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Development and Nutritional Assessment of Ginger Candy Supplemented with Beetroot Pomace Powder

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: To standardize and develop candy incorporated with ginger and supplemented with beetroot pomace powder and assess the nutrient composition, physiochemical parameters, phytochemical properties, examining of the supplemented hard candies using Scanning Electron Microscope and to analyze the acceptability by conducting sensory analysis.
Study Design: Experimental research design.

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Place and Duration of Study: The experiment was conducted in the Food Science Analysis Laboratory, Department of Food and Nutrition, School of Home Science, and USIC (University Sophisticated Instrumentation Centre), Babasaheb Bhimrao Ambedkar University, Lucknow, between September 2023 to May 2024.

Methodology: The candies were prepared by incorporating varying concentrations of pomace powder such as 5%, 10%, and 15%, with ginger hard candy as the control sample. The nutritional, physiochemical, and phytochemical properties of the selected supplemented hard candy (T_2) and control candy (T_0) were examined and sensory analysis was also done.

Results: The formulation with 10% pomace powder was determined to be the most acceptable overall. The supplemented hard candy (T_2) had higher levels of fat, fiber, protein, energy, pH, total soluble solids and titratable acidity than the control candy (T_0), which had higher levels of moisture, ash and carbohydrates. The presence of phytochemical properties such as flavonoids, terpenoids, tannins and glycosides were observed in both the candies.

Conclusion: The Ginger based hard candy (T_0) and Ginger-beetroot supplemented hard candy (T_2) have both acceptable sensory and nutritional characteristics but the ginger-beetroot supplemented hard candy was found significantly higher as compared to ginger based hard candy based on both nutritional and sensory attributes.

Keywords: Beetroot pomace; evaluation; functional food; ginger; hard candy.

1. INTRODUCTION

India accounts for 8% of global fruit production and 15% of world vegetable production [1]. Fruits and vegetables are produced in large quantities in India, but despite this, much of it is lost owing to a lack of facilities. As a result, processing fruits and vegetables is an effective approach to prevent perishables from deterioration.

Beetroot, also known as Beta vulgaris, is a root vegetable that contains a high level of biologically accessible phytonutrients as well as several other health-promoting components such as anthocyanins, carotenoids, minerals like sodium, potassium, magnesium, calcium, phosphorus, zinc, and iron, and fiber [2]. Beetroot contains a high concentration of bioactive compounds such as phenols, flavonoids, carotenoids, and betalains. Beetroots are one of the 10 most effective antioxidant vegetables, according to recent research [3]. Furthermore, epidemiologic studies found that a typical person's diet, which consists mostly of high-fiber, low-GI foods high in carbohydrates, may help prevent them from a variety of diseases, including cardiovascular disease and diabetes mellitus. Despite the considerable nutritional value, less beetroot is consumed than other root vegetables as it is not preferred by consumers as a vegetable because of the earthy flavor.

The beetroot pomace, although still rich in betalains and phenols, is disposed away as manure and feed. As parallel to whole beetroot, its by-product is potentially also a powerful source of bioactive compounds and could be utilized for the development of functional food [4]. Beetroot pomace is one such source of naturally occurring antioxidant chemicals that can be used as dietary supplements or additives in foods. Therefore, beetroot pomace candy can boost beetroot consumption. Beetroot in form of candy can improve sensory acceptability and its consumption can reduce the risk of anemia in people especially women.

Ginger (*Zingiber officinale*), a herbaceous perennial plant from the Zingiberaceae family, is commonly utilized as a spice and in traditional medicine. They are useful in alleviating nausea caused by seasickness, morning sickness, and chemotherapy [5]. It is also beneficial in treating inflammation, rheumatism, colds, heat cramps, and diabetes [6,7]. In addition, ginger is also used for masking the flavor of medicines.

Candying is one of the oldest forms of food preservation and antedates the development of refined sugar [8]. Confectionary products, such as hard candy, are the ideal food matrix for delivering these catechins and other antioxidant compounds because they dissolve slowly in the mouth, have a long shelf life, and can be developed with high sensory acceptability. According to Akib et al., [9], functional foods are hard candies that have been formulated to offer both basic nutrition and health-promoting and disease-preventing qualities. To improve people's beetroot intake and help them adopt it into their diets, the current study set out to manufacture ginger-beetroot candy with beetroot pomace powder. Candy is more enticing to the consumer since it is easier to consume.

2. MATERIALS AND METHODS

Raw materials such as ginger, red beetroot (*Beta vulgaris L*.), honey and sugar were procured from a nearby local market in Lucknow, UP. Additional chemicals and reagents were obtained from the Department of Food and Nutrition at Babasaheb Bhimrao Ambedkar University, Lucknow, Uttar Pradesh, for the study of nutritional, physiochemical and phytochemical analysis.

2.1 Preparation of Beetroot Pomace Powder

Before their processing, beetroots underwent a number of preliminary unitary steps, which included washing with water to get rid of any potential adhering foreign entities, peeling, and grating using a stainless steel grater. The grated beetroot was squeezed using a muslin cloth to remove the juice and the remaining pomace obtained was dried for 4 hours at 70±10°C in a dehydrator. After drying, the dehydrated beetroot pieces were ground into a fine powder. To ensure size homogeneity, the fine powder was sieved through a 80 mm mesh sieve. After which, sample of the beetroot powder was stored in a container.

2.2 Extraction of Ginger Juice

The ginger was washed with water to remove any dirt or undesired elements, then peeled and crushed in a mixer grinder with some water, and the juice was then strained through a strainer.

2.3 Preparation of Candies

The supplemented hard candies were prepared by adding 100g of sugar in 125ml of ginger juice and 4 tbsp of honey, which were then cooked over medium heat. The mixture was stirred continuously to ensure homogeneity and prevention of burning, the temperature was checked using a thermometer. By lowering a tiny amount of sugar solution into cold water, the mixture was confirmed to have reached the hard ball or soft crack stage (131 ^{o}C). On reaching the desired stage, the heat is turned off and beetroot pomace powder was added to it while stirring the mixture. The candy mixture was poured into the moulds to shape the candy, and they were then chilled in the refrigerator at 2-4^{o} C for about 20-30 minutes to achieve the firm heart shape. After which, they were removed from the mould and dusted with powdered sugar to avoid sticking to one another. Next, the candies were placed in a glass jar.

Heat the ginger juice and sugar, allow it to dissolve completely

↓

Add honey and keep on stirring till the desired consistency is achieved (131^{o}C)

↓

Add the beetroot pomace powder into the mixture while stirring it

↓

Pour the mixture into the mold to shape the candy

↓

Allow the candy to chill in the refrigerator for 20 -30 minutes for firm shape

↓

Remove the candy from the mold and dust it with powdered sugar

↓

Ginger-beetroot candy

Fig. 1. Flowchart for preparation of ginger-beetroot candy

2.4 Nutritional Composition

2.4.1 Estimation of moisture content

Moisture content in the sample was determined according to the protocol provided by (AOAC 930.15). The sample was weighed, its initial weight recorded, and subsequently placed in an oven at 135ºC for 2-3 hours. After being taken out of the hot air oven, the sample was allowed to cool in the desiccator for some time and the final weight was determined by weighing the cooled sample and recording it. The moisture was calculated by using the following formula:

$$\text{Moisture (\%)} = \frac{W_S-(W_2-W_1)}{Ws} \times 100$$

Where, Ws = Weight of the sample
W1= Weight of dish
W2= Weight of dish after drying

2.4.2 Determination of ash

By incinerating the sample at 500°C for two hours, the total inorganic matter, or ash content, was ascertained using the technique described by (AOAC 942.05). After reduction to their most stable form—oxides or sulphates—the remaining inorganic components are regarded as ash. Calculation was done by applying the following formula:

$$\text{Ash (\%)} = \frac{W_2-W_1}{Ws} \times 100$$

Where, Ws =Weight of the sample
W_1=Weight of crucible
W_2=Weight of crucible with ash

2.4.3 Determination of crude fiber

The (AOAC 978.10) procedure was used in order to determine the crude fibre. It was calculated by using the formula:

$$\text{Crude fiber (\%)} = \frac{W_1-W_2}{Ws} \times 100$$

Where, Ws=Weight of the sample
W_1=Weight of crucible with fiber
W_2=Weight of crucible with ash

2.4.4 Determination of crude protein

The micro Kjeldhal's approach, as detailed in Ranganna's method (2012), was used to determine the crude protein.

2.4.5 Determination of carbohydrates

Using the formula given by (AOAC, 1990), the total amount of carbohydrates was determined:
Total Carbohydrates = 100% - (Moisture - Fat - Protein - Ash - Crude Fiber)

2.4.6 Determination of fat

The crude fat was calculated using the (AOAC 2003.05) technique. The following formula was used for the final calculations:

$$\text{Crude fat (\%)} = \frac{W_2-W_1}{Ws} \times 100$$

Where, Ws=Weight of the sample
W_1=Weight of flask
W_2=Weight of flask with fat

2.4.7 Determination of energy

The total energy is obtained using the formula:

Total energy = 4(Carbohydrates + Protein) + 9 Fat

2.5 Physiochemical Analysis

pH measurement: A microprocessor pH meter (Labtronics LT-501) was used to estimate the pH of the candy. In order to determine the pH of the candies, 2 g of each candy was weighed and dissolved in 50 ml distilled water in a beaker, the pH meter rod was dipped in the solution, and the readings were noted.

TSS: The TSS of the candy was determined using a digital refractometer (Milwaukee MA887). Firstly, the refractometer was turned on and the surface was cleaned with the help of distilled water and cotton. After which, a drop of sample was placed on the prism to determine the TSS and the reading was recorded. It was read directly at room temperature.

Acidity: The titratable acidity was determined by titrating a known quantity of sample solution against a standard 0.1 N NaOH solution until it turned light pink in the presence of a phenolphthalein indicator. Each sample was weighed at one gram, diluted in distilled water, and titrated against 0.1 N NaOH using phenolphthalein as the endpoint marker. Citric acid was employed to express acidity in percentage terms. Pink colour indicates the endpoint [10,11]. Acidity was estimated using the following formula:

Titratable acidity = ml NaOH × N NaOH×meq.weightofacid×100 / ml sample titrated

where, meq. = milli equivalent
meq. weight of citric acid = 0.06404

2.6 Phytochemical Analysis

Flavonoid: NaOH test: To 1 ml of sample, few drops of 2N NaOH solution was added. The presence of yellow colour will indicate a positive result [12].

Phenolic compounds: $FeCl_3$ test: In 1ml of sample, add 2ml of distilled water, followed by 3-4 drops of ferric chloride solution. The formation of blue-green colour will yield a positive result [12].

Terpenoids: Salkowski test: 2 ml of chloroform was added to 1 ml of sample, following that 3 ml of concentrated H_2SO_4 was also added to it. The occurrence of red-brown colour in the top phase indicates a positive outcome [13].

Saponin: Foam test: A few drops of water were added to a 1ml sample and vigorously shaken; the existence and persistence of froth was monitored for a few minutes [12].

Quinone: H_2SO_4: To 1ml of sample, 1ml of concentrated H_2SO_4 was added. The presence of red colour indicates a positive result [12].

Glycosides: Keller-Kiliani test: 3ml of chloroform and H_2SO_4 were added into 1ml of sample to create a layer. Occurrence of brown ring at interphase suggests a positive result [14].

Tannins: Braemer's test: 2ml of 10% alcoholic ferric chloride is mixed with 2 ml of sample. Appearance of dark blue color will indicate its presence [15].

2.7 Scanning Electron Microscope (SEM)

McMullan's [16] approach was used for sample preparation. The SEM analysis of each sample was done using a high-resolution SEM (JSM 6490) from Japan (JFC 1600, Auto fine coater) [17]. The sample was grounded to a powder form and stored it in Eppendorf microcentrifuge tubes to protect its relative humidity. Then, 2-4 mm of each sample was collected and coated using a J.E.O.L. sputter coater; samples were evaluated at 1 K. V. [18]. The image was obtained in representative areas of the tested sample and viewed under high magnification.

2.8 Sensory Analysis

After the preparation of hard candies, a semi-trained panel of 25 panelist were drawn from staff and students of Babasaheb Bhimrao Ambedkar University, to assessed the candies based on their sensory impression. Each panelist received four samples, each marked with a T for candy and a numeric value denoting the different samples' subscripts such as T_0(control sample), T_1(5% beetroot pomace), T_2 (10% beetroot pomace) and T_3 (15% beetroot pomace). The hard candies were evaluated using the composite scoring test, which considered various sensory factors such as color, consistency, flavor, lack of defect, and overall acceptability. This method of assessment shows which qualities are lacking in an inferior product, which is important for product grading and quality attribute comparison. Sensory scores for each attribute were assigned to each product based on the weighted score. This method gives more information compared to the straight numerical method.

3. RESULTS AND DISCUSSION

Various analysis of the control (T_0) candy and the most acceptable supplemented (T_2) hard candy has been done and the results of this study have been classified and discussed under the following:

3.1 Nutritional Composition

3.1.1 Moisture content

The moisture content of the control (T_0) candy was found to be higher than the supplemented (T_2) hard candy. The value of the moisture content found in T_0 and T_2 was 1.19% and 1.06% respectively. Whereas Muhammad Farhan et al.,[19] reported 0.33% moisture in hard candy developed from beetroot and Kajal Dhawan et al.,(2023)reported 0.89% moisture in hard candy developed from matcha-ginger candy which is significantly lower.

3.1.2 Fat content

The T_2 showed a slightly higher crude fat content compared to T_0. The total crude fat found in the control (T_0) and supplemented (T_2) candy was 0.12% and 0.17% respectively. Similarly, results with slight difference were also observed by Sehajveer Kaur et al.,[20].

3.1.3 Fiber content

The total fiber content in the T_0 and T_2 obtained was 0.21% and 0.53%. The T_2 shows higher content than the T_0 which indicates that the T_2 is a better source of dietary fiber than T_0. Muhammad Farhan et al.,(2024) also developed candy with 10% beetroot powder and reported 0.20% fiber. This shows that the dietary fiber found in T_2 in this article is significantly higher than the above cited article as T_2 consist of both beetroot and ginger, hence the higher fiber content.

3.1.4 Ash content

The ash content of the T_0 and T_2 was 3.49% and 2.85% respectively and so it indicates that the T_0 has higher ash content than that of T_2. Shreya Bhattarai and Rakesh Kusma [21], in their research have reported 1.75% ash in candy developed from beetroot, which shows significantly lower than the above mentioned T_2 value.

3.1.5 Protein content

The protein content of T_2 was found to be 3.04g which was higher than that of T_0 i.e. 2.12g per 100gm.

3.1.6 Carbohydrates content

The carbohydrates content of T_0 and T_2 obtained was 92.87% and 92.35%, and so it shows that T_0 has higher carbohydrate content than T_2. Muhammad Farhan et al.,(2024) also has reported similar results of carbohydrate content in beetroot candy.

3.1.7 Energy content

The total energy content of T_2 obtained was found to be slightly higher than the T_0. The energy content in T_0 and T_2 was found to be 381.04 kcal and 383.09 kcal respectively. Similar results with slight difference of the energy content in beetroot candy was also reported by Muhammad Farhan et al.,(2024).

3.2 Physiochemical Analysis

3.2.1 pH of candy

The pH value obtained for the supplemented candy(T_2) was more as compared to the control candy(T_0). pH value of T_0 and T_2 obtained was 5.8 and 6.5 respectively.

3.2.2 Total soluble solids

The samples indicated as the control sample (T_0) and the supplemented (T_2) sample have total soluble solids of 56.5 and 58.5 °Brix, respectively. In comparison to the control sample (T_0), it was found that the total soluble solids of the supplemented sample (T_2) was higher.

3.2.3 Titratable acidity

The control (T_0) and supplemented (T_2) sample had titratable acidity of 0.128% and 0.192%, respectively which means that the titratable acidity of T_2 was more as compared to the controlled (T_0) candy.

Table 1. Nutritional composition of the candies

Nutritional composition	Control Candy (T_0)	Supplemented hard Candy (T_2)
Ash (%)	3.49	2.85
Carbohydrates (%)	92.87	92.35
Energy (kcal)	381.04	383.09
Protein (gm)	2.12	3.04
Moisture (%)	1.19	1.06
Fat (%)	0.12	0.17
Fiber (%)	0.21	0.53

Table 2. Physiochemical analysis of the candies

Parameters	Control candy (T_0)	Supplemented hard candy (T_2)
pH	5.86	6.57
TSS (^{0}Brix)	56.5	58.5
Titratable Acidity (%)	0.128	0.192

3.3 Phytochemical Analysis

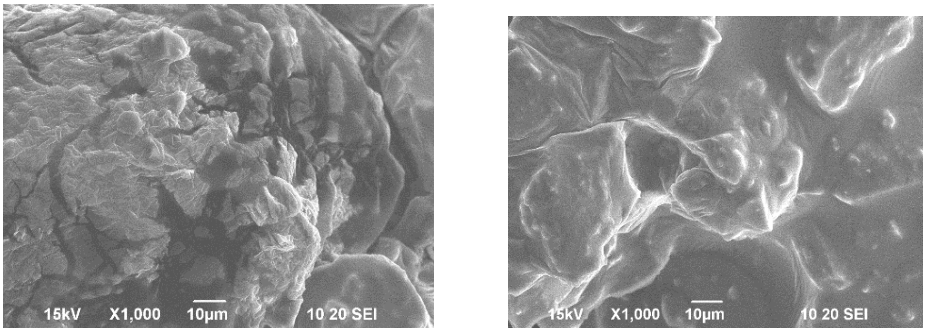
The qualitative analysis of phytochemicals was done on the candies. An examination of the phytochemicals - flavonoids, phenol compounds, quinones, terpenoid, saponin, glycoside, and tannins was performed on the control sample (T_0) and the supplemented sample (T_2). It was found that while phenolic chemicals, saponin, and quinone were absent from both samples, flavonoids, terpenoids, tannins and glycosides were present in both.

3.4 Scanning Electron Microscopy (SEM):

Scanning Electron Microscope (SEM) images were used to study the surface morphology of the candies. Result of SEM analysis are shown in Fig. 2.

3.5 Sensory Analysis

Each candy was assessed based on its sensory properties and the results are presented in Table 3. T_1 was found to have higher average colour score than T_0, T_2, and T_3, but T_2 had a higher average consistency, flavour, and defect-free score than T_0, T_1, and T_3. As a result, T_2 had a better overall acceptability rating than the other samples. While T_2 had the best overall acceptability score, all other samples were also found to have acceptable sensory characteristics.



(a) (b)

Fig. 2. Scanning Electron Micrograph (SEM) of (a) Control candy and (b) supplemented hard candy. Magnifications are 1000×

T_0 T_1 T_2 T_3

Fig. 3. Image of the hard candies- T_0 (Control sample), T_1 (5% beetroot pomace powder), T_2 (10% beetroot pomace powder), T_3 (15% beetroot pomace powder)

Table 3. Sensory evaluation of the supplemented hard candies

Parameter	T_0	T_1	T_2	T_3
Color	17.45	18.72	18.12	17.56
Consistency	17.02	18.08	18.48	17.08
Flavor	36.25	36.64	37.56	36.36
Absence of defects	16.4	17.32	18.72	16.6

4. CONCLUSION

The Ginger based hard candy (T_0) and Ginger-beetroot supplemented hard candy (T_2) have both acceptable sensory and nutritional characteristics but the ginger-beetroot supplemented hard candy was better as compared to ginger based hard candy based on both nutritional and sensory attributes. The T_2 had higher levels of fat, fiber, protein, energy, pH, total soluble solids and titratable acidity than the T_0, which had higher levels of moisture, ash and carbohydrates. The presence of phytochemical properties such as flavonoids, terpenoids, tannins and glycosides were observed in both the candies. Therefore, the current study indicated that beetroot pomace powder could be used for the preparation of candy with good sensorial quality.

The products of ginger and beetroot are available separately in the market but product incorporating both are hardly available. Hence in the future, more products including both ginger and beetroot can be developed as together they can provide an excellent source of phytochemicals, antioxidants along with fiber, all of which are helpful to health.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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