25	6.68	6.68	
7	25	6.72	6.72	6.72
4	25	6.76	6.76	6.76
2	25	7.00	7.00	7.00

6	25	7.08	7.08	7.08
9	25		7.36	7.36
3	25			7.64
Sig.		.175	.301	.065
Means for groups in homogeneous subsets are displayed. a. Uses Harmonic Mean Sample Size = 25.000.				

Appendix Table 13. Tukey test for Sensory Evaluation Aftertaste Acceptability

Treatment	N	Subset for alpha = 0.05
		1
5	25	6.76
8	25	7.04
2	25	7.12
1	25	7.20
9	25	7.24
6	25	7.40
7	25	7.48
3	25	7.52
4	25	7.60
Sig.		.215
Means for groups in homogeneous subsets are displayed. a. Uses Harmonic Mean Sample Size = 25.000.		

Appendix Table 14. Tukey test for Sensory Evaluation General Acceptability

Treatment	N	Subset for alpha = 0.05		
		1	2	3
5	25	6.48		
1	25	6.64	6.64	
4	25	6.84	6.84	
7	25	6.92	6.92	
8	25	6.92	6.92	
6	25	7.12	7.12	7.12
2	25	7.20	7.20	7.20
9	25		7.40	7.40
3	25			7.88
Sig.		.103	.068	.068
Means for groups in homogeneous subsets are displayed. a. Uses Harmonic Mean Sample Size = 25.000.				

Appendix Table 15. Crosstabulation of Color in Sensory Evaluation among treatments.

		Color				Total
		Pale Spring Bud	Straw	Sunglow	Deep Safron	
Treatment	1	18	7	0	0	25
	2	2	16	7	0	25

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	3	0	1	4	20	25
	4	17	7	1	0	25
	5	4	20	1	0	25
	6	0	12	13	0	25
	7	15	9	1	0	25
	8	0	10	11	4	25
	9	0	3	18	4	25
Total		56	85	56	28	225

Appendix Table 16. Crosstabulation of Aroma in Sensory Evaluation among treatments.

		Aroma					Total
		slight perceivable fern aroma	strong perceivable fern aroma	balanced perceivable fern-cinnamon aroma	slight perceivable cinnamon aroma	strong perceivable cinnamon aroma	
Treatment	1	0	7	6	7	5	25
	2	0	0	9	8	8	25
	3	0	2	14	2	7	25
	4	5	8	8	4	0	25
	5	3	8	10	3	1	25
	6	0	5	7	10	3	25
	7	5	3	11	6	0	25
	8	1	3	17	3	1	25
	9	0	4	17	3	1	25
Total		14	40	99	46	26	225

Appendix Table 17. Crosstabulation of Flavor in Sensory Evaluation among treatments.

		Flavor					Total
		slight perceivable fern flavor	strong perceivable fern flavor	balanced perceivable fern-cinnamon flavor	slight perceivable cinnamon flavor	strong perceivable cinnamon flavor	
Treatment	1	6	7	4	7	1	25
	2	2	2	10	8	3	25
	3	0	2	12	7	4	25
	4	1	13	4	7	0	25
	5	7	10	6	2	0	25
	6	2	9	9	5	0	25
	7	4	8	5	7	1	25
	8	0	11	3	5	6	25
	9	1	5	14	4	1	25
Total		23	67	67	52	16	225

Appendix Table 18. Crosstabulation of Aftertaste in Sensory Evaluation among treatments.

		Aftertaste				Total
		no bitter aftertaste	bitter aftertaste	moderately bitter aftertaste	slightly bitter aftertaste	
Treatment	1	16	2	3	4	25
	2	14	3	7	1	25

	3	11	5	7	2	25
	4	12	3	6	4	25
	5	7	8	5	5	25
	6	10	5	5	5	25
	7	13	3	6	3	25
	8	12	4	6	3	25
	9	9	6	8	2	25
Total		104	39	53	29	225

Appendix Table 19. ANOVA Table for the pH of Fern-Cinnamon Tea

Effect	Degree of Freedom	Sum of Square	Mean of Square	F	p
Intercept	1	1091.630	1091.630	1744025	0.000000
Fern	2	0.157	0.078	125	0.000000
Cinnamon	2	0.136	0.068	108	0.000000
Fern-Cinnamon	4	0.006	0.001	2	0.099866
Error	18	0.011	0.001		
Total	26	0.310			

Appendix Table 20. ANOVA Table for the Total Soluble Solids of Fern-Cinnamon Tea

Effect	Degree of Freedom	Sum of Square	Mean of Square	F	p
Intercept	1	27.98889	27.98889	260586.2	0.000000
Fern	2	0.23379	0.11689	1088.3	0.000000
Cinnamon	2	0.19681	0.09840	916.2	0.000000
Fern-Cinnamon	4	0.04068	0.01017	94.7	0.000000
Error	18	0.00193	0.00011		
Total	26	0.47321			

Appendix Table 21. ANOVA Table for the Water Activity of Fern-Cinnamon Tea

Effect	Degree of Freedom	Sum of Square	Mean of Square	F	p
Intercept	1	12.55698	12.55698	3725699	0.000000
Fern	2	0.00169	0.00084	250	0.000000
Cinnamon	2	0.00088	0.00044	131	0.000000
Fern-Cinnamon	4	0.00006	0.00002	5	0.008771
Error	18	0.00006	0.00000		
Total	26	0.00269			

Appendix Table 22. ANOVA Table for the Moisture Content of Fern-Cinnamon Tea

Effect	Degree of Freedom	Sum of Square	Mean of Square	F	p
Intercept	1	3143.278	3143.278	39730.46	0.000000
Fern	2	128.465	64.232	811.89	0.000000
Cinnamon	2	6.110	3.055	38.62	0.000000
Fern-Cinnamon	4	0.498	0.125	1.57	0.223950
Error	18	1.424	0.079		
Total	26	136.497			

Appendix Table 23. ANOVA Table for the Color of Fern-Cinnamon Tea ($L*$)

Effect	Degree of Freedom	Sum of Square	Mean of Square	F	p
Intercept	1	75937.37	75937.37	560760.6	0.000000
Fern	2	363.13	181.57	1340.8	0.000000
Cinnamon	2	5.45	2.72	20.1	0.000026
Fern-Cinnamon	4	17.17	4.29	31.7	0.000000
Error	18	2.44	0.14		
Total	26	388.19			

Appendix Table 24. ANOVA Table for the Color of Fern-Cinnamon Tea ($a*$)

Effect	Degree of Freedom	Sum of Square	Mean of Square	F	p
Intercept	1	16169.04	16169.04	101955.7	0.000000
Fern	2	1496.14	748.07	4717.1	0.000000
Cinnamon	2	4.04	2.02	12.7	0.000356
Fern-Cinnamon	4	10.16	2.54	16.0	0.000009
Error	18	2.85	0.16		
Total	26	1513.20			

Appendix Table 25. ANOVA Table for the Color of Fern-Cinnamon Tea ($b*$)

Effect	Degree of Freedom	Sum of Square	Mean of Square	F	p
Intercept	1	69529.02	69529.02	739991.2	0.000000
Fern	2	653.10	326.55	3475.4	0.000000
Cinnamon	2	3.89	1.95	20.7	0.000021

Fern-Cinnamon	4	13.39	3.35	35.6	0.000000
Error	18	1.69	0.09		
Total	26	672.07			

Appendix Table 26. ANOVA Table for the Fern-Cinnamon Tea Color Sensory Evaluation

Effect	Degree of Freedom	Sum of Square	Mean of Square	F	p
Intercept	1	11392.00	11392.00	11935.74	0.000000
Fern	2	8.54	4.27	4.47	0.012466
Cinnamon	2	45.72	22.86	23.95	0.000000
Fern-Cinnamon	4	14.58	3.64	3.82	0.005077
Error	216	206.16	0.95		
Total	224	275.00			

Appendix Table 27. ANOVA Table for the Fern-Cinnamon Tea Aroma Sensory Evaluation

Effect	Degree of Freedom	Sum of Square	Mean of Square	F	p
Intercept	1	11750.56	11750.56	14613.78	0.000000
Fern	2	1.71	0.85	1.06	0.347816
Cinnamon	2	24.99	12.49	15.54	0.000000
Fern-Cinnamon	4	1.07	0.27	0.33	0.856500
Error	216	173.68	0.80		
Total	224	201.44			

Appendix Table 28. ANOVA Table for the Fern-Cinnamon Tea Flavor Sensory Evaluation

Effect	Degree of Freedom	Sum of Square	Mean of Square	F	p
Intercept	1	10732.96	10732.96	9378.315	0.000000
Fern	2	6.00	3.00	2.621	0.075016
Cinnamon	2	23.36	11.68	10.206	0.000058
Fern-Cinnamon	4	4.48	1.12	0.979	0.420068
Error	216	247.20	1.14		
Total	224	281.04			

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Appendix Table 29. ANOVA Table for the Fern-Cinnamon Tea Aftertaste Sensory Evaluation

Effect	Degree of Freedom	Sum of Square	Mean of Square	F	p
Intercept	1	11866.47	11866.47	8742.011	0.000000
Fern	2	0.04	0.02	0.013	0.986989
Cinnamon	2	9.45	4.72	3.480	0.032530
Fern-Cinnamon	4	4.84	1.21	0.892	0.469406
Error	216	293.20	1.36		
Total	224	307.53			

Appendix Table 30. ANOVA Table for the Fern-Cinnamon Tea General Acceptability Sensory Evaluation

Effect	Degree of Freedom	Sum of Square	Mean of Square	F	p
Intercept	1	11165.44	11165.44	14160.03	0.000000
Fern	2	6.97	3.48	4.42	0.013155
Cinnamon	2	20.22	10.11	12.82	0.000005
Fern-Cinnamon	4	8.04	2.01	2.55	0.040189
Error	216	170.32	0.79		
Total	224	205.56			