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Physico-chemical characteristics and consumer preference of various brew concentrations of Coffee substitutes made from the combination of Malunggay leaves, Okra seeds, and Ipil-Ipil seeds

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Abstract The study investigated the physico-chemical characteristics and consumer preference of various brew concentrations of coffee substitutes made from malunggay leaves, okra seeds, and ipil-ipil seeds. The results suggested that the brew concentration of F3 (5.0 g/330 mL water) had the highest potential marketability than F1 (1.0 g/330 mL water) or F2 (2.5 g/330 mL water). Among the three brew concentrations, F3 showed the highest total dissolved solids and lowest pH, hence resembling the actual coffee the most. This is also evident with the results of the consumer preference as F3 was the most preferred by consumers, regardless of age group and sex.

Keywords: Malunggay leaves, Okra seeds, Ipil-Ipil Seeds, Coffee substitute, Brew concentration

Introduction

Coffee has already become an integral part of human society. People may drink coffee just after waking up to activate their mood, when taking a break from work, meeting with friends and other people, or simply for personal satisfaction. Consumers claim drinking coffee energizes them and can have therapeutic effects (Samoggia and Riedel, 2019). This reported effect is due to coffee containing caffeine, which can enhance a person's mood and alertness, improve performance, and speed up blood flow. In the right amount, caffeine has no severe side effects as it reduces anxiety and elevates mood. However, excessive consumption can lead to anxiety, restlessness, and sleeplessness (Richards and Smith, 2015). In addition, children born to mothers who consume coffee or other

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caffeinated beverages are smaller and leaner than other children. The baby's reduced size at birth may raise their risk of acquiring diabetes, heart disease, and obesity as they mature (Gleason *et al.*, 2021).

Due to these adverse effects, several studies have looked at the development of coffee substitutes; these are non-coffee products that imitate the taste, flavor, and aroma of the actual coffee but with added nutritional benefits and without the aforementioned adverse effects (Mostafa *et al.*, 2021). These are generally prepared by roasting plant materials, such as leaves, roots, fruit, and seeds, then brewed for consumption. The roasting step is crucial as it induces the Maillard reaction, which produces various chemicals, such as pyrazines, furans, ketones, and aldehydes, that contribute to the taste, flavor, and aroma of the coffee substitute that is very similar to the actual coffee (Majcher *et al.*, 2013 as cited by Mostafa *et al.*, 2021). Some coffee substitutes that were proven to be suitable for consumption and are received positively by consumers include roasted quinoa seeds (Fouad Abou-Zaid, 2022), chicory root (Charoenphun and Puttha, 2021), roasted date, roasted barley (Tarawneh *et al.*, 2021), a mixture of roasted malunggay seeds, ampalaya seeds, and okra seeds (Carag, 2022), and roasted durian seeds (Natania and Wijaya, 2022) among others.

In the Philippines, coffee is widely enjoyed in almost every household (Rappler, 2015). According to the report of Statistica (2023), the consumption of coffee in the country rose to about 18.2% from 2.8 million 60-kg bags in 2014 to 3.31 million 60-kg bags in 2020. The recent COVID-19 pandemic also significantly increased coffee consumption (Thubsang *et al.*, 2022; Batista *et al.*, 2023). The alarming increase in coffee consumption among Filipinos led to the conceptualization of this study, which intended to develop a coffee substitute that can be marketed to Filipinos to lessen the consumption of coffee and lower the risk for the aforementioned adverse effects. In this study, the substitute-formulated coffee consisted of a combination of various plant-based ingredients commonly found and accessible in the backyards of most Filipino households: malunggay leaves (*Moringa oleifera*), okra seeds (*Abelmoschus esculentus*), and ipil-ipil seeds (*Leucaena leucocephala*). Malunggay leaves are beneficial in several chronic conditions, including hypercholesterolemia, high blood pressure, diabetes, insulin resistance, non-alcoholic liver disease, cancer, and overall inflammation (Vergara-Jimenez *et al.*, 2017). It has also been shown to contain vitamins (A, C, and E), minerals (potassium, calcium, magnesium, iron, and copper), phenolic compounds, and protein (Hekmat *et al.*, 2015; Saini *et al.*, 2014). On the other hand, okra seeds have appreciable amounts of oil and protein (Gemede *et al.*, 2015). It also contains several phenolic compounds, such as oligomeric catechins (2.5 mg/g of seeds) and flavonol derivatives (3.4 mg/g of seeds) (Arapitsas, 2008). Both catechins and flavonols have antioxidant, antimicrobial, anti-inflammatory, and anticancer properties (Bae *et al.*, 2020). Okra seeds are also used as coffee substitutes in Turkey (Calisir *et al.*, 2005). Lastly, ipil-ipil seeds are found to be a good source of protein at about 31.1% of the seed (Sethi and Kulkarni, 1994). In addition, it is also rich in essential amino acids such as isoleucine, leucine, phenylalanine, and histidine, minerals such as calcium and phosphorus, and vitamins such as thiamine, riboflavin, niacin, beta carotenes, and ascorbic acid (Sethi and Kulkarni, 1995). The study by Zayed *et al.* (2018) reviewed that ipil-ipil seeds have anthelmintic, antioxidant, antidiabetic, and antimicrobial properties. It has also been traditionally roasted and used as a coffee substitute in the Philippines.

The objectives were to determine the effect of coffee substitute brew concentration on the total dissolved solids (TDS), the pH, the preference of consumers across various age groups, and the preference of male and female consumers.

Materials and methods

Preparation of ingredients

The malunggay leaves, okra seeds, and ipil-ipil seeds were collected from the backyard within the Municipality of Alfonso Lista, Ifugao, Philippines. The malunggay leaves were all matured without signs of wilting or discoloration. The okra seeds were of proper maturity, not too young and mature. The ipil-ipil seeds were harvested from green ipil-ipil pods. Once harvested, the ingredients were washed with tap water and distilled water. The washed ingredients were then air-dried and sun-dried. After drying, each ingredient was roasted separately on a frying pan over low heat until they changed color and gave off an aromatic smell. After roasting, each ingredient was cooled down and then powdered using a food processor. Each powdered ingredient was separately stored in an air-tight glass container.

Preparation of coffee substitute powder mixture

The following ingredients were mixed to prepare the coffee substitute powder mixture: 0.25 kg of dried malunggay leaves powder, 0.50 kg of roasted okra seeds powder, and 1.00 kg of roasted ipil-ipil seed powder.

Preparation of coffee substitute drink

The coffee substitute drink was prepared following a variation in brew concentration, as shown in Table 1.

Table 1. Coffee substitute formulations prepared

Formulation	Coffee Substitute Brew Concentration (g/330 mL water)
F1	1.0
F2	2.5
F3	5.0

The distilled water was used to prepare the coffee substitute drink. The measured coffee substitute powder was added upon reaching the distilled water's boiling point. After 5 min of brewing, the coffee substitute brew mixture was immediately filtered using a cheesecloth to remove the residual coffee substitute powder. The filtrate was immediately stored in an insulated stainless liquid container, ready for the succeeding tests.

Measuring the total dissolved solids

Each formulation's TDS was measured using a calibrated TDS meter. The TDS meter was dipped into the cooled coffee substitute sample. The TDS reading was recorded.

Measuring the pH

The pH for each formulation was measured using a calibrated pH meter. Similarly, the pH meter was dipped into the cooled coffee substitute drink. The pH reading was recorded.

Preference test

Purposive sampling was done in selecting 360 respondents. The selected respondents were all regular coffee drinkers. The respondents were distributed into the selected socio-demographic characteristics as shown in Table 2.

Table 2. Socio-demographic characteristics of the respondents

Respondent	Number	Percent (%)
Age Range		
20 - 29	120	33.3
30 - 39	120	33.3
40 - 49	120	33.3
Sex		
Male	176	48.9
Female	184	51.1
Overall	360	100

The informed consent form was given to the respondents before the taste test of the coffee substitute drinks. After that, the different coffee substitute formulations were given and distributed in disposable paper cups. Only the information about the used ingredients was disclosed to the respondents. Any information about the brew concentration of each formulation was undisclosed to prevent bias.

The respondents answered, “Assuming all the formulations have the same price, which formulation would you likely be going to buy in the market?”. The respondents were given distilled water to clean their palate between each formulation's tasting. The preference test ran from December 2022 to January 2023.

Statistical tools

Mean was used to summarize the measured TDS and pH. One-way Analysis of Variance (ANOVA) was used to check the significant difference among the formulations in the abovementioned parameters. For its post-hoc test, Tukey’s Honest Significance Test was used. Frequency was used in summarizing the preference count for each formulation. The Chi-square Goodness of Fit Test was used to check the significant difference in the preference count across age groups and sex. For its post-hoc test, the Pairwise Binomial Test with Bonferroni Adjustment was used. All hypothesis testing was done at $\alpha = .05$.

Results

Effect of coffee substitute brew concentration on total dissolved solids

It was found that as the coffee substitute brew concentration increased in each formulation, the TDS significantly increased ($p < .05$), with F3 having the highest TDS measurement (Table 3).

Table 3. The effect of coffee substitute brew concentration on the total dissolved solids

Formulation	Coffee Substitute Brew Concentration (g/330 mL H_2O)	TDS†	F	p-value	Decision
F1	1.0	265.67_a	46.5	0.002	Reject Ho
F2	2.5	394.00_b			
F3	5.0	622.33_c			

† Means not sharing subscripts differ significantly at a = 0.05, as the Tukey post-hoc Test indicates.

Effect of coffee substitute brew concentration on pH

It was found that as the coffee substitute brew concentration increased in each formulation, the pH significantly decreased ($p < .05$), with F3 having the lowest pH measurement (Table 4).

Table 4. The effect of coffee substitute brew concentration on the pH

Formulation	Coffee Substitute Brew Concentration (g/330 mL H_2O)	pH†	F	p-value	Decision
F1	1.0	7.76_a	114.4	<0.001	Reject Ho
F2	2.5	6.58_b			
F3	5.0	6.11_c			

† Means not sharing subscripts differ significantly at a = 0.05, as the Tukey post-hoc Test indicates.

Effect of coffee substitute brew concentration on preference of consumers in terms of age group

Most 20 - 29-year-old consumers preferred F2, closely followed by F3. However, the preference over F2 and F3 did not significantly differ ($p > .05$). F1 was significantly the least preferred of the three formulations ($p < .05$). Similar observations were found among the 30 - 39-year-old and 40 - 49-year-old consumers (Table 5).

Table 5. The effect of coffee substitute brew concentration on the preference of consumers of different age groups

Age Group	Coffee Substitute Brew Concentration (g/330 mL H_2O)	Preference Count†	χ^2*	p-value	Decision
20 – 29					
F1	1.0	16_a	22.85	<.000	Reject Ho
F2	2.5	57_b			
F3	5.0	47_b			
30 – 39					
F1	1.0	18_a	18.20	<.000	Reject Ho
F2	2.5	52_b			
F3	5.0	50_b			
40 - 49					
F1	1.0	20_a	16.25	<.000	Reject Ho
F2	2.5	45_b			
F3	5.0	55_b			

† Count data not sharing subscripts differ significantly at a = 0.05 as indicated by the Pairwise Binomial Test with Bonferroni Adjustment.

Effect of coffee substitute brew concentration on preference of consumers in terms of sex

It was found that most male consumers preferred F3 over F2 and F1 (Table 6). In particular, F1 was significantly the least preferred ($p < .05$) among the three. Although male consumers preferred F3 more, it did not significantly differ ($p > .05$) from their preference for F2.

On the other hand, most female consumers preferred F2 over F3 and F1. Similarly, F1 was significantly the least preferred ($p < .05$) among the three. While female consumers preferred F2 more, it did not significantly differ ($p > .05$) from their preference for F3.

Table 6. The effect of coffee substitute brew concentration on the preference of consumers of different sex groups

Sex	Coffee Substitute Brew Concentration (g/330 mL H_2O)	Preference Count†	χ^2*	p-value	Decision
Male					
F1	1.0	21_a	38.72	<.000	Reject Ho
F2	2.5	69_b			
F3	5.0	86_b			
Female					
F1	1.0	34_a	21.63	<.000	Reject Ho
F2	2.5	83_b			
F3	5.0	67_b			

† Count data not sharing subscripts differ significantly at a = 0.05 as indicated by the Pairwise Binomial Test with Bonferroni Adjustment.

Discussion

The amount of total dissolved solids (TDS) affects the sensory properties of the resulting brew, specifically the bitterness, smoky, and roast-like aromas (Liang *et al.*, 2021). In this study, F3 was found to have the highest TDS. Since F3 had the highest brew concentration among the three formulations, it released the most flavor and aroma components into the coffee substitute brewed drink.

Coffee is naturally acidic as it contains many acids, such as citric, malic, and quinic acids, among others (Yeagar *et al.*, 2021). The acidity contributes to the coffee's bitter taste and astringent flavor (Seninde and Chambers, 2020). Hence, for the coffee substitute to have a similar taste and flavor as real coffee, it must also fall into the usual coffee pH range of 4.85 - 5.13 (Rao and Fuller, 2018). However, this study found that none of the coffee substitute formulations fall within this usual coffee pH range. It was also found that increasing the coffee substitute brew concentration decreased the pH. It can be attributed to the higher brew concentrations having more extractable components than the lower brew concentrations, as evident in the measured TDS across the three formulations. It is further supported by the study of Batali *et al.* (2021), which found that TDS and pH were negatively correlated and TDS and acidity were positively correlated. Furthermore, the study of Varady *et al.* (2022) cited that the acidic and smoky flavor is positively correlated to the TDS. Hence, increasing the brew concentration can further increase the TDS, thus further lowering the pH down the usual coffee pH range.

Several other modifications in the current process can be recommended to improve the pH of the resulting coffee substitute brewed drink. The study by Maharani *et al.* (2021) found that increasing the brewing time resulted in lower pH, as the longer brewing time allowed for more flavor and aroma components extraction. Since this study fixed the brewing time to 5 minutes, further increasing the brewing time can decrease the pH to the desired range. Fikry *et al.* (2019) also found that roasting conditions can affect the pH of the resulting coffee substitute brewed drink. In particular, their study found that increasing the roasting temperature and roasting time will decrease the pH of the resulting brewed drink and, to an extent, improve color, aroma, and taste. Hence, optimizing the roasting condition used in this study can potentially improve the pH of the resulting coffee substitute brewed drink.

The preference test for the various coffee substitute formulations revealed that most consumers, regardless of age group and sex, prefer F2 and F3 over F1. The result of the preference test can be related to the measured TDS and pH, where F2 and F3 had higher TDS and lower pH than F1. This is supported by the study of Batali *et al.* (2021), which found that acidity and TDS affect consumer liking and preference, where consumers find more acidic brews more appealing than less acidic brews.

Based on the overall results, F3 is recommended for potential marketability as it is the preferred formulation by consumers, regardless of age group and sex. It is due to it having the highest TDS and the lowest pH, thus resembling the characteristics of the actual coffee more. It is recommended that future studies should further explore the optimization of the coffee substitute preparation process used in this study and determine the caffeine content and the nutritional content of the coffee substitute formulations to further support the advantages of its usage as compared to coffee.

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