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RESEARCH ARTICLE

Sensory attributes and acceptability of *Ardisia elliptica* Thunb. berry products

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Abstract

Ardisia elliptica Thunb. (AE) is an underutilized shrubs that serve as a potent and cost-effective source of raw materials for nutraceuticals and pharmaceuticals. Research revealed that these berries contain phytochemical compounds such as anthocyanins, flavonoids, tannins and quinones with a high 88 %-89 % antioxidant potential, which benefits human health. This study evaluated the sensory attributes and acceptability of AE extract, ice cream, jam, juice and wine. The assessment utilized the Hedonic scale, frequency count and mean analysis. The sensory and acceptability attributes of the *A. elliptica* extract were liked very much in terms of its appearance, taste and texture. In contrast, its aroma and mouthfeel were liked moderately and generally accepted very much. For AE ice cream, the appearance was liked very much in different variations, the taste, texture and mouthfeel were liked moderately and the aroma was liked slightly and accepted moderately. AE jam and juice were both liked and accepted very much despite their astringency. Moreover, the AE wine was liked and accepted moderately, too. These significant findings serve as vital bases for identifying nutritious and cheap raw material sources, enhancing the value of the diverse *A. elliptica* Thunb. plant.

Keywords: *Ardisia elliptica* ; ice cream; jam; juice; sensory attributes; wine

Introduction

Ardisia elliptica Thunb. commonly known as the shoe button ardisia, shoeberry, or Christmas berry, it is a flowering plant belonging to the family Myrsinaceae.

This ornamental shrub has been found in the Southeast Asian Tropics and has been considered invasive (1, 2). The leaves are shaped as elliptic to elliptic-obovate, leathery or alternate. The petals are light pink. The flowering stage occurs in the warmer months following the fruiting. The flowers are small, star-shaped and often in clusters and panicles. Each flower is about 4-5 mm in diameter and has 5 petals. The clusters of flowers develop from the leaf axils. Each flower has both male and female reproductive organs. The flowers develop into small spherical berries. These berries are initially white, turn green and mature into a deep, glossy red color. They are typically 4-6 mm in diameter and each berry contains several seeds. It can be grown with minimal cultivation and management. The plant can bear fruits in just a year from planting (3-5).

If properly managed, the plant is very productive and the fruits are bigger due to its high seed viability of 99%. In ideal conditions, mature plants can thrive for 2-4 years and can produce 400 fruits (6). The height is around 5 meters only, which hastens harvesting. Cutting off the main trunk is observed to be better as the plant will sprout and the sprout can again bear fruits in the next fruiting season. However, the taste of the fruit is bland and astringent, which makes the fruit not appealing when freshly eaten.

Quirino State University had planted more or less 400 *A. elliptica* inside the school. After 3 years, it has been harvesting robust fruits since then. The fruits are purple-black and are believed to have antioxidants. The fruit extracts are believed to have health benefits such as antibacterial activity and phytochemicals (7). But this fruit is not yet widely known in the province and nearby markets.

For decades, phytochemicals have been utilized worldwide for traditional herbal medicine. Pharmaceutical industries and researchers now greatly emphasize the phytochemical studies of tropical fruits, which are underutilized (8). Plant extract serves as a good source of bioactive compounds and also as a natural pigment with potential as colorants in food and pharmaceutical products (9, 10). Moreover, the presence of photochemicals in the different plant parts is used by the locals for healing certain disorders (11, 12).

Secondary metabolites are often unique to particular plants and act as anti-feedants, sex hormones and antibiotic agents, such as alkaloids, steroids, flavonoids (13), anthocyanins, phenols, quinones, saponins, tannin and terpenoids (14) (Table 1).

With these characteristics, AE berries must be utilized and maximized to their potential. Its berries need to be

Table 1. Phytochemical screening of *Ardisia elliptica* Thunb. berries.

Phytochemical nutrients	Raw materials		
	***Ardisia elliptica* extract**	***Ardisia* with bignary wine**	***Ardisia* with duhat wine**
Anthocyanins	+	+	+
Flavonoids	+	+	+
Phenols	-	+	+
Quinones	+	+	+
Saponins	-	+	+
Tannins	+	+	+
Terpenoids	-	+	+

+ - Present, **-** -Absent.

preserved while waiting to be utilized for other products for industry and economic purposes.

For the safety and health of consumers, microbiological assessment must be done to pass quality assurance for food and juices developed. Levels of microorganisms should be determined, too, to prevent potential health hazards and imminent spoilage for some time. Shelf life must be established to prevent any untoward health and safety incidents (15) when AE extracts are used as enhancers or blends, or as a main ingredient.

It must be noted, though, that microbial growth in foods is complex. It is affected by genetic, biochemical and environmental factors. The intrinsic factors such as the composition of the food itself, compounds added, pH, nutrient content, presence of antimicrobial constituents, biological structures and water activity; extrinsic factors such as time, gas composition and temperature and food processing factors. These factors, if determined, can be manipulated to control microbial growth for health concerns and be entirely safe from fungal spoilage (16-20).

The % of alcohol in wine must be ensured to facilitate caution when served. It will also serve as a means of comparison with the available commercial wines in the market. Knowledge of this character will be a crucial basis for the modification of AE products for ride-on with other fruit wines made in season (21, 22).

In addition, the determination of the above factors will allow researchers and consumers to identify appropriate methods to use to unleash and uplift the potential of AE products. Considering the productiveness of this plant, product development using the fruits is necessary to maximize the utilization of this crop for consumption. This study will serve as a basis to encourage farmers to grow this kind of crop, encourage processors or manufacturers to develop more products and encourage consumers to buy and consume the locally available products. This study will also open the door for continuing research endeavors to explore the medicinal components and other products for commercialization.

Specifically, this study explored maximizing the potential of AE food products, such as ice cream, jam, juice and wine, that can be made out of this rich, cheap raw material. As such, these must be well-tested to prevent any contamination and hazardous effects to consumers. Further, the findings generated will bring new horizons on the proper utilization of the said species without sacrificing its nutritional contents, minimize losses and strengthen the act of its conservation.

Materials and methods

This study utilized Descriptive Research Methodology, with data sourced from documented results of laboratory analyses conducted by the accredited laboratory in the region (Fig. 1).

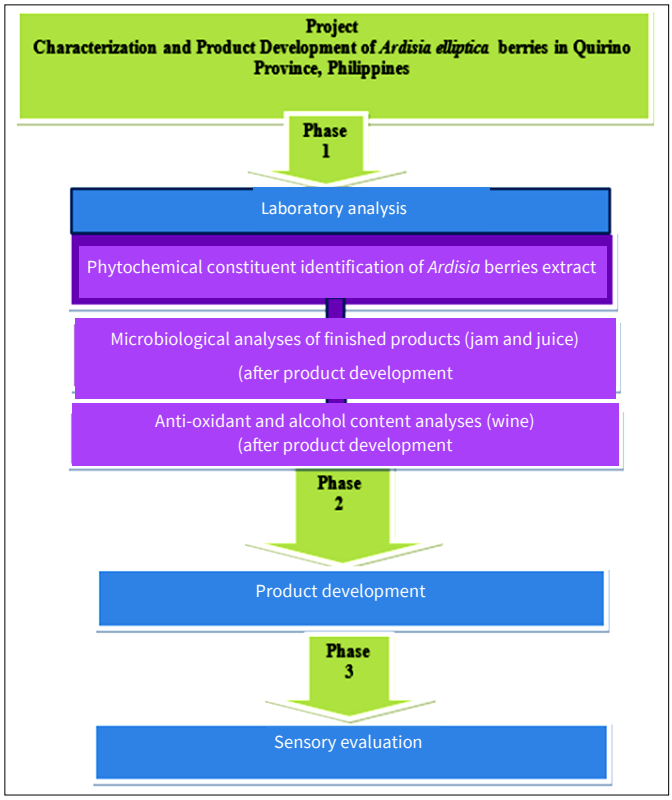

Fig. 1. The conceptual framework of the study.

Research environment

The samples were collected from the Quirino State University -Diffun (QSU-D) campus plantation. The plantation was geocoded within the latitudinal scales of 16.596962 and longitudinal scales of 121.507636.

The development of the products took place at the Quirino Young Entrepreneurs Association (QYEA) Laboratory processing and QSU Marketing-Diffun, Quirino. The process adhered to the protocols of sensory analyses.

Research instrument

A researcher-made questionnaire was used as the instrument for gathering the data needed. The data were analyzed using the Hedonic scale, frequency count and mean.

Data gathering procedure and analyses

Extraction process

Samples were collected on March 10, 2021, at the Quirino Young Entrepreneurs Association (QYEA) Lab processing within the university.

The parts of the plants used were matured fruits because it is suitable for juice extraction. The juice was extracted through the following processes, which were determined to be suitable for the berries and their products.

For wine-making, it was through cold pressing; for juice: blanching of fresh fruit followed by cold pressing; for jam: blanching the fresh fruit and then pressing; and for ice cream, the fresh fruits were also cold-pressed.

Respondents

The participants included students, faculty and staff members from various departments of the QSU-Diffun campus. Among the 70 evaluators, there were 5 professionals and trained food tasters and evaluators.

Specific criteria were followed for selecting the evaluators, including ensuring they were non-smokers, had not chewed for at least 2 h, did not have artificial teeth and were not using perfumes or eating smelly spicy ingredients.

The principles of sensory evaluation of food were strictly adhered to. The tasters received a brief orientation on the research and instructions on using the evaluation scale.

The sensory evaluation process involved steps such as thorough cleaning and extraction of the AE berries, planning and preparation of ingredients, formulation of products, primary food tasting to assess material freshness, readiness of evaluators, revision based on treatment results, final food tasting using the Hedonic scale and formulation of the final product. Fig. 2 illustrates the general flowchart of the procedure for each product.

Hedonic scale

The 9-point Hedonic scale was adapted and employed to assess the level of preference and overall acceptability of the products (23) (Table 2).

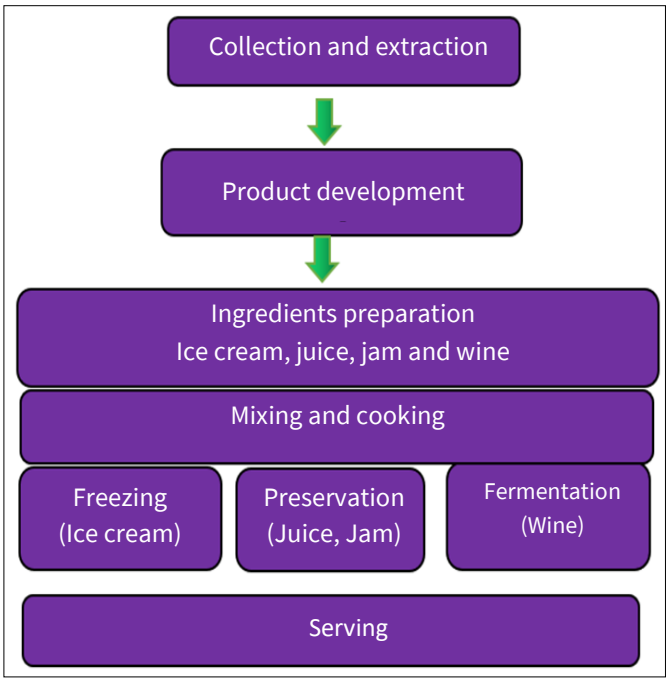

Fig. 2. Flowchart for each product.

Table 2. Hedonic Scale.

Scale	Range	Description	
		Sensory Evaluation	General Acceptability
9	8.50-9.00	Like extremely	Extremely acceptable
8	7.50-8.49	Like very much	Accepted very much
7	6.50-7.49	Like moderately	Moderately accepted
6	5.50-6.49	Like slightly	Accepted slightly
5	4.50-5.49	Neither like nor dislike	Neither accepted nor accepted
4	3.50-4.49	Dislike slightly	Slightly not accepted
3	2.50-3.49	Dislike moderately	Not accepted slightly
2	1.50-2.49	Dislike very much	Not accepted very much
1	1.00-1.49	Dislike extremely	Extremely not accepted

Results and Discussion

Sensory and Acceptability attributes of *A. elliptica* products

A. elliptica fruit extract

Table 3 reveals that *A. elliptica* berry extracts sensory attributes, such as its texture (mean 8.33), appearance (8.25) and taste (7.50), were liked very much, while its mouthfeel (7.00) and aroma (6.75) were liked moderately. It was also very much accepted.

The evaluators liked very much the smooth texture and the enticing red-purple coloring of the extract. In terms of its aftertaste, the astringent (sour bitter) taste and aroma of freshly picked fruit were the most stated observations. The astringent effect (*pagka-ata-at* in the common dialect) is the distinct character that the AE berry made to be talked about.

There is not much published research conducted as to sensory attributes and acceptability of the extract up to this time as far as the researchers are concerned. However, as to the chemical content, the findings of some studies are offered.

In some studies, leaves and fruit extracts of AE contained similar major compounds, such as 5-hydroxymethyl-2-furan carboxaldehyde, 2,4-di-tert-butylphenol and clindamycin, known as an antibiotic (24-32).

Another study found that AE fruit extract contains chemo-preventive potential, embelin. This Embelin was identified as one of the active compounds and may serve as a chemical marker for quality assurance purposes (33, 34).

A. elliptica berry ice cream

Table 4 indicated that *A. elliptica* ice cream was highly flavored in terms of appearance (7.55) and taste (7.40) while receiving moderate ratings for mouthfeel (6.96), texture (6.81) and aroma (6.38). The ice cream was moderately accepted, with no astringent effect observed when mixed with soya and other fruits in varying proportions of soya and fresh milk. To

Table 3. Sensory and Acceptability attributes of *Ardisia elliptica* extract.

Raw material	Appearance	Taste	Texture	Mouthfeel	Aroma	General acceptability
Ardisia elliptica extract	8.25	7.50	8.33	7.00	6.75	7.50
Qfualitative description	Like very much			Like moderately		Accepted very much

Table 4. Sensory and acceptability attributes of *Arfisia elliptica* ice cream.

Ice cream	Appearance	Taste	Texture	Mouth feel	Aroma	General
Ardisia +soya 3 cups each	8.20	8.00	7.60	7.80	7.20	8.20
Ardisia +soya 2 cups each	6.86	6.57	5.57	5.71	5.29	6.43
Ardisia +avocado + sweetrener 1 cup each	7.60	7.64	7.27	7.36	6.64	7.45
Mean	7.55	7.40	6.81	6.96	6.38	7.36
Qualitative description	Like very much		Like moderately		Like slightly	Accepted moderately

maintain its optimal sensory attributes, it is recommended to store the ice cream at a temperature that balances all components to prevent curdling.

Curdling can be avoided by mixing the AE extract with acidic substances. Ice cream quality is typically evaluated based on the flavor, body and texture, color and packaging and melting characteristics. The flavor of berries and fruits can be infused into frozen dairy desserts using fresh, frozen, or processed fruits, natural extracts, imitation flavors, or various combinations.

AE fruits and leaf extracts not only have a significant amount of anti-bacterial activity against bacteria, their fruit also contains a higher content of phenol (71± 0.03 GAE/mg extract dry weight) than its leaves (37 ± 0.05 (Gallic acid equivalent) GAE/mg extract dry weight, flavonoid content and Iron (2+), radical inhibition of 70% for fruit and 60% for leaves. Through Liquid Chromatography Mass Spectrometry (LCMS), the fruit extracts contained gingerol, aspidin, kampherol and stercusin, while the leaves contained gingerol, aspidin, triangularine and salicyl acyl glucuronide. Vitamin E, 5-hepylresornicol, 2-nonylmalonic acid and alpha amyrenol and phenol (35-37).

These are manifestations that AE fruit and leaves are a potential source of effective anti-microbial and antioxidant agents in pharmaceutical and food industries.

The choice of flavoring influences the flavor profile, body and texture and appearance of the final product. Ideally, the ice cream flavor should evoke the taste of the sweetest fresh fruit and ice cream. Frozen fruit preparations are commonly used to address issues related to seasonality, availability and perishability of fresh fruit (38). To the researchers' knowledge, there are no published studies yet on this specific application of *A. elliptica* berries.

A. elliptica berry jam and juice

Research findings, as documented in Table 5, have demonstrated the appeal of *A. elliptica* jams when compared to blends incorporating calamansi and pineapple juice. Jams with the addition of pineapple were notably preferred due to their sensory attributes, from mouthfeel (7.61), taste (7.66), appearance (7.74), texture (7.76) and aroma (7.78), garnering significant favor and it is generally accepted very much (8.04). The light purple color of the outputs is enticing to look upon. The added calamansi and pineapple did not overpower the taste and aroma, instead, it added to its palatable taste because it lessened the astringency. Thus, it is noteworthy that *Ardisia elliptica* jam received considerable acceptance, indicating its potential in culinary applications.

Native to Southeast Asia, *A. elliptica* (AE) is an evergreen shrub that bears small, round, glossy fruits, which have garnered attention for their diverse culinary uses, particularly in crafting delicious jams and juices. These fruits present a distinctive blend of sweet and tangy flavours, characterized by a slight acidity reminiscent of cranberries, making them an intriguing addition to various culinary creations (39).

The vibrant red-hued fruits of *A. elliptica* possess remarkable pectin-rich properties, making them an excellent choice for crafting delectable jams. The process involves cooking the berries with sugar and sometimes pectin, resulting in a delightful spread that harmonizes sweetness and tartness in perfect balance (40-42). It must be emphasized sternly that proper, clean and safe preparation of the berries affects their shelf life (43).

Furthermore, *A. elliptica* berries lend themselves to creating flavorful juices. Through gentle pressing or blending of the berries and subsequent straining of the pulp, a refreshing and tangy juice is extracted. Some recipes may involve dilution or blending with other fruits to enhance the nuanced taste profile. It can be gleaned from Table 6, that AE juice was liked very much in terms of its aroma (7.29), taste (7.45), mouthfeel (7.52), texture (7.71) and appearance (7.87) and overall accepted very much.

The AE juice maintained its enticing light purple color. It has a smooth texture when drunk and an after-effect of the tangy taste (mouthfeel and aroma) of AE. The smell remained even when added with some mixture to taste (44, 45).

Beyond their culinary allure, *A. elliptica* berries offer potential health benefits. Laden with antioxidants, vitamins (such as vitamin C) and various beneficial compounds, these fruits contribute to overall well-being. Some studies hint at their potential to bolster immune health and provide anti-inflammatory properties. Nevertheless, further research is essential to delineate their specific health advantages.

Table 5. Sensory evaluation of *Ardisia elliptica* berry jam.

AE jam	Appearance	Taste	Texture	Mouthfeel	Aroma	GA
With kalamansi	7.61	7.0	7.55	7.16	7.29	7.52
With pineapple	7.87	8.32	7.97	8.06	8.29	8.55
Mean	7.74	7.66	7.76	7.61	7.78	8.04
Qualitative Description			Like very much			Accepted very much

Table 6. Sensory evaluation of *Ardisia elliptica* berry juice.

AE juice	Appearance	Taste	Texture	Mouthfeel	Aroma	GA
Mean	7.87	7.45	7.71	7.52	7.29	7.90
Qualitative Description			Like very much			Accepted very much

A cautionary note is warranted regarding the consumption of *A. elliptica* fruits for culinary purposes. It is imperative to ensure accurate identification and safe handling of these wild or unfamiliar plants due to potential variations in toxicity or allergenicity.

For these, *A. elliptica* stands out as a versatile fruit, celebrated for its delightful flavors and potential health benefits. While it has found its way into jams and juices, ongoing exploration and research could unveil further culinary and health-related potentials of this intriguing fruit.

A. elliptica berry wine

Table 7 shows the sensory attributes of *A. elliptica* berries when made into wine with bignay and duhat (plum) fruit extracts. The aroma (7.07), appearance (7.30), texture (6.90), mouthfeel (6.74) and taste (6.62) were liked moderately which made it be accepted moderately too.

According to most adjudicators, there was an acrid (mapakla), sappy and astringent (sour-bitter taste or ata-at in local dialect) taste when mixed with bignay wine and a strong bitter-sweet taste when with duhat wine. These attributes are distinct from AE berries. These qualities shown though, were liked by some and made them drink more because of the belief that dark-colored drinks from fruits are rich in antioxidants (46, 47).

There were no published studies yet regarding this specific type of food application of AE as of the researchers' knowledge. This study would provide insights into the potential flavour profiles, fermentation methods and challenges associated with creating wine from these berries. However, the above findings would be an additional basis for the continuous quest for more utilization of the plant. Regional variations may be present but are still on their way to being discovered or may be known but not published.

Conclusion

A. elliptica berry extract was liked very much in terms of its sensory attributes, such as texture, appearance and taste, while liked moderately in terms of mouthfeel and aroma. It was also accepted very much. When *A. elliptica* extract was made into ice cream in variations, it was liked very much in terms of its appearance and taste and liked moderately as to its mouthfeel, texture and aroma. It was moderately accepted, too. *A. elliptica* added with bignay wine was liked and accepted moderately in terms of its sensory characteristics, such as appearance, aroma, texture, mouthfeel and taste. Based on the nutritional contents, researchers must pursue the development of these food products and verification studies must be done on other parts of the fruit for specific diseases or ailments to strengthen the findings of the study, particularly having a nutritive value and a potential medicine.

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Authors' contributions

RVG and MTB collaboratively conceived and coordinated the protocols for the conduct of the processes of sensory evaluation and acceptability of the products and analyzed the data and RVG completed the final manuscript.

Compliance with ethical standards

Conflict of interest: The authors have no conflict of interest to disclose.

Ethical issues: None.

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Table 7. Sensory evaluation of *Ardisia elliptica* berry wine

AE wine	Appearance	Taste	Texture	Mouthfeel	Aroma	GA
Ardisia + bignay wine	7.31	6.69	6.94	6.77	7.20	6.91
Ardisia + duhat wine	7.29	6.54	6.86	6.71	6.94	6.84
Mean	7.30	6.62	6.90	6.74	7.07	6.88
Qualitative Description			Like very much			Accepted very much

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