Original Article

PHYTOCHEMICAL ANALYSIS, SENSORY EVALUATION AND ACCEPTABILITY OF PLANT LEAVES FOR HERBAL TEA: TOWARDS INTELLECTUAL PROPERTY ASSET

MARNIE B. SAZON
Iloilo Science and Technology University - Barotac Nuevo Campus, Jalaud, Barotac Nuevo, Iloilo, Philippines
Email: marniebsazon@gmail.com
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Abstract

The study was conducted in Iloilo City in order to determine the organoleptic and phytochemical results of the herbal tea from three different species of plants. The experiment involved three factors such as plant species, levels of maturity and amount of ground leaves. This was a 3 * 3 * 3 factorial experiment in CRD. The study consisted of organoleptic and phytochemical evaluation. The data gathered were subjected to both descriptive and inferential statistics with the results of the latter interpreted at the alpha level of 0.05. The study revealed the the sensory evaluation revealed that the factor such as plant species and amount of ground leaves significantly affected the aroma of herbal tea. Significantly best tea was obtained from malunggay at 4 g and 6 g. The rest of the factors and the interactions did not significantly affect the aroma of herbal tea. However, generally the four sensory attributes were verbally described as excellent and were not significantly affected by maturity of the leaves. The factor such as plant species also significantly affected the color, flavor and general acceptability of herbal tea. The rest of the factors and the interactions did not significantly affect the color, flavor and general acceptability of herbal tea. The different formulations of tea powder were generally positive in phytochemicals. Malunggay herbal tea had significantly the best color, flavor and general acceptability among the plant species. The panelists rated the color, flavor, aroma and general acceptability of the three plant species, three levels of maturity and three amounts all as excellent. The phytochemical analysis of the three plant species differed in terms of reducing sugars where guava and malunggay was positive while guyabano was negative. The rest of the phytochemicals were mostly present in the three species. Alkaloids and flavonoids were present in considerable amounts in the three plant species namely guava, guyabano and malunggay. Glycosides, sponins, coumarin and betacyanin were present in the three plant species. Anthraquinones were present in guava and malunggay and considerable amounts were found in guyabano. Reducing sugars were present in guava and malunggay but not in guyabano. Terpenoids and emodins were found in considerable amounts in guava and malunggay but present in lesser amounts in guyabano. The sensory attributes differed significantly in the three plant species in terms of color, flavor and general acceptability. The aroma significantly differed by plant species and amounts of ground leaves per sachet.

Keywords: phytochemical analysis, sensory evaluation, acceptability, plant leaves, herbal tea, intellectual property asset.

INTRODUCTION

Plant derived materials in making tea is an important product in the world which is widely consumed as beverage due to its attractive aroma, taste and health benefits. Consumption of tea, in particular the green tea (G.T.), has been correlated with low incidence of chronic pathologies in which oxidative stress will be reported to be involved, such as cancer (Chung, et al., 2003) and cardiovascular diseases (Stang, et al., 2007; Babu and Liu, 2008).

Indigenous herbs are in general heavily under exploited in spite of their huge dietary potential. It is therefore imperative to explore the potential of indigenous plant materials in the development of new herb teas, for it represents enormous reservoir of biologically active compounds in various chemical structures – protective or disease preventive properties (phytochemicals). These phytochemicals often secondary metabolites present in smaller quantities in plants, include the alkaloids, steroids, flavonoids, terpenoids, tannins and many others (Nonita, et. al, 2010).

Phytochemical studies have attracted the attention of the researcher due to the development of new sophisticated techniques in search for additional resources or raw materials for food production, specifically tea. The researcher, together with Ephrathah Farms, as grower of plant-materials and producer of tea places emphasis on the analysis of herbal teas out of the different plant materials such as Moringa oleifera (malunggay), Psidium guajava (guava), and Annona muricata (guyabano) for herbal teas. It focuses on the establishment of the of the level of nutrition and pharmaceutical applications, and at the same time will serve as an important contribution to knowledge of working quality parameters for the standardization of the product based on organoleptic and physicochemical characteristics of the finished product for commercialization.

Phytochemicals are bioactive compounds found in fruits, vegetables, grains and plant beverages such as tea and wine which may decrease the risks of chronic diseases. The health effects attributed to the consumption of phytochemicals are due to the synergistic actions of bioactive dietary components which increase micronutrients and phytochemicals (Zhang, YJ, et al. 2015).

The Ephrathah Farms offers a variety of courses that has subjects that make use of tea processing technology and culinary arts. It is also the role of the academe to disseminate the importance of herbal tea benefits through proper utilization and at the same time encourage the community in engaging tea processing technology in order to augment and find solution to address alternative medicine to chronic diseases.

Results of this study would be utilized in the formulation of "local" herbal tea production and technological investments on the processing of products from which can be integrated into above mentioned subjects and the product output will be extended to the world market. It will be used also as an ingredient in some food products that will be concerned about the relationship between diet and health in the area of functional and neutraceutical foods which covers possible health benefits beyond just the nutrients contains, as well as supplements medicinal herbs due to its phytochemical compounds in promoting healthful reaction in the body.

Statement of the Problem

This research aimed to analyze the phytochemical properties and the organoleptic characteristics of three plant materials (guyabano, guava and malunggay) using the fresh and dried leaves samples and the degree of maturity at Iloilo Science and Technology University – Barotac Campus during Academic Year 2019 – 2020 and intended output as basis for Intellectual Property asset.

Specifically, this study answered the following questions:

1. How can tea powder be developed as to the different levels of maturity at various amounts of 2 g, 4 g and 6 g using:

1.1 guava;

1.2 guyabano, and

1.3 malunggay leaves?

2. To what extent is the level of acceptability of the formulation by the trained and consumer panelists in the following sensory attributes:

2.1 aroma;

2.2 color;

2.3 flavor; and

2.4 general acceptability?

3. Is there significant effect of the different formulations to the sensory attributes?

4. Based on the aforementioned formulation of the tea powder, what are their phytochemical properties?

5. Do phytochemical properties differ in herbal tea from different plants?

6. Based on the findings, what Intellectual Property Asset can be drafted?

Significance the Study

As tea being considered as the world's second most consumed beverage, next to water, technology and supply must also evolve and broaden its range to meet such demand. Herbal teas have been proven to have medicinal and therapeutic benefits in which highly increases its value.

The results of this study will benefit and bring about knowledge, awareness, and information to the persons in the community, like the:

Government. Help the government in providing safety, health promoting products and an alternative solution, with an aid of this innovation, to the existing body of knowledge to broaden the source for manufacturing herbal teas.

Entrepreneurs. The specific details of the bioactive composition of these sources will provide them a good idea in engaging in healthy lifestyle related businesses.

Iloilo Science and Technology University (ISAT-U). The outcome of this study will contribute in the realization in the vision of the university which is to become the center of excellence in research, instruction, production, and extension services for progressive leadership transcending global technological, business, and industry-driven education.

Instructors. The new technology can serve as new guide for effective teaching on food processing and preservation, specifically on accessible plants for herbal tea processing technology.

Researchers. Support researchers in reference for a further study of herbal tea concentrations.

Extension personnel. The outcome of this study will give valuable information in adopting and implementing the technological guide to help the members of the community in processing of herbal teas in their respective households.

Students. Application of the new technology will give them additional knowledge and information in the processing and benefits of herbal tea.

Review of Literature

Phytochemicals

Phytochemicals are organic compounds which are non-nutrient but are essential in biological activity. According to Kaur (2019), these may act as reservoirs of protein synthesis or as detoxicating compounds. Examples are tannins which act as plant metabolites (Sieniawska & Baj, 2017). Anthraquinones are another example which function to provide pigmentation (Science Direct, 2019). Glycosides are another group of phytochemicals. They aid in the polymerization of sugars or glucose. There are sugars which act as reducing agents, opposite to the function of glycosides (Rizzo, 2019). Examples of glycosides are saponins. These regulate cholesterol and reduce risk of cancer (Phytochemicals, 2019). Another group of phytochemicals is the flavonoids which function as aid in pigmentation and protection (Mathesius, 2018). Phlobatannins are types of tannins which are part of metabolism (Ali et al., 2018). Steroids are phytochemicals which may act as hormones (Study, 2019). Terpenoids are phytochemicals which are involved in growth and development (Tholl, 2015). So with coumarin which govern cell growth (Rohini & Srikumar, 2014). Example of anthraquinones are emodins and have therapeutic effects in humans (Science Direct, 2019). Anthocyanin is a phytochemical responsible for color and protection of tissues (Landi et al., 2015). The same is true with betacyanin which has a protective function (Nakashima et al., 2011).

The findings was supported by the study of Pokharel (2016), that, the phytochemical study of extracts of cytotoxic active plant species Drypetes lasiogyna and Tabebuia bahamensis species from Paluma rainforest, Northern Queensland, Australia and Abaco Island, Bahamas, respectively, has been carried out where separation, identification and characterization of chemical components were done by applying chromatographic and spectroscopic techniques. The pharmacologically active components isolated from Drypetes lasiogyna include novel compound 5α-dammar-20-ene-24, 25-diol-3-yl caffeate along with 5α-dammar-20-ene-3β,24,25-triol and friedelin whereas taraxeryl acetate was extracted from Tabebuia bahamensis.

The study of Zhen, J. (2016) on chemistry and bioactivity of Africa medicinal plants discussed that, there were three different traditional African medicinal plants Ximenia caffra, Hibiscus sabdariffa and Combretum micranthum, were selected for phytochemical investigations and potential pharmacological activities. For Ximenia caffra, more than ten polyphenol compounds were identified in the leaf sample using LC/UV/MS profiling, including gallic acid, catechin, quercetin, kaempferol and their derivatives. The antioxidant capacities of leaf extract were determined by Folin-Ciocalteu assay as 261.87 ± 7.11 mg GAE/g and ABTS free radical scavenging assay as 1.46 ± 0.01 mmol TE/g. The anti-proliferative effect of Ximenia caffra leaf extract was measured by MTS assay with IC50 value of 239.0 ± 44.5 μg/ml. Cell-based assays show that the leaf extract inhibits the mRNA expression of pro-inflammatory genes (iL-6, iNOS, and TNF-α) by using RT-qPCR, indicating its anti-inflammatory effects. Further studies suggest that the underlying therapeutic mechanism may involve the suppression of NF-κB, a shared pathway between cell death and inflammation.

For Hibiscus sabdariffa, which is originally native to Africa, the phytochemical the phytochemical profile of leaves from 25 different populations from worldwide accessions were determined by LC/MS and compared with each other. Ten polyphenols including neochlorogenic acid, chlorogenic acid, cryptochlorogenic acid, quercetin, kaempferol and their glycosides were identified together with 5-(hydroxymethyl)furfural, some of which were quantified with ii commercially available standards.

The leaves have shown anti-oxidant activities as measured by Folin-Ciocalteu assay and ABTS free radical scavenging assay. Leaves extracts reduced LPS-induced NO production in RAW 264.7 cell in a dose-dependent manner indicating the extract's potential anti-inflammatory activity. The compound 5- HMF was identified in dried samples and later investigated as a biomarker of the freshness of the leaf samples. For plant Combretum micranthum, in prior phytochemical investigations, our lab identified a group of new skeleton compounds named kinkeloids. As a continuation of this project, two total synthetic methods for these novel compounds kinkeloids A group and B were developed, which were then applied for regioisomers determination, scale-up synthesis and potential analogues synthesis. The key and final step was achieved by Mannich reaction, through which the piperidine moiety coupled to the flavan moiety. One method goes through the synthesis ofintermediate compound eriodictyol followed by further de-oxygenation using NaBH3CN, while the second scheme involves the formation of o-quinone methide and the inverse electron-demand Diels-Alder reaction. The identities of synthesized kinkeloids were further confirmed through the comparison with the ones in the plant leaves extract using LC/MS.

The enantiomers of each previous identified flavan molecules in the leaf samples were successfully separated on AD-RH column. A series of novel kinkeloids analogues were synthesized with different flavonoid aglycones and the attached nitrogen-containing moieties.

The synthesized analogues were screened for the inhibitory activity of α-glucosidase, in which compound 23 has the lowest IC50 of 4.1 μM. Kinetic analysis indicates synthesized compounds 15 and 23 inhibit enzyme in a non-competitive model with Ki value of 37.8 ± 0.8 and 13.2 ± 0.6 μM. Further docking study suggests that the preferred binding pocket is close to the catalytic center, correlating to the experimental results very well. Structure activity relationship study indicates that 4'-hyroxyl group and the 4-position carbonyl group are important for the inhibitory activity. Addition of extra hydrogen bonding and hydrophobic groups on ring A may increase the inhibitory activity.

The study of Wu, V. D. (2018) on method development for chemical analysis of medicinal herbs, revealed that, the bioactive components in herbs are complex in their composition and often vary in amounts from harvest to harvest. Quality control in the field of herbal medicine is challenging to analytical chemists who must validate a product's identification and potency. In this work, thin layer chromatography (TLC), gas chromatography-mass spectrometry (GC-MS) with both electron impact and proton transfer chemical ionizations, and liquid chromatography-mass spectrometry (LC-MS) are employed to identify the chemical composition of reishi mushroom, also known as ling zhi mushroom (Ganoderma lucidum), dang gui root (Angelica sinensis), and fang feng root (Radix saposhnikoviae).

The variation in levels of bioactive components of therapeutic interest was also qualitatively investigated for different types of processed herbal samples. The major ingredient compounds, ganoderic acid A ($C_{30}H_{44}O_7$), ganoderic acid F ($C_{32}H_{42}O_9$), and ganoderic acid H ($C_{32}H_{44}O_9$) were identified in ling zhi mushroom, ferulic acid ($C_{10}H_{10}O_4$) and ligustilide ($C_{10}H_{14}O_2$) in dang gui, and cimifugin ($C_{16}H_{18}O_6$) in fang feng. The mass fragments observed during MS analyses were positively identified as components of the above bioactive compounds in each of these herbs, justifying the use of these analytical instruments as an effective option for herbal medicine identification and quality control.

Further Griffonia simplicifolia is a legume indigenous to western region of Sub-Saharan Africa. While the seeds of this plant are known forbeing the most abundant natural source of 5-hydroxtryptophan (5-HTP), a widely consumed alternative treatment for conditions involving a serotonin imbalance, many phytochemical characteristics of this species remain unreported. In order to further characterize the phytochemical composition of Griffonia simplicifolia, the 5-HTP, nitrile glycoside, polyphenol, antioxidant, protein, flavonoid, mineral, fatty acids, and tocopherol content of several different populations of griffonia seeds and leaves collected from various regions of Ghana and Liberia were evaluated. For comparison, the 5-HTP content of 18 commercial products on the nutraceutical supplement market was quantified in order to verify the declared amount on their labels match their measured amount. Total polyphenol content of griffonia leaves was 21.16 ± 0.48 GAE/g and antioxidant capacities of leaves and seeds were 12.31 ± 0.45 TEAC/g and 216.50 ± 13.88 TEAC/g, respectively.

Protein content of griffonia leaves was 6.89 ± 0.47 BSAE/gram and protein content of seeds was 33.58 ± 1.52 BSAE/gram. Average fatty acid, α-tocopherol, and γ-tocopherol content of seeds were 269.54 ± 2.77 mg/g, 22.62 ± 1.54 µg/g, and 86.58 ± 4.01 µg/g, respectively. Average flavonoid content of griffonia leaves was 9182.02 ± 140.90 µg/g. The average 5-HTP content from all the sampled seed populations was 120.84 ± 9.00 mg/g and total nitrile glycosides averaged 14.25 ± 1.65 mg/g. Griffonia seeds were found to be a source of manganese but not calcium, and a high source of iron, zinc, magnesium, copper, and phosphorus. Among the various populations, the most substantial differences in secondary metabolite accumulation was observed in polyphenol, antioxidant, and flavonoid content of leaves as well as nitrile glycoside and tocopherol content of seeds. Pasteurizing seeds with dry heat does not significantly affect the 5-HTP content and seeds with black coloured endosperms contained lower amounts of 5-HTP and nitrile glycosides than seeds with yellow endosperms. The 5-HTP content of all 18 dietary supplements was within ± 15% of the amounts declared on their labels.

Herbal Medicines

Herbal medicines, which are also described as botanical medicines or phytomedicines, mostly originate from plant seeds, berries, roots, leaves, bark, or flowers and may be used either in their primary forms or combined into mixtures (Deng, 2002). They can also be formulated into tablets, pills, and liquids (supplements), as well as being commercially available in the form of proprietary medicines. The reasons for medicinal herbal use may differ with different cultures. For example, indigenous cultures, such as African and Native American, used herbs in their healing rituals, while other cultures developed traditional medical systems (such as Ayurveda in India and traditional Chinese medicine) in which herbal therapies were used systematically. The utilization of herbal medicinal products has seen a steady increase in market sales. In fact, the World Health Organization (WHO, 2002) estimates that the global market for herbal medicines currently exceeds US $ 60 billion annually and the forecast is that the market for herbal products is expected to be $93.5 billion by 2015. In North America, an estimated 50% of the population has used complementary or alternative medicine at least once. In the U.S. more than 114 million people, about half the adult population consume herbal/dietary supplements (National Health Interview Survey.

According to the United States Commission for Alternative and Complementary Medicines, this culminates to $17 billion spent on traditional remedies in the U.S. alone (WHO, 2002). Phytochemicals are non-nutritive compounds that are derived from plants, fruits, or vegetables (Liu, 2004). Phytochemicals have been heavily researched due to their purported health benefits that go beyond basic nutrition. These phytochemicals may reduce the risk of major chronic diseases, including colon cancer (Vos and Schrijver, 2003; Haslam, 2003).

Herbal Teas or Leafy Herbal Teas (LHT)

Traditional and herbal teas have been consumed for centuries, not only for their taste, but also as disease preventing agents. Traditional tea, derived from the plant Camellia senesis, is the most widely consumed beverage in the world next to water, and market research also suggests that herbal teas are increasing in popularity in recent years. Derived from plants other than the Camellia senesis, herbal teas have been utilized for centuries for their medicinal properties. Studies suggest a positive correlation between herbal tea consumption and the reduction of select chronic diseases. Some health benefits that are associated with herbal teas include anticancer, hypotensive, antidiabetic, and antimutagenic properties; which have been attributed to the presence of antioxidative phytochemicals (Vos and Schrijver, 2003; Haslam, 2003). Tea blends are becoming increasingly popular in the U.S. as an alternative to “true tea.” Tea blends are also highly sought after due to their purported health benefits. Some tea blends that are common in the U.S. consist of raspberry leaf, strawberry leaf, and hibiscus leaf teas. Tea blends are also often infused with spices for improved taste and increased positive effects on health, including the prevention of some chronic diseases such as cardiovascular disease, diabetes, obesity and cancer.

The scientists of John Hopkins University (Shopee, 2019; Gopalakrishnan et al., 2019; Food and Agriculture Organization, 2019) were cited to have shown that herbal tea from moringa has no fats but is rich in protein and vitamins. The odour and taste of the tea were found desirable especially in just enough concentration—that is, not too light nor too strong. The colour of the tea is brownish maroon which is not pale nor too dark. Because of these, the malunggay tea is acceptable (Pascual, 2019). Herbal teas are generally obtained from some plants identified by the people of the old days and these have now flourished among the countries as acceptable beverage. The mature leaves of these identified plants which differ from country to country are best when mature (Cowan, 2019; Love the Garden, 2019).

Herbs for Tea

A herb is a plant or plant part valued for its medicinal, savory, and aromatic qualities. Plant-derived substances have been of great interest due to their variety applications (Tiwari et al., 2011). Herbs have been greatly used in many countries since centuries ago to treat a wide range of medical illness. Both wild and cultivated ones have been widely accepted until the present for preparation of refreshing drinks, such as teas (Samall et al., 2012). Preparation of teas by infusing the fresh or dried herbs had been the standard procedure up to this date. Herbal teas have many health benefits, and the widespread popularity, such as green tea, rooibos, and chamomileis due to their therapeutic effects against some chronic diseases (Joubert et al., 2008 in Omogbai and Ikenebomeh, n.d.).

Samall et al., 2012 stated that there is a botanical evidence is the most widely consumed beverage worldwide, second to water. There are three main varieties of tea; green, black, and oolong. The preparation process is the only difference between the three. Green tea is from unfermented leaves that contains the highest concentration of antioxidants, polyphenols (Ernst and Coon, 2001; Van Vonderen et al., 2000; Samall et al., 2012).

Moringa oleifera, a plant native to the tropics, is an important food source in most parts of the world because it can be grown easily. Its leaves, flower, fruit, seeds, bark, and roots are used as an alternative medicine. M. oleifera can be prepared as extracts, decoctions, poultices, creams, oils, emollients, salves, powders, porridges andhave been reported to have hypotensive, anticancer, and antibacterial properties activity (Fahey 2005). A study by Wahab and Elabor, 2016 reported that M.oleifera has high percentage of alkaloids and flavonoids but low in tannins and saponin composition. The presence of these phytochemicals can be associated with their antimicrobial, antifungal, diuretic, and analgesic properties. Leaves act as a good source of natural antioxidant due to the presence of ascorbic acid, flavonoids, phenolics, and carotenoids (Anwar et al., 2005; Makkar and Becker 1996). M. oleifera leaf extract has also been report to have been used as purgative, applied as poultice to sores, rubbed on the temples for headaches, used for piles, fevers, sore throat, bronchitis, eye and ear infections, scurvy and catarrh, control glucose levels (Morton 1991; Fuglie 2001; Makonnen et al., 1997; The Wealth of India, 1962; Dahot 1988). Aqueous leaf extracts regulate thyroid hormone and can be used to treat hypothyroidism and exhibited an antioxidant effect (Pal et al., 1995a; 1995b; Tahiliani and Kar, 2000). A recent report showed M. oleifera leaf may be applicable as a prophylactic or therapeutic anti-HSV (Herpes simplex virus type 1) medicine and may be effective against the acyclovir-resistant variant (Lipipun et al., 2003). A similar study by Bamishaiye et al., 2011 in Nigera, focuses on the phytochemical compostion at three stages of maturation of M. oleifera leaves. Data showed that late stage maturation of M. oleifera leaves recorded to have the highest percentage of phytochemical composition namely, alkaloids, tannins, phenolics, saponins, flavonoids, steroids, phylobatannins, and tripertenes.

Annona muricata, is used in traditional medicine is the decoction of bark, root, seed or leaf for a variety of applications. It is widely distributed around the world, which it is easily accessible for medicinal use against cancer and other pharmacological treatments (Tisott et al., 2013; Coria-Tellez et al., 2018). 212 bioactive compounds have been reported to be found in A. muricata. Acetogenins are the predominant compounds, followed by alkaloids, phenols, and other compounds. Majority of the phytochemicals have been identified from organic extract, but aqueous extracts have been the recent focus for phytochemical profiling (Coria-Tellez et al., 2018). A study by Foong and Hamid 2012 indicated that ethanolic extract of A. muricata has a potential of becoming an inflammatory agent as it has been shown to be effective for acute inflammation and chronic inflammation in a dose dependent manner. Also, it is able to produce anti-arthritic effects by significantly suppressing pro-inflammatory cytokines.

Psidium guajava, a native to tropical America but has a wide distribution and naturalization, leaves are used in traditional medicine as astringent, anodyne, febrifuge, antispasmodic, in wounds, ulcers, cholera, diarrhea, vomiting (Vaidyaratnam 1995;

Anonymous 1998c), for swollen gums and ulceration of mouth (Nadkarni 1985b). Its leaves contain catechol, tannins, wax, resins, sugars, carotene, vitamins B1, B2, B6, niacin (Anonymous 1998b), essential oil, vitamin C (Ambasta 1986), calcium and manganese in combination with phosphoric, oxalic, and maleic acids (Nadkarni 1985a). Leaf extracts have been reported to have biological activities such as antidiarrheal (Lutterodt 1992), antitussive and antimicrobial (Jairaj et al., 1999), analgesic, anti-inflammatory, CNS depressant (Olajide et al., 1999), tropical hemostatic (Jairaj et al., 2000), and antiamoebic (Tone et al., 1998). A study by Mukhtar et al., 2004 reported that P. guajava leaves has a significant hypoglycemic activity as is evident in acute and subacute treatments in diabetic rats.

Methodology

Ephrathah Farms is seen as a family-friendly destination. Taking pride to its endless blue skies and being one with Mother Nature, one may focus more on relaxation activities such as guided vegetable picking, perfectly organic food presentations, rappelling and wall climbing, the zip line, and its glass chapel for weddings and retreats. With these facilities, the establishment focuses on the agri-tourism as it helps boost the image of the agricultural sector and the recreational activities for tourists. Innovation and assessment of the herbal tea products through technology have not been given focus in the development of its products. Hence, this research was conducted at Ephrathah Farms.

The processing of samples was conducted at the Environmental Research and Analytical Laboratory of the Research Hub of the Iloilo Science and Technology University – Main Campus particularly, the phytochemical profiling. The sensory evaluation was done at ISATU – Barotac Nuevo Campus. The room is air-conditioned to assure comfort of the sensory panelist.

The experimental method was used in this study, utilizing the different factors. In the phytochemical analysis, each plant species has sample. In the organoleptic analysis, the 3 * 3 * 3 factorial experiment was followed using CRD (Completely Randomized Design). The factors and their levels were as follows: Factor A – Plant species (A1 – Guava, A2 – Guyabano, and A3 – Malunggay); Factor B – Maturity (B1 – Young, B2 – Mature, and B3 – Old); and Factor C – Amounts (C1 – 2 g, C2 – 4 g, and C3 – 6 g).

Data collected from the organoleptic or sensory evaluation were tabulated, consolidated and subjected to analysis using Analysis of Variance (ANOVA) at 0.05 level of significance. In case of significant effect of the factors, the LSD (Least Significant Difference) test was used also at 0.05 level. The results of these processes served as basis for Intellectual Property for scientific innovation.

The sensory acceptability responses of the different herbal teas was evaluated by thirty (30) taste panelists as respondents. They were given score/code guide sheets for recording the scores during the sensory evaluation procedure. The instrument used was thoroughly explained to the respondents for full and precise sensory evaluation. The sensory evaluation followed the Likert Scale for the ratings of the herbal teas and the mean ranges were verbally described as follows:

Results and Discussion

Sensory Evaluation

The sensory evaluation on herbal tea was performed on aroma, color, flavor and general acceptability.

Aroma. Table 1 reflects the mean aroma of herbal tea from guava leaves of different maturity. The highest mean of 8.02 was that of old leaves. This was followed by mature leaves while the lowest was that of young leaves. However, the mean differences were not statistically significant. Cowan (2019) stated that a plant grown for herbal tea should be harvested when the leaves reached maturity implying that just before leaf fall.

Table 1 Mean Aroma of Herbal Tea from Guava Leaves of Different Maturity

MATURITY	**WEIGHT (G)**			**MEAN**	**DESCRIPTIVE INTER-PRETATION**
	2	**4**	**6**		
Young	7.60	7.97	8.00	7.86	**E**
Mature	7.90	8.10	7.83	7.94	**E**
Old	7.87	8.10	8.10	8.02	**E**

Legend: E – Excellent (7.41-9.00)

Table 2 reflects the mean aroma of herbal tea from guyabano leaves of different maturity. The highest mean was obtained from mature leaves followed by the old leaves. The young leaves gave the lowest mean. The mean differences were not statistically significant. The descriptive interpretations of the means were all excellent indicating that any of the maturity is very desirable. This is in contrast to the statement of Cowan (2019) saying that young and old leaves are not desirable.

Table 2 Mean Aroma of Herbal Tea from Guyabano Leaves of Different Maturity

MATURITY	**WEIGHT (G)**			**MEAN**	**DESCRIPTIVE INTER-PRETATION**
	2	**4**	**6**		
Young	7.60	7.77	7.77	7.71	**E**
Mature	7.70	7.87	7.97	7.85	**E**
Old	7.63	7.90	7.93	7.82	**E**

Legend: E – Excellent (7.41-9.00)

Table 3 reflects the mean aroma of herbal tea from malunggay leaves of different maturity. This highest mean was from old leaves followed by mature leaves. The lowest mean was from the young leaves. However, the mean differences were not statistically significant. This means that maturity of the leaves did not matter. Any had excellent aroma contrary to the statement of Cowan (2019) that only the mature ones are desirable.

Table 3 Mean Aroma of Herbal Tea from Malunggay Leaves of Different Maturity

MATURITY	**WEIGHT (G)**			**MEAN**	**DESCRIPTIVE INTER-PRETATION**
	2	**4**	**6**		
Young	8.07	8.17	8.30	8.18	**E**
Mature	8.13	8.17	8.40	8.23	**E**
Old	8.20	8.20	8.40	8.27	**E**

Legend: E – Excellent (7.41-9.00)

Table 4 reflects the mean aroma of herbal tea at different amounts of ground leaves. The highest mean was 8.07 described as liked very much from 6 g of dried leaves. This was followed by 4 g with a mean of 8.03 described as liked very much while 2 g had the lowest mean of 7.86 described as liked very much. The LSD test revealed that the 4 g and 6 g had statistically similar aroma which was significantly higher than that of 2 g. This implies that 4 g and 6 g are enough amounts of ground leaves than 2 g which is less to provide desirable odour. This is in contrast to the 2 g practice cited by Teitulia (2019) amount of loose tea per cup of water either hot or cold.

Table 4 Mean Aroma of Herbal Tea at Different Amounts (Weights)

WEIGHT (G)	MEAN*	DESCRIPTIVE INTERPRETATION
2	7.86b	**E**
4	8.03a	**E**
6	8.07a	**E**

*Means having a common letter are not significantly different at 0.05 level using LSD (Least Significant Difference) test.

Legend: E – Excellent (7.41-9.00)

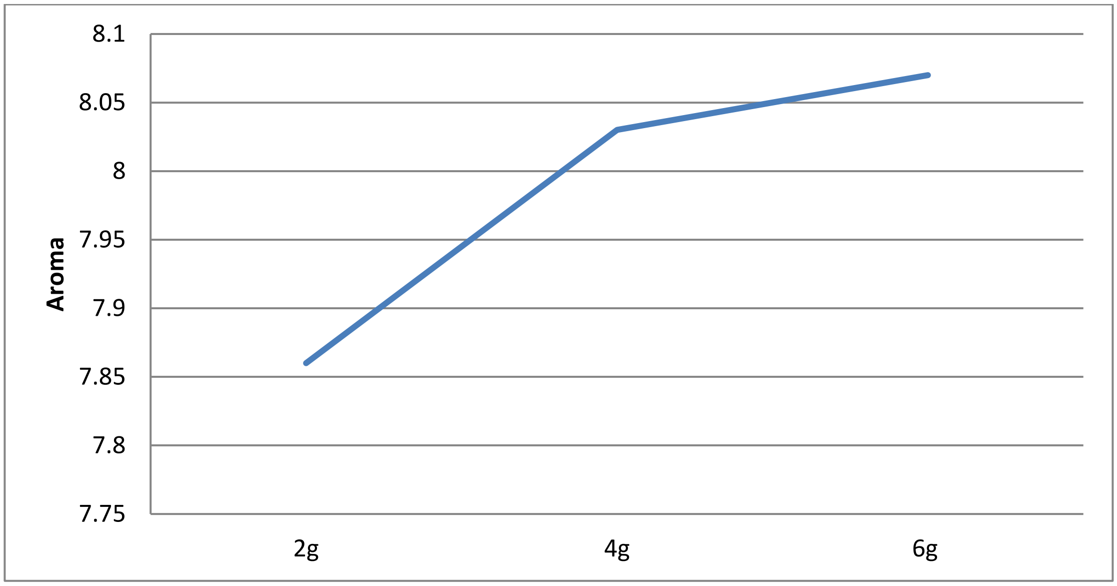

Figure 1 Mean Aroma of Herbal Tea from Different Amounts of Ground Leaves

Table 5 reflects the mean aroma of the tea from different plant species. The highest mean or 8.23 described as liked extremely was obtained from malunggay leaves. This was followed by guava leaves with a mean of 7.94 described as liked very much while the lowest mean of 7.79 described as liked very much was obtained from guyabano. The LSD test in the said table indicates that malunggay had significantly better aroma than guava and guyabano herbal tea. This implies that guava and guyabano herbal tea had less desirable aroma because it has stronger odour than malunggay herbal tea. According to scientists from John Hopkins University (Shopee, 2019), malunggay herbal tea are desirable because it has no fats but rich in protein and vitamins. The odour of the tea enhances its desirability.

Table 5 Mean Aroma of Tea from Different Plant Species

PLANT	MEAN*	DESCRIPTIVE INTERPRETATION
Guava	7.94b	**E**
Guyabano	7.79b	**E**
Malunggay	8.23a	**E**

*Means having a common letter are not significantly different at 0.05 level using LSD (Least Significant Difference) test.

Legend: E – Excellent (7.41-9.00)

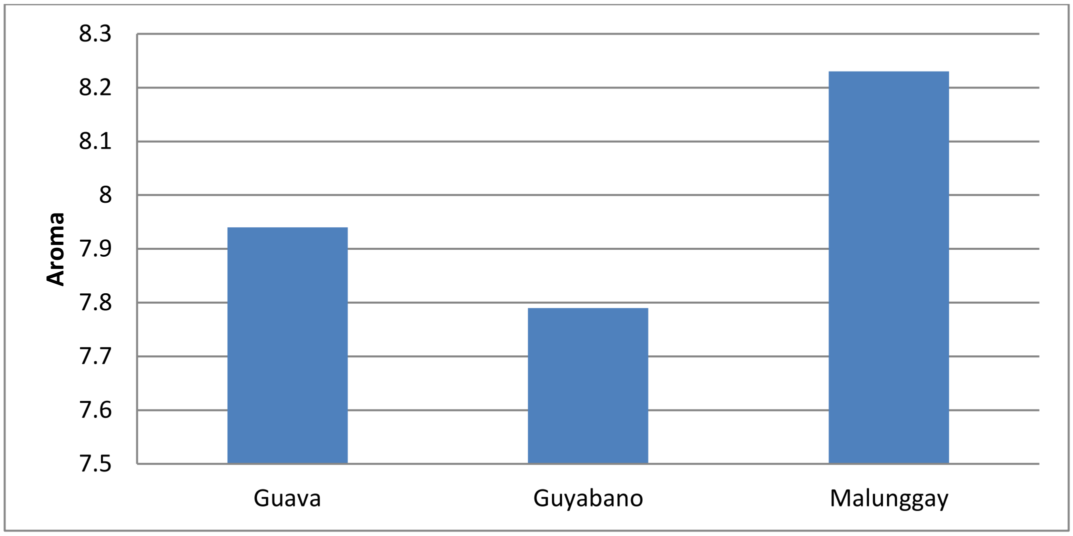

Figure 2 Mean Aroma Ratings of Herbal Tea from Different Plant Species

Table 6 presents the analysis of variance on aroma of different herbal tea. The factors such as plant and amount of herbal tea (weight) had statistically significant effects on aroma. The factor which is maturity and the interactions of the three factors such as A * B, B * C, A * C, and A * B * C had no significant effect. These were shown by the F-values which had significances less than or higher than 0.05, the alpha level.

Table 6 Analysis of Variance on Aroma

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIFI-CANCE
Plant (A)	26.195	2	13.098	14.231	0.000*
Maturity (B)	2.195	2	1.098	1.193	0.304ns
Weight (C)	7.121	2	3.560	3.869	0.021*
Plant (A) * Maturity (B)	0.338	4	0.085	0.092	0.985ns
Plant (A) * Weight (C)	2.479	4	0.620	0.673	0.611ns
Maturity (B) * Weight (C)	.390	4	0.098	0.106	0.980ns
Plant (A)* Maturity (B)* Weight (C)	1.499	8	0.187	0.204	0.990ns
Error	720.633	783	0.920		
Total	760.851	809			

* - significant at 0.05 level

ns – not significant

Color. Table 7 reflects the mean color of herbal tea from guava leaves of different maturity. The higher mean was that of old and young leaves compared to the mature leaves. The mean differences, however, were not statistically significant. Thus, the maturity did not matter as to the colour of the herbal tea. This was in contrary to the statement in Love the Garden (2019) that the mature leaves are more desirable than the young and old ones.

Table 7 Mean Color of Herbal Tea from Guava Leaves of Different Maturity

MATURITY	WEIGHT (G)			MEAN	DESCRIPTIVE INTER-PRETATION
	2	4	6		
Young	8.20	8.32	8.21	8.24	**E**
Mature	8.13	8.23	8.33	8.23	**E**
Old	8.13	8.20	8.40	8.24	**E**

Legend: E – Excellent (7.41-9.00)

Table 8 shows the mean color ratings of herbal tea from guyabano leaves of different maturity. The highest mean was from old leaves followed by young leaves. The lowest was from mature leaves. However, the mean differences were not significant. So, the maturity of the leaves did not matter. This is in contrary to the statement of Cowan (2019) saying that mature leaves are the most desirable.

Table 8 Mean Color of Herbal Tea from Guyabano Leaves of Different Maturity

MATURITY	WEIGHT (G)			MEAN	DESCRIPTIVE INTER-PRETATION
	2	4	6		
Young	8.10	8.20	8.37	8.22	**E**
Mature	8.00	8.00	8.27	8.09	**E**
Old	8.97	8.00	8.03	8.33	**E**

Legend: E – Excellent (7.41-9.00)

Table 9 reflects the mean color of herbal tea from malunggay leaves of different maturity. The highest mean was obtained from the young leaves followed by mature leaves. The lowest mean was obtained from the old leaves. However, the mean differences were not statistically significant meaning that maturity did not matter. This was in contrast to the statement in Love the Garden (2019) that mature leaves are most desirable.

Table 9 Mean Color of Herbal Tea from Malunggay Leaves of Different Maturity

MATURITY	WEIGHT (G)			MEAN	DESCRIPTIVE INTER-PRETATION
	2	4	6		
Young	8.27	8.40	8.50	8.39	**E**
Mature	8.33	8.37	8.33	8.34	**E**
Old	8.30	8.27	8.00	8.19	**E**

Legend: E – Excellent (7.41-9.00)

Table 10 reflects the mean color of herbal tea from different plant species. The highest mean of 8.31 described as liked extremely was obtained from malunggay. This was followed by guava with a mean of 8.24 described as liked extremely and guyabano with a mean of 8.10 described as liked very much. The mean differences were statistically significant and the LSD test revealed that malunggay had significantly the best color. The color of malunggay herbal tea was just right brownish while that of guava and guyabano were lighter. As Shopee (2019) puts it, the colour of malunggay tea is desirable especially if the amount is just right—not too strong and not too light.

Table 10 Mean Color of Herbal Tea from Different Plant Species

PLANT	MEAN*	DESCRIPTIVE INTERPRETATION
Guava	8.24b	**E**
Guyabano	8.10c	**E**
Malunggay	8.31a	**E**

*Means having a common letter are not significantly different at 0.05 level using LSD (Least Significant Difference) test.

Legend: E – Excellent (7.41-9.00)

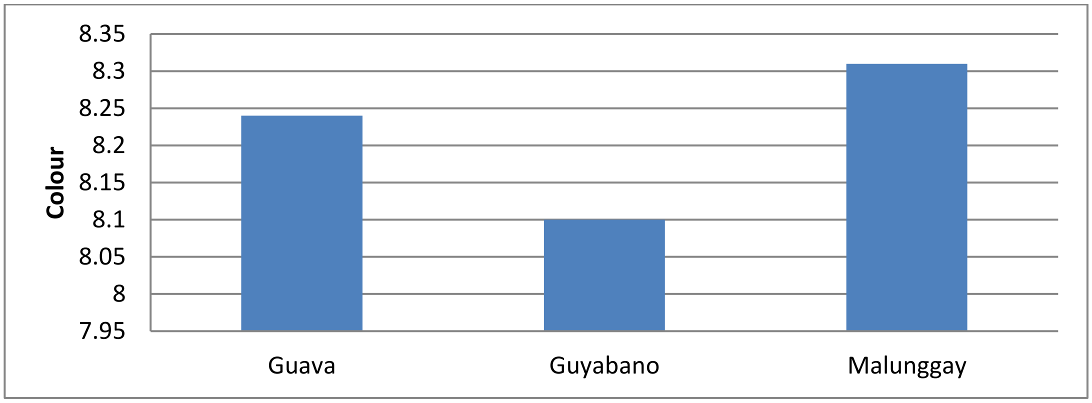

Figure 8 Mean Color Ratings of Herbal Tea from Different Plant Species

Table 11 is the analysis of variance on color of different herbal tea. The effects of plant species as a factor was statistically significant as the F-value had a significance which is less than 0.05, the alpha level. The effects of other factors such as level of maturity, weight and the interactions of factors such as A * B, B * C, A * C, and A * B * C were not statistically significant. There were differences, therefore, in the color of the herbal tea from different plant species.

Table 11 Analysis of Variance on Color

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIFI-CANCE
Plant (A)	5.825	2	2.912	4.487	0.012*
Maturity (B)	2.684	2	1.342	2.068	0.127ns
Weight (C)	1.588	2	0.794	1.223	0.295ns
Plant (A) * Maturity (B)	1.560	4	0.390	0.601	0.662ns
Plant (A) * Weight (C)	1.635	4	0.409	0.630	0.641ns
Maturity (B)* Weight (C)	.864	4	0.216	0.333	0.856ns
Plant (A)* Maturity (B) * Weight (C)	3.402	8	0.425	0.655	0.731ns
Error	508.200	783	0.649		
Total	525.758	809			

* - significant at 0.05 level

ns – not significant

Flavor. Table 12 reflects the mean flavor of herbal tea from guava leaves of different maturity. The highest mean was obtained from the old leaves followed by the young leaves. The lowest mean was obtained from the mature leaves. However, the mean differences were not statistically significant which denotes that maturity did not matter. This was nevertheless, contrary to the statement in Love the Garden (2019) that mature leaves are most desirable.

Table 12 Mean Flavor of Herbal Tea from Guava Leaves of Different Maturity

MATURITY	WEIGHT (G)			MEAN	DESCRIPTIVE INTER-PRETATION
	2	4	6		
Young	7.77	7.68	7.69	7.71	**E**
Mature	7.67	7.63	7.63	7.64	**E**
Old	7.80	7.70	7.83	7.78	**E**

Legend: E – Excellent (7.41-9.00)

Table 13 reflects the mean flavor of herbal tea from guyabano leaves of different maturity. The highest mean was from old leaves followed by mature leaves. The young leaves gave the lowest mean. However, the mean differences were not statistically significant meaning that maturity did not matter. This is in contrast to the statement of Cowan (2019) saying that mature leaves are most desirable.

Table 13 Mean Flavor of Herbal Tea from Guyabano Leaves of Different Maturity

MATURITY	WEIGHT (G)			MEAN	DESCRIPTIVE INTER-PRETATION
	2	4	6		
Young	7.77	7.83	7.57	7.72	**E**
Mature	7.57	7.90	7.90	7.79	**E**
Old	7.80	7.83	7.80	7.81	**E**

Legend: E – Excellent (7.41-9.00)

Table 14 reflects the mean flavor of herbal tea from malunggay leaves of different maturity. The highest mean was obtained from old leaves followed by young leaves. The lowest mean was from mature leaves. The mean differences, however, were not statistically significant denoting that maturity did not matter. Nevertheless, in Love the Garden (2019), it was stated that mature leaves are most desirable.

Table 14 Mean Flavor of Herbal Tea from Malunggay Leaves of Different Maturity

MATURITY	WEIGHT (G)			MEAN	DESCRIPTIVE INTER-PRETATION
	2	4	6		
Young	8.30	8.27	8.33	8.30	**E**
Mature	8.30	8.13	8.33	8.25	**E**
Old	8.40	8.17	8.50	8.36	**E**

Legend: E – Excellent (7.41-9.00)

Table 15 reflects the mean flavor of tea from different plant species. The highest mean of 8.30 described as liked very much was obtained from malunggay. This was followed by guyabano with a mean of 7.77 described as liked very much while guava had the lowest with a mean of 7.71 described as liked very much. The LSD test indicated that malunggay had significantly better flavour than guyabano and guava herbal tea. Pascual (2016) confirms the fact that malunggay herbal tea has a sound taste.

Table 15 Mean Flavor of Herbal Tea from Different Plant Species

PLANT	MEAN*	DESCRIPTIVE INTERPRETATION
Guava	7.71b	**E**
Guyabano	7.77b	**E**
Malunggay	8.30a	**E**

*Means having a common letter are not significantly different at 0.05 level using LSD (Least Significant Difference) test.

Legend: E – Excellent (7.41-9.00)

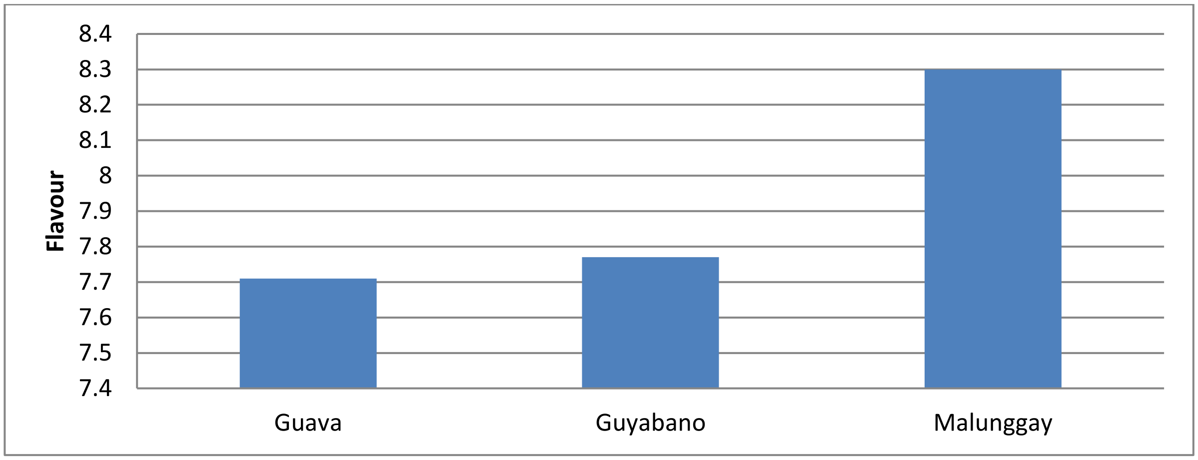

Figure 9 Mean Flavor Ratings of Herbal Tea from Different Plant Species

Table 16 presents the analysis of variance on flavor of different herbal tea. The effect of plant species as the factor was statistically significant as the F-value had a significance which is less than 0.05, the alpha level. The effects of the other factors such as level of maturity and amount (weight) of leaves and the interactions of the factors such as A * B, B * C, A * C and A * B * C were not statistically significant as the F-values had significances greater than 0.05, the alpha level.

Table 16 Analysis of Variance on Flavor

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIFICANCE
Plant (A)	57.207	2	28.604	29.713	0.000*
Maturity (B)	1.119	2	0.559	0.581	0.560ns
Weight (C)	.267	2	0.133	0.139	0.871ns
Plant (A) * Maturity (B)	.519	4	0.130	0.135	0.970ns
Plant (A) * Weight (C)	2.837	4	0.709	0.737	0.567ns
Maturity (B)* Weight (C)	1.704	4	0.426	0.442	0.778ns
Plant (A)* Maturity (B) * Weight (C)	1.570	8	0.196	0.204	0.990ns
Error	753.767	783	0.963		
Total	818.989	809			

* - significant at 0.05 level
ns – not significant

General acceptability. Table 17 presents the mean general acceptability ratings of herbal tea from guava leaves of different maturity. The highest mean was obtained from old leaves followed by young leaves. The lowest mean was obtained from mature leaves. The mean differences were, however, not statistically significant connoting that maturity did not matter. Nevertheless, Cowan (2019) stated that mature leaves were most desirable.

Table 17 Mean General Acceptability of Herbal Tea from Guava Leaves of Different Maturity

MATURITY	WEIGHT (G)			MEAN	DESCRIPTIVE INTER-PRETATION
	2	4	6		
Young	7.80	8.06	7.90	7.92	**E**
Mature	7.80	7.87	7.83	7.83	**E**
Old	7.83	8.03	8.10	7.99	**E**

Legend: E – Excellent (7.41-9.00)

Table 18 presents the mean general acceptability ratings of herbal tea from guyabano leaves of different maturity. The highest mean was obtained from the old leaves followed by mature leaves. The young leaves obtained the lowest mean. However, the mean differences were not statistically significant denoting that maturity did not affect the general acceptability. This is in contrast to the statement in Love the Garden (2019) that mature leaves are most desirable.

Table 18 Mean General Acceptability of Herbal Tea from Guyabano Leaves of Different Maturity

MATURITY	WEIGHT (G)			MEAN	DESCRIPTIVE INTER-PRETATION
	2	4	6		
Young	7.90	8.00	7.87	7.92	**E**
Mature	7.83	7.83	8.13	7.93	**E**
Old	8.00	7.97	7.90	7.96	**E**

Legend: E – Excellent (7.41-9.00)

Table 19 reflects the mean general acceptability of herbal tea from malunggay leaves of different maturity. The highest mean was obtained from the old leaves followed by mature leaves. The lowest mean was obtained from young leaves. The mean differences were, however, not statistically significant meaning that maturity did not affect the general acceptability. This is in contrast to the statement of Cowan (2019) saying that mature leaves are the most desirable.

Table 19 Mean General Acceptability of Herbal Tea from Malunggay Leaves of Different Maturity

MATURITY	WEIGHT (G)			MEAN	DESCRIPTIVE INTER-PRETATION
	2	4	6		
Young	8.23	8.30	8.33	8.29	**E**
Mature	8.27	8.53	8.50	8.43	**E**
Old	8.37	8.43	8.60	8.47	**E**

Legend: E – Excellent (7.41-9.00)

Table 20 is the mean general acceptability of herbal tea from different plant species. Malunggay had the highest mean of 8.40 described as liked extremely followed by guyabano with a mean of 7.94 described as liked very much. Guava had the lowest mean of 7.91 described as liked very much. The LSD test revealed that malunggay had significantly better general acceptability than the other species. Malunggay is acceptable and is desirable (Pascual, 2016).

Table 20 Mean General Acceptability of Herbal Tea from Different Plant Species

PLANT	MEAN*	DESCRIPTIVE INTER-PRETATION
Guava	7.91b	**E**
Guyabano	7.94b	**E**
Malunggay	8.40a	**E**

*Means having a common letter are not significantly different at 0.05 level using LSD (Least Significant Difference) test.

Legend: E – Excellent (7.41-9.00)

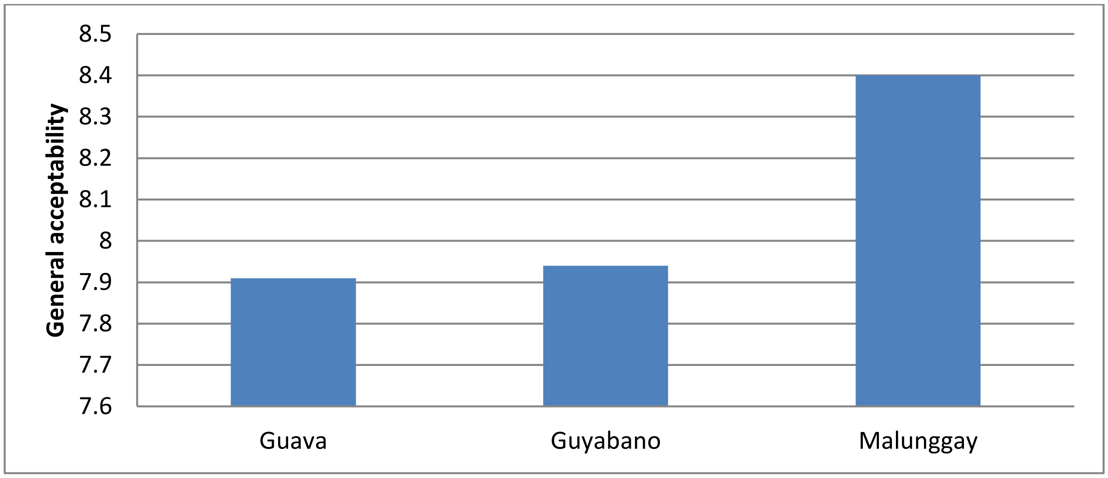

Figure 10 Mean General Acceptability of Herbal Tea from Different Plant Species

Table 21 shows the analysis of variance on general acceptability. The effect of plant species as the factor was statistically significant as the F-value had a significance which is less than 0.05, the alpha level. The other factors such as level of maturity and amount as well as A * B, B * C, A * C and A * B * C interactions had effects which were not statistically significant.

Table 21 Analysis of Variance on General Acceptability

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIFI-CANCE
Plant (A)	39.891	2	19.946	28.315	0.000*
Maturity (B)	1.262	2	0.631	0.896	0.409ns
Weight (C)	2.536	2	1.268	1.800	0.166ns
Plant (A) * Maturity (B)	1.494	4	0.373	0.530	0.714ns
Plant (A) * Weight (C)	0.953	4	0.238	0.338	0.852ns
Maturity (B)* Weight (C)	1.049	4	0.262	0.372	0.828ns
Plant (A)* Maturity (B) * Weight (C)	2.706	8	0.338	0.480	0.871ns
Error	551.567	783	0.704		
Total	601.458	809			

* - significant at 0.05 level
ns – not significant

The sensory evaluation revealed that malunggay herbal tea is superior to both guyabano and guava. Also among the amounts of ground leaves, 4 g and 6 g are more desirable than 2 g. The foregoing results are in terms of aroma, color, flavor and general acceptability. Malunggay leaves are rich in protein aside from the other plant food nutrients (Food and Agriculture Organization, 2019). These are also rich in vitamins and minerals (Gopalakrishnan et al., 2019). Thus, the discovery that malunggay leaves are best for herbal tea among other species adds to the value already attached to this plant.

Phytochemical Analysis

Table 22 reflects the results of the analysis of herbal tea as to the presence of phytochemicals. Phytochemicals are non-nutrient compounds that are essential in biological activity. These are termed otherwise as bioactive chemicals. Among the phytochemicals are alkaloids. These may act as reservoirs of protein synthesis or as detoxicating compounds (Kaur, 2019). The analysis in the study revealed intense colour in the three species namely guava, guyabano and malunggay indicating presence of considerable amounts of alkaloids. As to tannins, the analysis revealed absence of these phytochemicals. Tannins are plant metabolites and they function as part of metabolism (Sieniawska & Baj, 2017). The analysis revealed varying amounts of anthraquinones. These compounds provide colour (Science Direct, 2019). These are present in guava and malunggay but considerable amounts were present in guyabano. Glycosides were found to be present in guava, guyabano and malunggay. These are necessary for the polymerization of sugars (Science Direct, 2019). The reducing sugars are present in guava and malunggay but absent in guyabano. These act as reducing agents (Rizzo, 2019). Saponins were present in the three species. Saponins are glycosides which regulate blood cholesterol and reduce the risk of cancer (Phytochemicals, 2019). Intense colours or considerable amounts of flavonoids were found in the three species. Flavonoids are metabolites with multitude of functions such as protection from ultraviolet rays and pigmentation (Mathesius, 2018). Phlobatannins were absent in the three species, however. These are types of tannins which are metabolites or function as part of metabolism (Ali et al., 2018). Steroids were present in malunggay but absent in guava and guyabano. These compounds can act as hormones (Study, 2019). Terpenoids were present in guyabano but intense colours or considerable amounts were found in guava and malunggay. Terpenoids are metabolites involved in growth and development (Tholl, 2015). Coumarin was present in the three species. This compound has been found to govern the growth of cells (Rohini & Srikumar, 2014). Considerable amounts of emodins were found in guava and malunggay although this is present also in guyabano. Emodins are anthraquinones and in humans have therapeutic effects (Science Direct, 2019). Anthocyanin was not found in the three species. This compound is responsible for colour and protection of tissues (Landi et al., 2015). Betacyanin, however, was present in the three species. This compound has protective function (Nakashima et al., 2011).

Table 22 Results of Phytochemical Analysis

PHYTOCHEMICAL	GUAVA	GUYABANO	MALUNGGAY
1. Alkaloids	++	++	++
2. Tanins	-	-	-
3. Anthraquinones	+	++	+
4. Glycosides	+	+	+
5. Reducing sugars	+	-	+
6. Saponins	+	+	+
7. Flavonoids	++	++	++
8. Phlobatannins	-	-	-
9. Steroids	-	-	+
10. Terpenoids	++	+	++
11. Coumarin	+	+	+
12. Emodins	++	+	++
13. Anthocyanin	-	-	-
14. Betacyanin	+	+	+

Legend:
++ (Intense colour)
+ (Natural colour - presence)
- (Absence)

Summary of Findings

The study was conducted in Iloilo City in order to determine the organoleptic and phytochemical results of the herbal tea from three different species of plants. The experiment involved three factors such as plant species, levels of maturity and amount of ground leaves. This was a 3 * 3 * 3 factorial experiment in CRD. The study consisted of organoleptic and phytochemical evaluation. The data gathered were subjected to both descriptive and inferential statistics with the results of the latter interpreted at the alpha level of 0.05.

The study revealed the following findings:

1. The sensory evaluation revealed that the factor such as plant species and amount of ground leaves significantly affected the aroma of herbal tea. Significantly best tea was obtained from malunggay at 4 g and 6 g. The rest of the factors and the interactions did not significantly affect the aroma of herbal tea. However, generally the four sensory attributes were verbally described as excellent and were not significantly affected by maturity of the leaves. The factor such as plant species also significantly affected the color, flavor and general acceptability of herbal tea. The rest of the factors and the interactions did not significantly affect the color, flavor and general acceptability of herbal tea.

2. The different formulations of tea powder were generally positive in phytochemicals. Malunggay herbal tea had significantly the best color, flavor and general acceptability among the plant species.

3. The panelists rated the color, flavor, aroma and general acceptability of the three plant species, three levels of maturity and three amounts all as excellent.

4. The phytochemical analysis of the three plant species differed in terms of reducing sugars where guava and malunggay was positive while guyabano was negative. The rest of the phytochemicals were mostly present in the three species. Alkaloids and flavonoids were present in considerable amounts in the three plant species namely guava, guyabano and malunggay. Glycosides, sponins, coumarin and betacyanin were present in the three plant species. Anthraquinones were present in guava and malunggay and considerable amounts were found in guyabano. Reducing sugars were present in guava and malunggay but not in guyabano. Terpenoids and emodins were found in considerable amounts in guava and malunggay but present in lesser amounts in guyabano.

5. The sensory attributes differed significantly in the three plant species in terms of color, flavor and general acceptability. The aroma significantly differed by plant species and amounts of ground leaves per sachet.

Conclusions

Based on the findings of the study, the following conclusions were arrived at:

1. Best aroma, color, flavor and general acceptability are present in herbal tea from malunggay. These attributes are excellent also for the three plant species such as guava, guyabano and malunggay, three maturity of leaves such as young, mature and old and three amounts of ground leaves per sachet such as 2 g, 4 g and 6 g.

2. Aroma is better in 4 g and 6 g of ground leaves than at 2 g.

3. The herbal tea from three levels of maturity of leaves, namely, young, mature and old have similar aroma, color, flavor and general acceptability.

4. Glycosides, sponins, coumarin and betacyanin are present in the leaves of malunggay, guava and guyabano.

5. Anthraquinones are present in guava and malunggay and considerably more amounts are present in guyabano.

6. Reducing sugars are present in guava and malunggay but not in guyabano.

7. Terpenoids and emodins are found in considerable amounts in guava and malunggay but present in lesser amounts in guyabano.

8. The presence of many phytochemicals in the three plant species proves the Health Belief Model which is the theory in this study.

Recommendations

Based on the results of the study, the following recommendations are propounded:

1. The study revealed the superiority of malunggay in terms of the organoleptic evaluation and phytochemical analysis results. Also, the organoleptic evaluation revealed that the amounts of 4 g and 6 g gave the best aroma of herbal tea. Therefore, it is recommended that herbal tea be prepared from dried and ground malunggay leaves at 4 g to 6 g per sachet of the ground leaves.

2. This innovation will, however, be solely in the name of the author so permission must be secured from her in the use of such for commercial purposes.

3. Other studies may be recommended in other plant species particularly legumes.

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