

Evaluation of Sensory Acceptability, Functional Properties, and Proximate Composition of Four Novel Functional Foods Incorporated With *Garcinia quaesita* Leaves

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ABSTRACT

Purpose: *Garcinia quaesita* is an exquisite spice used extensively in imparting flavor to foods, and in curing diseases in Ayurveda. Considering the seasonality of the fruit rind, abundance of the leaves, and potential functional properties displayed by the leaves, this study was intended to develop functional foods incorporating garcinia leaf extract and assess their sensory, functional, and nutritional properties.

Research Method: Herbal tea, herbal crackers, herbal appetizers and herbal confectionery incorporated with garcinia leaves were developed and assessed for their sensory qualities. As in functional properties, total polyphenol content, total antioxidant activity, and total flavonoid content of the products were measured while the proximate composition was analyzed to obtain basic nutritional composition.

Findings: All the products were sensory accepted; with mean scores above, “3” from a 5-point hedonic scale in each attribute, while retaining the basic nutritional composition of their particular food categories. Each product reported significant amounts of polyphenols and flavonoids with remarkable antioxidant activity, whereas, the highest reported values were shown by Herbal tea, consisting of *G. quaesita*, *P. guajava*, *C. verum* and *C. sinensis*. Being comprised of direct herbal infusions as well as the synergetic effect of the herbal materials seems the potential factors behind these elevated functional properties.

Research Limitations: The main research limitation was the limited accessibility to sensory panelists, raw materials, chemicals and laboratories due to the pandemic situation during the study period.

Originality: The study demonstrates the concept of incorporating *Garcinia quaesita* leaf extract in food products to impart functional properties while retaining higher sensory acceptability.

Keywords: Functional foods, *Garcinia* leaf, Herbal, Sensory acceptability

INTRODUCTION

Recently, Non-communicable Diseases (NCDs) have been the most dominant reason for death and disabilities. At present, the global death percentage due to NCDs is reported to be over 70% of all deaths. It is around 41 million people per year according to the latest statistics by the World Health Organization in 2020 and approximately 16 million deaths in people less than 70 years of age (Horton, 2013; WHO, 2020).

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The situation is not much different in Sri Lanka, where a study suggests that hospitalizations due to diabetes mellitus, hypertensive disease, and ischemic heart disease will increase by 36%, 40%, and 29%, respectively in 2010 compared to 2005; a Study in 2014 stated that NCDs have been the leading cause of death for the past 20 years (Premaratne *et al.*, 2005; Siegel *et al.*, 2014).

This scenario has shifted global attention towards diet-related medical interventions such as functional foods to diminish the situation. The term functional foods is simply used for foods or food components that may have health benefits that reduce the risk of specific diseases or other health concerns (Doyon and Labrecque, 2008). With the global knowledge flow, the public is now moving towards a health-conscious trend in their consumption patterns, which has created a rising demand for functional foods with health and nutritional benefits, and a predominant preference for nutraceuticals instead of pharmaceuticals.

Above such circumstances, Sri Lanka has a huge potential in creating herbal functional foods and nutraceuticals as it is a country rich in biodiversity, which consists of a lavish profile of medicinal plants. It is also one of the most favorable natural environments to grow them. Even though Sri Lanka has a rich profile of medicinal plants, several underutilized plants with medical properties could be utilized to develop functional foods. *Garcinia quaesita*, popularly known as “Rath Goraka” is such a medicinal plant that is endemic to Sri Lanka (Nimanthika and Kaththiriarachchi, 2010). *G. quaesita* is popularly known for its functionality in reducing the effects of hyperglycemia, and hypercholesterolemia due to the main acid component; Hydroxyl Citric Acid (HCA) (Hemshkhar *et al.*, 2011). Although substantially lesser than in fruit rinds, it is reported that garcinia leaves also contain a sizeable amount of HCA (Asish *et al.*, 2008). Also, a recent study indicates that the garcinia leaves contain considerable amounts of alkaloids, glycosides, tannins, flavonoids, etc. (Madappa and Bopaiah, 2012; Kokilanathan *et al.*, 2021). However, to the best of our knowledge, no research or publications on food application of garcinia leaf extract have been published to date, which would be quite beneficial if explored, given the seasonality of the fruit rind as well as the abundance of leaves throughout the year. According to a recent study by Liyanagamage *et al.*, (2020 a), *G. quaesita* fruit rind extract at a therapeutic dosage of 1 g/kg shows a substantial anti-hyperglycemic impact. Furthermore, the isolated active compound Garcinol demonstrated significant acute antihyperglycemic activity at a very

low dose of 10 mg/kg, comparable to the effect of 0.5 g/kg Glibenclamide. Moreover, a 14-day toxicity trial for a herbal treatment aimed at reducing hyperglycemia and dyslipidemia that comprises *G. quaesita* and three other medicinal herbs found no adverse effect, organ damage, or toxicity in Wister rats (Liyanagamage *et al.*, 2020 b).

Somehow, sensory acceptability is a major concern in selecting, developing, and marketing of food products. Several studies have evident that when selecting a food commodity, consumers are highly concerned about the product’s palatability and other quality parameters in addition to nutrition and health benefits. Therefore, sensory acceptability has been identified as one of the determining factors in food purchasing decisions (Lawless and Heymann, 2010; Meiselman and MacFie, 1996). However, in the functional food sector, sensory acceptability is mostly sacrificed to the functional properties. Hence, in designing a novel functional food or enhancing the functional properties of a common food by incorporating an active ingredient, considering only the nutritional and functional properties is not sufficient. Sensory quality also should be considered specifically in aiming to penetrate the market. Though the sacrifice of palatability for functional characteristics has halted, the value of functional foods in everyday consumption patterns has not diminished due to the daily rising risk of NCDs.

The objective of this study was to assess the potential of incorporating *G. quaesita* leaf extract in some novel functional foods about both consumer acceptability and functional properties.

MATERIALS AND METHODS

Material Collection and Research Location

G. quaesita leaves were taken from the faculty premises and were authenticated under ref no. AHEAD/DOR 05/C2 by National Herbarium, Department of National Botanic Gardens, Peradeniya and Acc. No.3006 at Bandaranaike Memorial Ayurvedic Research Institute, Nawinna, Sri Lanka.

All the other ingredients were purchased from the consumer retail market, Kamburupitiya, Matara, Sri Lanka. The research was conducted at the Food Research Centre, and Food Analysis Laboratory, Department of Food Science and Technology, Faculty of Agriculture, University of Ruhuna, Sri Lanka.

Product Development

Herbal tea: All of the herbs used in the herbal tea product were collected, cleaned, and dried in a dehydrator (Excalibur EXC10EL). Then, together with the other ingredients, it was ground into a fine powder and shifted through a strainer to remove both coarse particles and dust. Formulations were carried out using a scientific design of trial and error, and the most acceptable few samples were chosen through preliminary evaluations. The final formula was chosen through sensory examination with a panel of 30 semi-trained sensory evaluation panelists. Moreover, another sensory study was used to determine the best brewing conditions. The final formulation and brewing conditions were then tested for sensory preference against a commercially available green tea product.

Herbal cracker: In the development of the herbal cracker, Garcinia leaves were harvested, cleaned, wiped, and crushed into small particles and dehydrated to reduce the moisture content. Garlics were washed, and cut into small pieces, dehydrated, ground into smallest pieces, and sieved to remove coarse particles. The cracker was made according to the procedure of Alam *et al.*, (2014) with some modifications. Following a trial and error design, dried garcinia leaf bits and garlic were mixed with the other dried ingredients of the cracker in predefined w/w percentages. The dough was kneaded for 20 minutes. Crackers were flattened out and cut into appropriate forms before being baked at 180°C for 12 - 15 minutes. The most acceptable incorporation level was determined through a preliminary sensory evaluation. The top four formulations were then reviewed by a panel of 30 semi-trained sensory panelists. Since an exact equivalent was not available on the market, the final composition was compared to a commercial herbal cracker with curry leaves.

Herbal appetizer: For the herbal appetizer, dried garcinia leaf powder along with several Sri Lankan spices were used. Some components were eliminated during the preliminary experiments, and the amounts of incorporation were adjusted. As the constituents readily had functional characteristics, the main concern was given to the appealing taste of the mixture. For the sensory evaluation, each formulation was made into a broth soup with added water. The preferred mixture was pressed and moulded into pellets with added fat and food gum. The sensory panel assessed both raw and cooked samples descriptively. Benchmarking was not possible because there is no comparable product in the present commercial market.

Herbal confectionary: The gummy candy was made with the incorporation of herbal extracts; cinnamon bark and garcinia leaves. To get the herbal extracts, cinnamon bark powder and fresh garcinia leaves were macerated with water and held separately in a boiling water bath. The contents were vacuum-filtered and then centrifuged to remove debris and crude particles. Product development was carried out in accordance with the approach outlined by Burey *et al.*, (2009), with certain adjustments. Gelatin, sugar, and liquid glucose were mixed and heated accordingly, and herbal extracts were incorporated through a trial-and-error design. The whole mixture was then strained, poured into an oil-coated mould, and refrigerated until set (4 hrs). The optimal formulation was chosen after considering the remarks of a semi-trained sensory panel. The final recipe was assessed descriptively.

Sensory Analysis

The preliminary sensory evaluations were carried out using five individuals chosen based on prior knowledge and expertise in sensory evaluations, as proposed by Watts *et al.*, (1989). A 30-member panel was recruited for the descriptive sensory evaluations, with higher consideration given to representing a wide socioeconomic range and concerning accessibility but not expertise (Hough *et al.*, 2006).

The panelists were invited to the research center, and a separate evaluation area was assigned. Panelists were initially given a brief introduction to the product and contents to prevent any potential allergies; however, this had no effect on their evaluation judgment. The panelists were asked to rate the offered products on a 5-point hedonic scale for a few or all of the following sensory qualities: color, appearance, aroma, texture, thickness, taste, bitterness, acidity, aftertaste, and overall acceptability. The samples were given three number codes ("000"). The panelists were provided with ballet sheets, pens, tissue papers clean water and unsalted crackers to cleanse the palate, in between samples.

Proximate Composition Analysis

All the products were analyzed for their moisture, carbohydrate, crude protein, crude fat, crude fiber and total ash composition through AOAC methods. Moisture content (AOAC 931.04), crude protein content (AOAC 920.87), total fat content (AOAC 922.06), and total ash content (AOAC 923.03) were determined (AOAC International, 2021) and the results were expressed on dry weight (DW) basis. All the assessments were performed in triplicates.

Functional Properties Analysis

The prepared novel products were either ground, blended, or brewed and mixed with water in preparing dilution series. All the functional property assays have followed the suggested methods in Li *et al.*, (2015) with some modifications.

The total polyphenol content was evaluated by measuring the colorimetric reactivity of samples with Folin-Ciocalteu reagent (Li *et al.*, 2015). Gallic acid was used to make the standard solution series. The sample solution (sample, diluted sample, standard, or blank) (1 mL) was transferred to a test tube, and 5 mL of Folin-Ciocalteu reagent was added. After that, 4 mL of 7.5% Na₂CO₃ solution was added and the mixture was properly mixed before being allowed to stand at room temperature in the dark for 30 minutes. The absorbance of 10 mm path length cells against water was measured with a UV-Vis Spectrophotometer set to 765 nm.

The Ferric Reducing Antioxidant Power (FRAP) technique was used to assess antioxidant activity (Li *et al.*, 2015; Yi *et al.*, 2016). 300 mM Acetate buffer: 10 mM TPTZ (2,4,6-tripyrindyl-s-triazine): 20 mM FeCl₃ were mixed in 10:1:1 proportions to make the FRAP reagent. Trolox was dissolved in 50% Methanol to provide a standard solution series ranging from 20 ppm to 360 ppm. In a test tube, the sample or standard solution (0.1 mL) was added, followed by 3 mL of FRAP reagent. The mixture was heated to 37 °C. After 30 minutes of incubation, the absorbance was measured at 593 nm.

The total flavonoid content was determined by colorimetric analysis of the sample reaction with AlCl₃ reagent (Li *et al.*, 2015; Yang and Liu, 2012). Methanolic solutions of Quercetin were utilized as standards. They were made in the 20-160 ppm range. A test tube was filled with 1 mL of standard solution or samples or 50% methanol (blank). The mixture was then violently agitated with 0.5 mL of 2% AlCl₃ and 0.5 mL of 50% methanol. It was then kept at room temperature for 10 minutes to incubate. Readings at 425 nm wavelength were then obtained.

RESULTS AND DISCUSSION

Functional foods have captured undeniable attention with the increased risk of NCDs and the dietary relationship of NCDs. Though in the earlier days, people were willing to sacrifice sensory qualities, for the health concerns of functional foods, many recent studies show that the tendency is now ceasing (Grigor

et al., 2016). Therefore, to get a competitive advantage in the functional food and beverage industry, innovators must focus on making the food appealing and palatable while also including functional properties.

Product Development

The sensory characteristics of the novel functional foods influenced the final recipes the most. The percentages of herbal inclusion in the final formulations of the innovative products were as shown in Table 01.

Sensory Analysis

Sensory evaluation is one of the major modes of assessing food acceptability for new product developments, existing product development, and food product/process advancements since the beginning of food technology.

The initial novel product developments engaged a series of sensory evaluations that occupied trained panelists. The results obtained were analyzed through the Friedman test to obtain the mean ranking of the sensory scores (Wickramasinghe *et al.*, 2020). Thereby the final product recipes and formulations were selected referring to the highest mean ranking scores.

Depending on the availability of commercial equivalents, final items were either descriptively assessed or benchmarked with their comparable commercial products. The mean rank scores obtained by descriptive sensory evaluations of all four products are depicted below in Fig.01.

As each developed product scored a mean rank value above “3” in each attribute, the incorporation of *G. quaesita* leaves in functional foods was proven possible with considerable consumer acceptability.

The herbal tea and the herbal cracker already had competitive market products in the market, with many other herbal incorporations. Therefore, the final comparison was done along with a commercially established comparable product. According to the analyzed data of the benchmarking sensory evaluation, both the novel products; herbal tea and herbal crackers showed satisfactory overall preference over the established similar commercial products. Where the novel herbal tea and novel herbal cracker showed no significant difference ($P > 0.05$) in the overall preference for commercial substitutes (Wickramasinghe *et al.*, 2020).

Table 1: Percentage of herbal incorporation in finalized recipes of novel herbal functional food products

Novel Herbal Product	Herbal Tea	Herbal Cracker	Herbal Appetizer	Herbal Confectionary
Herbal Incorporation (W/W %)	Garcinia 40% Guava 20% Cinnamon 20%	Garcinia 10% Garlic 5%	Garcinia 30% Garlic 10% Cinnamon 5% Coriander 5%	Garcinia 10% Cinnamon 5%



Figure 1: Sensory Acceptability of novel herbal products for each sensory attribute

Even though the other two items, herbal appetizer and herbal confectionery, had no commercial products to compare them to, they were able to get acceptable mean scores in each sensory attribute during the descriptive sensory analysis.

Additionally, to the numerical data obtained from sensory evaluations, panelists highlighted the pleasant sour taste imparted by *G. quaesita* to all novel functional foods. In the herbal tea, panelists preferred the herbal combination of higher garcinia leaf content with lesser guava leaf content whereas, garcinia was responsible for a citrusy sour taste while guava leaf gave an astringent taste. The herbal cracker was accepted as a savory cracker, preferably with some salt and pepper according to the sensory panelists' comments and an acceptable rating of 4.8 out of 5 for its sourness. The taste profile induced by the incorporation of *G. quaesita* leaf extract in both herbal appetizers and herbal confectionery has also scored

above 4.5/5.0 with remarkable comments from the sensory panelists.

Proximate Composition Analysis

Proximate analysis was done in triplicates for each product. The nutritional qualities of all innovative products are compatible with those of their derivative food categories.

Functional Properties Analysis

The functional properties of each product were also analyzed in triplicates and the obtained data were analyzed through Microsoft Excel Professional Plus 2016.

Phenolic compounds are secondary metabolites produced by the shikimic and phenylpropanoid

Table 2: Proximate compositions of novel herbal functional food products

	Moisture (%)	Crude Protein (%)	Total Fat (%)	Crude Fiber (%)	Total Ash (%)	Carbohydrates (%)
Herbal Tea	8.91	8.14	3.30	7.69	3.99	67.97
Herbal Cracker	4.71	7.53	21.33	0.96	1.50	63.97
Herbal Appetizer	20.15	6.50	8.17	7.99	5.30	51.89

Table 3: Functional properties of novel herbal functional food products

Product	Total Polyphenols Content (ppm GAE)	Total Antioxidant Activity (ppm TE)	Total Flavonoid Content (ppm QE)
Herbal Tea	1945.00±0.91	3365.00±0.59	363.00±0.29
Herbal Cracker	338.56±0.08	447.14±0.11	36.58±0.04
Herbal Appetizer	710.98±0.65	939.00±0.24	76.816±0.09
Herbal Beverage	203.94±0.09	207.14±0.13	10.30±0.08

pathways, and they have a wide range of bioactive qualities. Even though phenolic compounds are not considered nutrients, they have several health-protective properties when consumed (De la Rosa *et al.*, 2018). Antioxidant, hypoglycemic, hypolipidemic, anti-tumor, and antidiabetic characteristics have all been linked to phenolic substances. Anti-inflammatory, anti-allergic, antiviral, antiproliferative, and anti-carcinogenic properties being associated with flavonoids have long been recognized. However, the above functional properties are in use for folk medicine and traditional culinary cuisine with the fruit rinds of *Garcinia*, but the properties of its leaves have not been explored recently. In a recent study the polyphenol content, antioxidant activity and flavonoid content of *G. quaesita* were assessed and found to be significant enough to be used in industrial food and pharmaceutical preparations. *G. quaesita* leaves contain 202.14 ± 2.27 mg GAE g⁻¹ total polyphenol content, and an antioxidant activity of 225.63 ± 2.01 mg TE g⁻¹, while the flavonoid content is 18.28 ± 0.13 mg QE g⁻¹ (Kokilananthan *et al.*, 2022; 2021). Therefore, the incorporation of *G. quaesita* leaves was an exceptional herbal value addition to create functional foods. However, obtaining the exact functional properties, bioactive composition and antioxidant activity of direct herbal extractions into functional food products is impractical due to various processing steps, ingredient and process interactions,

dilutions and many other reasons. Nevertheless, this study was able to display admirable and significant functional properties of *G. quaesita* through the four novel functional foods satisfactorily.

In the functional property assessment of the developed novel herbal food products, the total polyphenol content, total antioxidant activity and the flavonoid, content was obtained for the different functional foods prepared in this study is given in Table 03.

The total polyphenolic content was expressed in mg Gallic Acid equivalents per liter of brewed herbal tea (1945.000 ± 0.907 mg GAE/ 1g of sample). Herbal tea contained the highest amount of total polyphenols from all the novel products and the contribution was given from four ingredients; *Garcinia*, *Guava*, *Cinnamon* and *Green Tea*. Furthermore, as the product was taken from direct brewing of the ingredients and its being 100% extract itself has contributed to the higher levels of polyphenols content as well as the other functional properties. However, the obtained values in the developed novel herbal tea for the above properties were neither the exact total of the values obtained by individual ingredients nor there is any direct pattern in the fluctuations. Therefore, the synergetic action of the herbal ingredients might be the reason for fluctuation and increment in the tested functional compounds in the novel herbal tea product.

When only numerical values were compared, Herbal Gummy Candy had the lowest functional qualities. Because gummy candy is primarily sugar, it may not be designated as a hyperglycemic nutraceutical. However, the functional characteristics exerted by the herbal integration in them should be considered when evaluating their application as a functional food. When considering the amount of incorporations, different processing steps involved and the interactions between the phytochemicals with other ingredients or compounds it is impossible to compare the amount of functional properties with previous literature or the functional properties of the individual ingredients. Moreover, the widely studied interactions between phytochemicals with the macromolecules; proteins and carbohydrates, affect the functionality of the functional compounds (Hussain *et al.*, 2015). Yet the degree of interactions depends on various factors and therefore, predicting such effects is inexpedient.

CONCLUSION

Herbal incorporation of *Garcinia quaesita* in developing novel functional foods is accepted with significant consumer preference while being

compatible with basic nutritional compositions (proximate compositions) of particular food types.

Despite the considerably higher polyphenol content, flavonoid content, and antioxidant activity observed in direct herbal extractions of *G. quaesita* compared to their presence in finished products, the development of functional foods emerges as a more efficacious strategy for assimilating herbal extracts into daily dietary practices.

Moreover, the study introduces the concept of garcinia leaf incorporation in enhancing the functional properties of several food types such as spice blends, confectionary, and savory biscuits or crackers.

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Declaration of Conflicts of Interest

The authors declare that they have no conflicts of interest.

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