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Development of Natural Food Colorants from Mangosteen Peel for Enhancing Nutritional and Sensory Profiles of White Chocolate and Cookies

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KEYWORDS

polyphenols, antioxidants, anti-inflammatory, white chocolate.

ABSTRACT:

Mangosteen (Garcinia mangostana) is a tropical tree it is cultivated for its tart-sweet fruit. Mangosteen fruit is highly valued for its juicy, delicate texture. The non-edible part of fruit is its peel, which is rich in Polyphenols, antioxidants, anti-inflammatory activity. In this context, several studies have identified it's potential to give higher value-added products the objectives of this work were to develop a natural food colorant and incorporate it into White chocolate and cookies. Mangosteen Peel powder was prepared by selecting ripen fruit dried and powdered. Aqueous extract was done by using crude powder at different temperatures. After extract was added to the white chocolate and cookies which increases the nutritional value of food without altering its taste profile.

1. Introduction

1.1 Garcinia mangostana

Mangosteen (*Garcinia mangostana* L.) is an evergreen tropical tree belonging to the *Clusiaceae* family that grows in Southeast Asia, and is cultivated mainly as a source of its highly palatable fruit, consisting of a fragrant white internal pulp divided in septa, contained in a dark purple rind. The seeds and pericarps of the fruit have a long history of use in the traditional medicinal practices. The main phytochemicals present in the species are isoprenylated xanthones, a class of secondary metabolites with multiple reports of biological effects, such as antioxidant, pro-apoptotic, anti-proliferative, antinociceptive, anti- inflammatory, neuroprotective, hypoglycemic and anti-obesity. The diversity of actions displayed by mangosteen xanthones shows that these compounds target multiple signaling

Pathways involved in different pathologies, and place them as valuable sources for developingnew drugs to treat chronic and degenerative diseases [1].

Figure.1*Garcinia mangostana* fruit showing pericarp and pulp.

The Mangosteen-fruit is dark purple or reddish, with white, soft and juicy edible pulp with a slightly acid and sweet flavor and a pleasant aroma Mangosteen is known as “the queen of fruits” because it is one of the best tasting tropical fruits. [2]

Furthermore, mangosteen contains bioactive compounds such as xanthones, terpenes, anthocyanins, tannins, phenols, and some vitamins. The nutritional value of mangosteen per 100 g includes 80.9 g of water, 0.5 g of

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protein, 18.4 g of carbohydrates, 1.7 g of fiber, 9 mg of calcium, 14 mg of phosphorus, 0.5 mg of iron, 2 mg of vitamin C, 0.09 mg of vitamin B1 (thiamin), 0.06 mg of vitamin B2 (riboflavin), and 0.1 mg of vitamin B5 (niacin). The main compounds in the content of mangosteen's pericarp are xanthones; such as α-mangostin16, γ- mangostin17, 8-deoxygartanin, garcinone E, mangostanol18, β-mangostin19, tovophyllin A and B20, mangostenin, and mangostenones C, D, and E22. The main xanthone derivative is α-mangostin, this compound has a variety of pharmacological activities such as antidiabetic, antioxidants, and anti-inflammatory. [3]

1.2 Chocolate

In 1573, the Swedish botanist Carl Von Linné (known as Linnaeus) gave a scientific nameto the cocoa plant in his famous book Species Plant arum. He called it Theobroma or 'food of the gods' in Latin (Katz 2003). While cocoa production and the consumption of derived products had existed for millennia. Cocoa production spread around the world. Today, Africa is the main producing region. Consumption patterns changed dramatically. The Spaniards added sugar to make chocolate sweeter, later fat was pressed out of the cocoa to make theChocolate more digestible, then milk was added to create 'milk chocolate', solid bars were created, and so on. [4]

Chocolate is well known for its fine flavor, and its history began in ancient times, when the Maya considered chocolate (a cocoa drink prepared with hot water) the "Food of the Gods". The food industry produces many different types of chocolate: in recent years, dark chocolate, in particular, has gained great popularity. Interest in chocolate has grown, owing to its physiological and potential health effects, such as regulation of blood pressure, insulin levels, vascular functions, oxidation processes, prebiotic effects, glucose homeostasis, and lipidmetabolism. [5]

2. Methodology

2.1 Sample collection and identification

Fresh ripen fruit was collected by a local market. Washed with tap water, then the fruitpeel was collected and shade drying until peel become dried and the fruit was identified by Prof V Krishna Senior Professor Department of Biotechnology, Kuvempu University (Botanist) as *Garcinia mangostana*and moved to further processing.

2.2 Preparation of aqueous extract

Dried peel was finely powdered by using pestle and mortar. 25g of the crude powder was taken in a 500ml beaker, to that 250 ml of distilled water was added. Mix thoroughly by using glass rod. Keep it in water bath at 100º C for 20 minutes by covering the mouth of the beaker. As soon as heating, the beaker was transferred to hot plate. A magnetic bead was putinto the beaker. The hotplate was run for 2 hours at the temperature maintaining at about 40º C and the rpm of the hotplate was adjusted to

The content was allowed to settle for a few minutes. After the separation of upper clear and colored solution, it was separated by lower residue. The upper solution is taken in a cleanpetri plate and it is dried using oven for 1 hour at 150º C. The dryness of the extract is tested by scratching the extract using a spatula. The powdered is collected by scraping. Finally the aqueous extract was filled in Eppendroff's tube. [8]

2.3 Product development

2.3.1 Preparation of Whole wheat and jowar, chocolate cookies

The cookie dough is made from 35g of whole wheat flour, 35g of jowar (Sorghum millet) flour, 5g of crude extract of mangosteen peel, 5g of cocoa powder, 1/8 table spoon of baking powder, 1/8 table spoon of baking soda as a rising agent, 50g of brown sugar powder and 1/8 table spoon of vanilla and 1/8 table spoon of salt is added.

All these ingredients are mixed with properly churned 50g of butter. Because of the highsmoking point of cocoa butter, it is ideal to use when cooking at high temperature as it will notburn easily. Mix well by adding some Choco chips and small amount of milk is added which is helpful to bind the dough. The dough is mixed well with fingers until the dough becomes smooth. Make small balls of the dough and small amount of milk can be added if the balls of the dough start to crack. Small balls of the dough are arranged on a silica sheet and they are pressed with designed mould to give a proper shape to the cookie.

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The silica sheet of cookies is placed in a commercial oven on a tray. The dough is baked for 18 minutes with no steaming and air circulation fan. After 18 minutes of baking the cookiesare taken out of the oven and they are allowed to cool to room temperature for few minutes. [9]

2.3.2 Preparation of Chocolate

For the preparation of chocolate 30g of white chocolate in a bowl and keep it in an ovenfor few minutes to melt the chocolate. Take out the chocolate after melting then check the temperature of the chocolate by using surface thermometer. The chocolate should be tempered, tempering is the process of heating and cooling chocolate to specific temperature to stabilize its crystalline structure. Seedling method of tempering chocolate is followed in which small pieces of already tempered chocolate is added to encourage proper crystallization. Temperingshould be continued till the temperature of the chocolate comes to 27-29º C. The tempered chocolate is transferred into a clean bowl, to that 5g of dried orange peel and cranberry fruit pieces and Choco chips mixture are added. 2 to 3 drops of orange essence are added to the tempered chocolate and mixed uniformly.

Then the mixture is poured into the chocolate piping bag. The chocolate is filled to a plate of silicon molds to give proper shape to the chocolate with the help of piping bag. Place The plate of molds in an air-conditioned room for an hour to solidify the chocolate. After onehour the chocolates are taken out of the molds. [11]

2.4 Nutritional analysis

2.4.1 Estimation of moisture content

For the determination of moisture content, about 10 g of the material was weighed into a weighed moisture box followed by drying in an oven at the temperature of 100-105ºC and cooled in a desiccator. The process repeated until a constant weight achieved. The loss in weight was expressed as percentage moisture content. [17]

$$\% \text{ Moisture} = \frac{M_{INITIAL} - M_{DRIED}}{M_{INITIAL}} \times 100$$

2.4.2 Estimation of fat content

Fat content was estimated as crude extract of the dry material. The dried sample (5-10 g) was weighed accurately in to a cotton plugged thimble. The thimble was then placed in a Soxhlet apparatus and extracted with anhydrous ether for about 16 hrs. The ether extract was filtered into a pre-weighed conical flask. The flask containing the extract was washed 4 to 5 times with small volumes of ether and the washings were also transferred. The ether was thenremoved by evaporation and the flask with the residue dried in an oven at 80-100ºC, cooled in a desiccator and weighed. [17]

2.4.3 Estimation of ash content

Ash analysis was usually done to wash away organic matter leaving inorganic one which help to determine amount and type of mineral in food. About 5-10g of the sample weighed accurately into a porcelain crucible which had been previously was kept in a muffle furnace for about 3-5 hrs. At about 600ºC after heat the sample over a low flame till all the material was completely charred. Then cooled the sample in a desiccator and weighed. Again, sample was heated in the muffle furnace for half an hour, cooled and weighed to ensure completion of ashing. Until two consecutive weights were same and the ash was almost turning white or greyish white in color, the process was repeated. Weight of ash was content of ash per 100 gmof sample. [17]

2.4.4 Estimation of protein content

Content of protein was obtained by determining the nitrogen content of the material andmultiplying the value with 6.25 which was regarded as crude protein content since the non- protein nitrogen (NPN) that are present in the material was not taken into consideration. True protein nitrogen could be estimated by subtracting NPN from the total nitrogen. [18]

2.4.5 Estimation of crude fiber content

5 gm of ground material was extracted with ether or to remove fat. If fat content was below 1%, extraction might be omitted. After extraction, boiling of 2.5g of dried material wasdone with 200ml of Sulphuric acid for 30min which then filtered and washed with boiling water till the sample was no longer acidic. Then boiled the sample with 200ml of sodium hydroxide solution for 30min followed by filtration and washed with 25ml of boiling 1.25% sulphuric acid, three-50 ml of water and 25ml alcohol. The residue was removed and transferred

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to a pre-weighed ashing dish (W1) and dried the residue for 2 hrs. At 130 ±2°C. The dish was cooled in a desiccator and weighed (W2). Then the dish was ignited at 600 ±15°C for 30min followed by cooling in a desiccator and reweigh (W3). [17]

% of Crude Fiber = Loss in weight on ignition (W2 - W1) – (W3 - W1) × 100 Weight of the sample

2.4.6 Estimation of carbohydrate content

The carbohydrate content was estimated by subtracting the sum of amount of moisture,total protein, ash, total fat and crude fiber from 100. The result was presented in percentage.[21]

2.4.7 Estimation of vitamins

2.4.7.1 Preparation of mixture standard vitamin solutions

The stock standard solutions of vitamin C, B1, B3, B5 and B6 and were prepared by dissolving 25 mg of each standard in 1 ml 0.1M hydrochloric acid in 25 ml standard volumetric flask. For preparation of standard stock solutions of vitamin B9 and B2, 25 mg of each standard were dissolved in one ml 0.1 M sodium hydroxide in 25 ml standard volumetric flask. The standard solution was stored in amber-glass bottles in the refrigerator at 4ºC. The working standards were prepared by diluting with phosphate buffer (1M, pH 5.5) [19]

2.4.7.2 Preparation of sample solution

Plant materials were washed with distilled water. The washed plant materials were cut into very small pieces, frozen in liquid nitrogen and kept at -20°C until analysis. 1 g each of freeze-dried sample was soaked in 10 ml water and extracted with 1 ml 0.1M Noah and 10 ml phosphate buffer (1M, pH 5.5) were added to it and kept in dark for 24 hours. The solution was first filtered through a Whatman No. 1 filter paper and the resulting filtrate was taken in a 25 ml volumetric flask and solution was topped up to the mark with HPLC grade water. The sample solution was filtered through 0.45 mm membrane filter before injection into LC system.The stock solutions of sample were kept in a refrigerator for further use. [19]

2.4.7.3 Chromatographic analysis of water-soluble vitamins

The chromatographic analysis was carried out following the method as described by Seal et al. (2017a) with minor modifications. The mobile phase contains acetonitrile (Solvent A) and aqueous trifluro acetic acid (TFA, 0.01% v/v) (Solvent B), the column was thermostatically controlled at 220 C and the injection volume was kept at 20 ml. A gradient elution was performed by varying the proportion of solvent A to solvent B. Total analysis time per samplewas 35 min. HPLC Chromatograms of all vitamins were detected using a photo diode array UV/detector at four different wavelengths (210, 245, 275 and 290 nm) according to absorptionmaxima of analyzed compounds. Detection of compound was done in same manner that followed in detection of phenolic acids and flavonoids. The data were reported as means ± standard error of means of three independent analyses. [19]

2.4.8 Estimation of mineral content

Mineral content (Na, K, Ca, Mg, Fe) was estimated following the procedure described by [29]with the help of device and method of an atomic absorption spectrophotometer (AAS). For preparing working sample, 0.5 g sample powder was taken in a 50 ml conical flask after that, 5ml of a mixture (5:1) of HNO3 and HCIO4 (Nitric perchloric acid) added and digested througha sand bath for 3–4 h. Then the digested sample mixture was filtered with Whatman no. 42 (2.5µm particle retention) filter paper and final volume was made up to the final volume of 100ml with distilled water in a 100 ml volumetric flask. For minerals quantification, 10 ml sampleextract was shifted to 50 ml volumetric flask and final volume made 50 ml with distilled water. Afterwards, the intensity of Na, K, Ca, Mg and Fe was estimated through AAS (atomic Absorption spectrophotometer; model-Pinnacle 900H; PerkinElmer). The following formula was used to quantify the concentration of minerals in rose petals. The following formula was used to determine the concentration of minerals. [20]

$$\% \text{ Minerals} = \frac{sample\ reading \times fina\ voume \times dilultion\ factor}{sample\ wieght}$$

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2.5 Sensory evaluation

Both the prepared products, chocolate and cookies were subjected to sensory evaluation.The primary requirement for any sensory test is the panel of members (panelists). Theminimum number of panelists required for this test is ten. They should be selected from a larger number of people and should be familiarized (trained) with the quality attributes of the product being tested (or they should be familiarized by proper briefing) and the procedure. They should also have at least average sensitivity to the sensory quality attributes like colour and appearance, flavor and taste etc. Besides, they should be willing to spend the time to do the test.

Sensory evaluation was done by Hedonic rating test. In this test four samples are tested for preference. The prepared two products were tested against two factory made products i.e. the panelists were asked to evaluate the attributes of the prepared product against the attributesof the factory-made product. [22]

3. Results and discussion

3.1 Selection and identification

Figure.2 Dried Mangosteen peels

Fresh ripen fruit was collected and it is identified as *Garcinia mangostana* and shade dried until peel becomes completely dried as shown in **Figure.1**and **Figure.2** displays powereddried peel.

(Duraisamy Gomathi *et al.,* 2013) *Evolvulus alsinoides (L.) L*. used for the investigation was obtained from Coimbatore District, Tamilnadu, India. The plant was authenticated by Dr.
P. Satyanarayana, Botanical Survey of India Tamil Nadu Agricultural University (TNAU) Campus Coimbatore. The voucher number is BSI/SRC/5/23/2011-12/Tech.-514. Fresh wholeplant material *of Evolvulus alsinoides* was washed under running tap water, air dried and powdered in electric blender. [6]

Figure.3 Crude extract

(Shaun Y.J. Sim *et al.,* 2016) Mangosteen pericarp powder (*Garcinia mangostana Linn.*) was obtained from a global supplier of botanical ingredients, NP Nutra. The mangosteens were grown and harvested in Thailand. Fresh mangosteens were cleaned, sun dried or tray dried at 68º C for 8 h, milled to powder, sieved (with greater than 95% through 80 mesh size) and packaged. [7]

3.2 PREPARATION OF AQUEOUS EXTRACT

As seen in **Figure.3** It shows the transition from crude extract to aqueous extract involved usingwater as solvent, initially heating was done in hot water bath and then transferred to hot plate with magnetic bead upper solution was taken and dried it was the aqueous extract which is further proceed to characterization.

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Figure.4 Preparation of aqueous extract

(Rony Mia, Md. Minhajul Islam 2022) The tallow tree barks were prepared by grindingusing a grinder machine for 1 min. After extracting the sample from the grinder chamber and placing it in a poly bag, approximately 1000 g of tallow tree bark powder were prepared and weighed using a digital balance meter. The sample was then prepared for use in the extractionprocedure. In order to get the dyes from the bark of the tallow trees, a water extraction was done. First, the power of the tallow tree bark was taken and made into a flux. Then, a different amount of powder and water were taken. There are a lot of different single-factor conditions that were looked at in this case, like the M: L Ratio (1:20, 1:40, 1:60, 1:80, 1:100, and 1:120).Then, at different temperatures, like (50 °C, 60 °C, 70 °C, 80 °C, 90 °C, 100 °C), the pH were 3,5,7,9,11,13, and time were 30 min, 50min, 70 min, 90 min and 110 min, and 130 min. Here, Noah and CH_3COOH were used to keep the water pH level stable. After prepared the solution,it was cold and then filtered through filter paper to get rid of a big particle from the water. [8]

3.3 Product development

Figure.12 Prepared cookies.

Figure. 13 Prepared chocolates.

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Figure 12 present a visual representation of developed cookies. The whole wheat flourand jowar flour are the major ingredients of the cookies. The cookies are brown in colour because of cocoa powder and butter, butter which gives the creamy

Flavor and promotes browning reaction along with unique blend of vanilla and jowar flavor. Texture is crispy on edges with slightly chewy in center. mangosteen aqueous extract doesn't impart any distinct flavor to cookies and also not alter taste profile of cookies but this increases the nutritional profile of our product.

(M. Imran *et al.*, 2016) in the current study, aqueous extracts of mosambi peel powder wereused to formulate functional cookies at different concentrations, such as 1%, 2%, and 3%. Forpreparing the cookies, creaming of shortening, sugar, and fresh eggs were added and mixed thoroughly. Subsequently, flour and baking powder were added and stirred to prepare the homogeneous dough. The cookie dough was cut with a mold and shifted to baking trays. Afterwards, the cookies were baked at 170 °C in the baking oven for 20 min [9].

(Rossi Indiarto *et al.*, 2022) the biscuits were prepared using the creaming technique by Dordoni et al. [Citation13] Table 1 lists the formulations of each sample. The egg yolk was added, combined with margarine and powdered sugar using a mixer. Furthermore, low-protein flour was added, along with whole-milk powder, cocoa powder, baking powder, and vanilla. Then, mangosteen peel extract was encapsulated at 1%, 3%, 5%, and 7% of the total weight of the dough, respectively. The process includes kneading the dough until it is smooth, flattening it to a thickness of 0.3 cm, and molding. Twenty minutes are required to bake biscuits at 150°C in a digital electric oven (KBO-300DRA, Kirin, Indonesia). [10]

Figure 13 revealed that the developed Chocolate was prepared by tempering process.Developed chocolate is creamy and smooth texture along with mild aroma of creaminess and orange essence providing rich mouth texture. While mangosteen aqueous extract may not provide any distinct flavour to chocolate the smooth texture remains unchanged but aqueous extract addition creates visually appealing hue and enhancing its aesthetics appeal along with it intensify the nutritive quality of chocolate.

(Zohreh Didar *et al.*, 2020) To prepare white chocolate, 20% of total cocoa butter and dry powders (sugar, whole and skimmed milk powders) were initially blended by gentle heating (40ºC) until the formation of a homogeneous mixture. Afterwards, the chocolate mass was pre- refined on a pilot-scale, three-roll refiner (Lehmann, Aalen, Germany), blended again, and heated to the temperature of 50ºC. Dry conching was carried out at the next stage for 45 minutes. In this step, the rest of the cocoa butter (80% of total) and soy lecithin were also added.Overall, the duration of conching was 360 minutes at the temperature of 60ºC. After conching, free or encapsulated pomegranate extract (1, 2, 3, 4, and 5 g/200 g) was mixed with the chocolate mass at the temperature of 32-33ºC. Following that, the mass was blended for approximately five minutes, and a three-stage tempering process (33-35ºC, 24-25ºC, and 25- 26ºC) was performed as well. Molding and vibration processes were also implemented at the temperature of 27-30ºC. The final step was cooling at 5ºC for 20 minutes, and the samples were Stored at 13-15ºC in the dark before analysis (13). Table 1 shows the samples and their specificcodes. [11]

3.4 Nutritional analysis

3.4.1 Nutritional composition of the Cookies

Activities	Amount (g)
Moisture	8.7 %
Fat	5.1
Protein	8.86
Fiber	1.53
Ash	0.33
Carbohydrates	75
Vitamin B1	0.69mg
Vitamin B2	3.01mg

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Vitamin B3	2.11mg
Vitamin B12	0.46µg
Vitamin B5	0.15µg
Vitamin B9	31.5µg
Calcium	17.7µg
Iron	4.6µg
Zinc	0.58µg

Table.3 Nutritional composition of cookies per 100g

Table 3 reveals the nutritional composition of cookies. 75g of total carbohydrates, which was predominate and in higher quantities compared to other nutrients. The moisture content was found to be relatively high value of 8.7%. Fiber content was found to be 1.53g

Followed by ash was 0.33g; they are present in limited quantities. The fat is about 5.1g which is contributed by added butter and the quantity was less than protein concentration which was8.16g.

The calculated quantity of B complex vitamins like B1, B2, B3 were 0.69mg, 3.01mg, and B3 2.11mg respectively. B2 present in a higher amount among the vitamin B-complex, other B-complex vitamins like B12 is 0.46, B5 is 0.15, B9 is 31.5 µg. Estimated mineral contentof cookies such as calcium, iron, zinc were found to be 17.7µg, 4.6µg, 0.58µg respectively. The calcium is present in an elevated amount.

(Mohamed Gadallah *et al.*, 2021) The results indicated that adding orange peel powder to prepared cookies caused a significant (P <= 0.05) increase in ash, fibre and lipids with a noticed decrease in crude protein and nitrogen-free extract. No significant (P≤0.05) difference was found in moisture content for cookies with orange peel powder compared to thecontrol sample. The low moisture (5.2 to 6.10%) in cookies is an important factor in their longshelf life without spoilage. Gradually, high contents of minerals and crude fibre were found atvalues of 1.32 and 1.35% and 2.60 and 3.63% with increasing the level of orange peel powderin cookies up to 15 and 20%, respectively when compared with control cookies. This result could be attributed to the high ash and fiber contents of orange peel powder. These findings are in agreement with those reported by Haque et al. (2015) and Oladipo et al. (2020)who mentioned that the utilization of orange peels in biscuits results in an increase of its contents of fiber and ash. [12]

(Sunidhi Mishra and Kusum Sharma *et al.*, 2019) Pumpkin flour biscuits were developedfor the proximate analysis in which moisture, protein, fat, fiber, carbohydrate, energy and ash value had been calculated and the mean value of the analysis are respectively- Moisture (6.59%), Fat (21.75gm/100gm), Protein (0.08gm/100gm), Carbohydrate (69.40gm/100gm), Fibre (0.16gm/100gm), Ash (1.91gm/100gm) and Energy (473.71kcal/100gm).[13]

3.4.2 Nutritional composition of the Chocolate

Activities	Amount (g)
Protein	6.0
Carbohydrates	55.3
Total Sugars	54.8
Added Sugars	46.3
Total Fat	36.0
Saturated Fat	21.6
Trans Fat	0.4
Cholesterol	24mg
Sodium	75mg

Table.4 Nutritional composition of chocolate per 100g

Nutritional composition of chocolate is demonstrated on **Table 4**. Estimated amountof carbohydrates is 55.3g per 100g which is present in larger quantity than other nutrients. Sugar is found as both total sugar and added sugar they contributing overall sweetness of chocolate, total sugar is found to be 54.8g and added sugar in 46.3, total sugar was present in superior amount than added sugar. Fat is present in chocolate as total fat, saturated fat

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and trans-fat promoting smooth texture of chocolate, total fat was found to be36.0g, saturated fat in 21.6g and trans-fat 04g, total fat was present in extended quantity and trans-fat in minimized quantity. An analysis of protein revealed protein was present in 6.0g. Cholesterol and sodium are present in mg, cholesterol was detected in chocolate is 24mg and sodium is 75mg in chocolate.

3.5 Sensory evaluation

Scorecard – Hedonic Rating Scale

Tray number : Name :

In front of you is a coded sample. Taste the sample and tick (/) how much you like and dislike it. You can taste the sample more than once.

	Appearance/ Colour	Taste/Flavor	Smell/ Odour	Texture/Mouthfeel
Like extremely				
Like very much				
Like moderately				
Like slightly				
Neither like or dislike				
Dislike slightly				
Dislike moderately				
Dislike very much				
Dislike extremely				

Table.5 Hedonic Scale

To analyze the results, numerical values are assigned to each point on the scale, 1 is usually given to 'like extremely' and 9 to 'dislike extremely'. The scores received for each sample from all the panelists are averaged and compared.

Since the numerical scores are assigned in the reverse order i.e., 1 for the highest quality and 9 for the lowest quality point, lower the score total or score average higher thepreference.

3.5.1 Sensory evaluation of cookies

Attributes	**Appearance/colour**	**Taste/Flavor**	**Smell/Odor**	**Texture / mouth feel**
Control	7.9	8.0	7.7	8.4
Test	8.33	8.33	8.33	8.33

Table.6 Mean scores of the attributes of both the control and test samples of cookies.

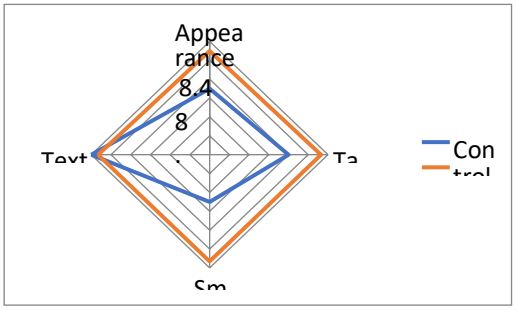

Figure.14 Radar scale representing the mean scores of the attributes of both the control and test samples of cookies.

Figure.14 shows a radar plot illustrating the sensory evaluation of cookies visually represents rating across various attributes like appearance, taste, smell and texture

The sensory evaluation of cookies was assessed by 15 panelists using 9 point hedonic scale. Average score for appearance of cookies was 8.33 cookies show crispy edges and browncolour. Mean score for taste of cookies was 8.33 the cookies have highlighted flavor of jowar, vanilla and harmonious sweetness. Median rating for smell was 8.33 the cookies have butteryaroma. Texture gets a mean score of 8.33 which indicates cookies have characteristics crispy texture.

The sensory evaluation of cookies revealed that cookies have visually appealing attributes, delightful flavor, good aroma and pleasing texture, the average rating across all attributes indicates positive reception from panelist.

(Muhammad Usman *et al.,* 2020) It was observed that by adding apple pomace powder in different treatments, the color attributes of cookies were affected significantly ($p < 0.01$). Mean values ranged from 2.90 to 8.10. Maximum marks were received by treatment (T2) while lowermarks secured by T5. Similarly, in case of flavor T5 had the lower value while T2 had the highest value and the mean ranged from 3.00 to 7.90 Results shows that due to the difference in treatments flavor was also effected. Taste, in different treatments, showed that T0 secured the highest value while the lowest for T5 with mean ranged from 5.00 to 8.00. The crispiness Of cookies decreased with the increase of apple pomace

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powder in cookie preparation except T1 having value 3.2 while the highest value was observed in T0 and T2 having score 7.2 and
7.1 Respectively. Highest scores of mouth feel, texture and overall acceptability were observedin T0 and the lowest score was found in T5. Values for each parameter ranged from 5.9 to 7.75,5 to 7.8 and 5 to 8 respectively. [14]

(Tariq Ismail *et al.*, 2014) Pomegranate peel supplemented cookies were evaluated for sensory characteristics i.e. taste, color, crispiness, texture and overall acceptability on 9-point HedonicScale (Land & Shepherd, 1988). Fifty sensory panelist members were selected based on their product discriminative ability for different sensory attributes. The objectives of study were briefed to the panelists. The judges were given questionnaires to record their observations. The information contained on the proforma was; 9 ¼ like extremely; 8 ¼ like very much; 7 ¼ likemoderately; 6 ¼ like slightly; 5 ¼ neither like nor dislike; 4 ¼ dislike slightly; 3 ¼ dislike moderately; 2 ¼ dislike very much; 1 ¼ dislike extremely. Sensory testing was made in the panel room completely free of food/chemical odor, unnecessary sound and mixing of daylight[15].

3.5.2 Sensory evaluation of chocolate

Attributes	**Appearance/colour**	**Taste/Flavor**	**Smell/Odor**	**Texture/ mouth feel**
Control	8.4	8.4	8.2	8.4
Test	8.8	8.6	8.86	8.66

Table.7 Mean scores of the attributes of both the control and test samples of chocolate.

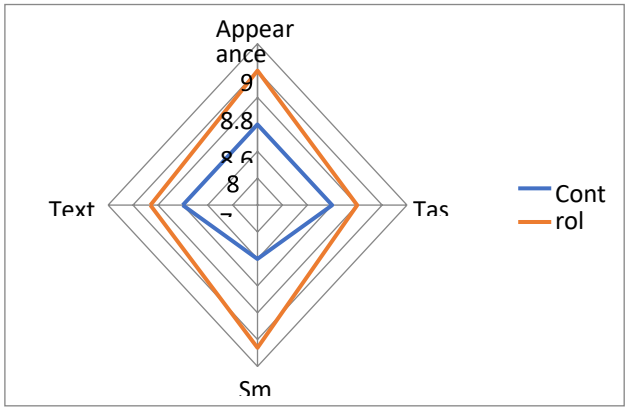

Figure.15 Graphical representation of the mean scores of the attributes of both the control andtest samples of chocolate.

Figure.15 shows the radar chart depicting sensory evaluation of chocolate illustrate rating across of multiple attributes such as appearance, taste, smell and texture.

The sensory evaluation of chocolate was assessed by 15 panelists using 9 point hedonicscale yielding a mean score was 8.8 for appearance of chocolate which shows smooth appearance and visually appealing hue from mangosteen aqueous extract. Evaluated mean score for taste was 8.6 chocolate have highlighted flavor of vanilla along with balanced sweetness.Average score of smell was 8.86 the aroma of chocolate was refreshing scent of orange essence. Resulted mean score for texture was 8.66 which indicates chocolate have characteristics smoothness and creaminess.

Overall chocolate received positive evaluation across all sensory attributes, indicating high level of satisfaction among panelist regarding its appearance, taste, smell and texture.

(Zsolt Ajtony *et al.*, 2023) Due to the strong change in the organoleptic properties causedby the fortification with grapefruit peel extract, the sensory evaluation was focused towards individuals who enjoy bitter flavors. However, the evaluators showed no significant preference for either chocolate in the categories of aftertaste, or astringency. In fact, a clear preference was shown for the enhanced bitterness of the chocolate. However, taste, flavor and overall acceptability was greater in the case of the control chocolates. A summary of the organoleptictrials can be seen in Fig. 4. There was no significant difference found within the evaluation of The visible traits of the chocolate. Even though the increase in bitterness may be welcome for some, further research may focus on improving the sensory characteristics of fortified chocolates. [16]

4. Conclusion

Mangosteen (*Garcinia mangostana*) is an evergreen tropical tree, it's is cultivated mainly as the source of its highly palatable fruit. The pericarp of fruit have the history of use in traditional medicine the main

phytochemical present in the pericarp is xanthonen which has properties like anti-inflammatory, anti-obesity, anti-oxidant, neuroprotective and hypoglycemic. Chocolate is considered as food of gods here cocoa is main ingredient. Mangoteen pericarp was collected and dried aqueous extract was prepared, prepared aqueous extract was used in development of whole wheat jowar chocolate cookies and white chocolate. Nutritional analysis of cookies reveals the presence of protein, B complex vitamins and minerals like calcium, iron and zinc. Nutritional analysis of chocolate shows the presence of fats and sugar. The nutritional analysis of both cookies and chocolate receive a positive feedback and high level of satisfaction. Mangosteen pericarp aqueous extract in product increase the nutritional profile and aesthetic appeal of product without affecting its sensory attributes.

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