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Fortification of Cookies with Pomegranate Peel and Grape Must Powder

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ABSTRACT

Background: Cookies is one of the popular snacks preferred by all age group of people. Generally, cookies are made with refined wheat flour, sugar and fat which contain more of high calories and low dietary fibre leading to increased obesity rate. The consumers' demand towards the nutritional needs in the desired food form can be satisfied with the cookies fortified with fruit or vegetable powders.

Methods: The study was conducted to analyse the nutritional value and consumer acceptability of cookies fortified with pomegranate peel and grape must powder. The cookies prepared from maida served as control. The pomegranate peel and grape must were dehydrated, powdered and blended with wheat and pearl millet flour.

Result: The results revealed that wheat flour cookies fortified with 5% grape must powder were highly acceptable with considerable increase in nutritional attributes. It can be concluded that use of fruit peel powder as one of the ingredients in cookies can be an alternate way to check food security and also provide an effective way for using fruit residues.

Key words: Cookies, Fortification, Grape must, Pearl millet flour, Pomegranate peel, Wheat flour.

INTRODUCTION

In India, with the increasing population the food production is also increasing especially the production of fruits is estimated to be 102.48 million tonnes in the year 2020-2021. Though the production of fruits is high, their availability in the market is comparatively less due to post harvest losses which accounts for 6.70-15.88% of total fruit production (NABCONS, 2022). Thereby, the fruit produces fetch higher prices in the market which make them unaffordable for the lower middle class and poor people. Due to this, nutritional security of the lower income people is checked and many of them are suffering from malnutrition which leads to various deficiency disorders like anaemia, beri-beri, scurvy, night blindness, etc. On the other hand, the people who can afford fruits prefer packed and ready-to-eat foods in the fast-moving world. Continuous consumption of these foods may lead to diabetes, obesity and cardiovascular diseases (Kearney, 2010).

The best way to attend all these issues is value addition of fruits. Only 10% of the production is processed to various products such as jam, jelly, marmalade, squash, ready to serve, preserves etc. It has been reported that nearly a half billion tonnes of wastes are generated by the global fruit processing industries (Antonisamy *et al*., 2023). This waste accounts more than 50% of fresh fruit which includes peels, trimmings, seeds and pomace and these residues may also possess nutritional or functional attributes higher than final processed product (Torres-León *et al*., 2018) and are potential source of sugars, minerals, dietary fibres, polyphenols, antioxidants, enzymes, organic acids and other bio-active compounds. Consumers should be aware of functional foods that can be prepared with these residues which are enriched with dietary supplements. Depending on the nature of the fruit by-product, they can be pre-processed (extracted or dried and ground) and incorporated into other food products (Pattnaik *et al*., 2021).

Cookies is one of the popular snacks preferred by all age group of people. Global annual consumption of cookies is 10 million tonnes (Ning *et al*., 2021). Per capita consumption of cookies in India is 8 kg per annum against 15 kg per annum in developed countries (Shukla *et al*., 2000). Despite its familiarity, cookies fail to supplement the dietary fibres required by the human body which can be improved by fortification with different fruit or vegetable by-products in the form of powdered fruit/vegetable and also by supplementing maida with wheat, ragi, pearl millet and other minor millets flour. When these alternatives are used along with the fruit peel or seed or must powder, the cookies can be turned into a complete healthy snack. Millet contributes an important portion in human diet due to rich

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source of dietary fibre, calcium, iron, zinc, lipids and proteins (Malik *et al*., 2002; Singh *et al*., 2006). As a food source it is soothing, easy to digest, non-glutinous and non-acid forming.

The fruit wastes like pomegranate peel, orange peel, banana peel, mango kernel, grape must, pineapple pomace, jackfruit seeds will be astringent or bitter in taste. However, incorporation of these fruit waste powders in cookie dough preparation to a certain level will not affect the taste and quality of the cookies. Innovation in food processing sector brings out new products with high nutritional status in an easier way to consume obviously in an economically friendly manner (Moura and Vialta, 2022).

Pomegranate (*Punica granatum* L.) belonging to the family Punicaceae is one of the widely grown fruit crops in tropical and subtropical regions of the world. Pomegranate originated in Iran and commercially cultivated in the Mediterranean countries, China, India and South America. The edible portion of the fruit is aril and the peel alone constitute for 26 to 40% of the whole fruit. Pomegranate peel contains high level of antioxidants and phenolic compounds especially flavonoids (anthocyanins, catechin) and tannins (punicalin, punicalagin, gallic acid and ellagic acid) and also serve as a great source of dietary fibre. It helps in preventing cardiovascular disorders, hypoglycemia, apoptosis and inflammatory diseases (Gullon *et al*., 2020).

Grape (*Vitis vinifera* L.) belonging to the family Vitaceae is the third most important fruit crop in the world. It is a good source of phenols, antioxidants and dietary fibre. More than 90% of the world's grape production is utilized in wine industry. The by-products constitute around 20% of the fresh fruit (Theagarajan *et al*., 2019) and are used for partial replacement of fat or sugar in value added product preparation and thereby reducing the calorific value of the product.

Considering the health benefits of pomegranate and grapes, the present study is aimed to incorporate the pomegranate peel and grape must powder either alone or in combination blended into flour used in the preparation of cookies and thereby enhancing their nutritive value.

MATERIALS AND METHODS

The experiment for the preparation of cookies fortified with pomegranate peel and grape must powder was carried out in UG Analytical Laboratory, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The ingredients required for the preparation of cookies such as refined maida, wheat and pearl millet flour, baking soda, butter, milk powder, pomegranate fruits and grapes bunches were procured from a local market in Coimbatore.

Preparation of fruit residue powder

Pre-treatment

Pomegranate peel was cut into pieces using stainless steel knife after its separation from other fruit parts. The skin and seeds of grapes were collected after juice extraction. Both pomegranate peel and grape must were treated with 2% salt solution for 10 minutes and then rinsed in tap water to remove the adhering salts present if any (Kushwaha *et al*., 2013; Reshmi *et al*., 2018). Then the peel and must were spread on a stainless-steel tray and dried at room temperature to remove the surface moisture.

Dehydration and powdering

Pre-treated pomegranate peel and grape must after drying at room temperature for 2 days were subjected to dehydration in tray drier at 65°C for 10 hours to remove the excess moisture. The dried residues were ground into powder form using a blender and sieved through 0.5 mm sieve (Ranjitha *et al*., 2018).

Flour blending

Cookies were prepared with five different combinations of flour and fruit residue powder along with three controls which contains flour alone as given in Table 1. The treatments include maida flour (S_1), wheat flour (S_2), pearl millet flour (S_3), wheat flour + pomegranate peel powder (S_4), wheat flour + grape must powder (S_5), pearl millet flour + pomegranate peel powder (S_6), pearl millet flour + grape must powder (S_7), wheat flour + pearl millet flour + pomegranate peel powder + grape must powder (S_8).

Preparation of cookies

From various previous studies, it was found that addition of both pomegranate peel powder and grape must powder to a level of 5% can enhance the nutritive value of cookies without affecting the taste and quality. The following procedure is adopted for preparation of cookies (Fig 1).

Nutrient and biochemical analysis

Nutritional profiling of the cookie samples was carried out based on the methods outlined in AOAC (2000). Moisture was determined by placing the sample in hot air oven at 105°C till a constant weight is achieved and loss of weight was recorded as moisture content in dried peel powder. Charred peel powder samples were ashed in muffle furnace at 550°C for 5-6 hours until constant weight is recorded and residual ash is weighed and expressed as percentage of pre-weighed peel powder. Total carbohydrate content was estimated by Anthrone method. When carbohydrates are dehydrated by conc. H_2SO_4, it forms furfural. Anthrone condenses with the carbohydrate furfural derivative to give green and blue colour in dilute and concentrated solutions respectively, which can be determined colorimetrically by recording absorbance at 620 nm. The protein content was determined by micro Kjeldhal method. Crude fibre content was estimated by acid and alkali digestion followed by ashing.

Total phenolic contents of the samples were determined by Folin-Ciocalteau method as adopted by Li *et al*. (2006) using pyrocatechol as standard. Absorbance was measured spectrophotometrically at 660 nm and results were expressed as mg/100 g equivalent of pyrocatechol. 2,2-diphenyl-1-picrylhydrazyl (DPPH) equivalent antioxidant

activity of the samples was determined by the method as adopted by Singh *et al*. (2006). Absorbance was measured spectrophotometrically at 517 nm and % DPPH scavenging activity was calculated using the formula:

$$\text{Percentage DPPH scavenging activity} = \frac{\text{Blank OD - Sample OD}}{\text{Blank OD}} \times 100$$

Fat content was estimated using Soxhlet equipment (Soxlet, 920.39, Make: Pelican, Model: SOCS Plus). The empty weight of the beaker (W1) was noted. Two grams of sample was weighed and put into a thimble to which 100 mL of petroleum ether was added and kept in the beaker. Then the beaker was attached to the soxhlet apparatus and extracted for about one and half hours. After extraction, the beaker was retrieved from the apparatus. The remaining solvent was evaporated by keeping in hot air oven. The beaker was cooled and weighed (W2).

$$\text{Fat content (\%)} = \frac{\text{W2 - W1}}{\text{Sample weight}} \times 100$$

The free fatty acids content in the cookies were estimated following the method described by Cox and Pearson (1962). The free fatty acid value is arrived by the following formula and expressed in mg KOH/g.

$$\text{Free fatty acid value} = \frac{\text{Titrate value} \times \text{Normality of KOH} \times 56.1}{\text{Weight of sample}}$$

The calorific value was arrived from total carbohydrate, protein and fat following the conversion and expressed in kcal.

$$\text{Calorific value (kcal)} = (\text{Total carbohydrate} \times 4) + (\text{Total protien} \times 4) + (\text{Fat content} \times 9)$$

The sensory characteristics such as colour, texture, flavour, taste and overall acceptability of the cookies were evaluated by 15 panellists (10 trained professionals and 5 untrained personnels) from Tamil Nadu Agricultural University, Coimbatore. The panellists scored the sample cookies using a 9 point hedonic scale where 9 meant for extreme likeness and 1 meant for extreme dislikeness (Akhtar *et al*., 2008).

Statistical analysis

The experiment was carried out by adopting completely randomized design with 3 replicates. Data were analyzed using one-way ANOVA and Least Significant Difference (LSD) was used to separate significant differences between means with the help of a statistical software package, SPSS v.20.00.

RESULTS AND DISCUSSION

Nutritional composition of fruit residue powder and cookies

The nutritional composition of pomegranate peel powder, grape must powder and cookies were assessed (Table 2 and 3). It was observed that pomegranate peel powder had higher total carbohydrates and moisture whereas other parameters like total protein, crude fibre, ash, fat, free fatty acids and calorific value were higher in grape must powder.

Total carbohydrate

The total carbohydrate content was high in S_8 cookies (60.17 g/100 g) and it was low in S_5 cookies (52.23 g/100 g). Total carbohydrate contents of maida, wheat and pearl millet controls were 66.38, 63.30 and 60.62 g respectively. As per the recommendations of nutrition experts, an average human should consume 282 g of carbohydrates per day and the major portion of recommended level of carbohydrate is

Table 1: Various combinations of cookies with different flour blending.

Treatments	Pomegranate peel powder (%)	Grape must powder (%)	Maida (g)	Wheat flour (g)	Pearl millet flour (g)
S_1	-	-	250	-	-
S_2	-	-	-	250	-
S_3	-	-	-	-	250
S_4	5	-	-	250	-
S_5	-	5	-	250	-
S_6	5	-	-	-	250
S_7	-	5	-	-	250
S_8	2.5	2.5	-	125	125

Table 2: Nutritional composition of fruit residue powder.

Parameters	Pomegranate peel powder	Grape must powder
Total CHO (g/100 g)	72.37	64.08
Moisture content (g/100 g)	5.65	4.59
Ash content (g/100 g)	3.45	3.70
Fat content (g/100 g)	3.60	9.30
Total protein (g/100 g)	12.39	14.39
Crude fibre (g/100 g)	2.54	3.94
Free fatty acid (%)	0.58	0.71
Calorific value (kcal)	371.44	397.58

obtained from the regular diet. Hence the supplementary food or snacks should contain low carbohydrate content. The fortification of fruit waste powder had lowered the level of carbohydrate in the cookies. From the results, it was found that the carbohydrate content of the fortified cookies is less when compared to control cookies. The addition of fruit residue powder considerably decreased total carbohydrate. Addition of guava peel flour (Bertagnolli *et al*., 2014) and eggfruit peel flour with wheat flour (Perez and Germani, 2007) reduced the carbohydrate level of the cookies.

Crude fibre

Crude fibre has less energy value and the fibre content of the samples varied from 2.09% in S_1 to 4.03% in S_5 cookies. The fibre content increased with the addition of pomegranate peel powder and grape must powder. Pearl mill*et a*lso contains a relative proportion of fibre which aids in slow release of sugar (Rai *et al*., 2008). According to Okpala and Akpu (2014), increasing the amount of orange peel powder greatly enhanced the fiber content of the bread. Similarly, Ikuomola *et al*. (2017) reported that cookies prepared from wheat flour and fortified with malted barley bran had higher fibre content than control. In another study, the addition of grape pomace powder (0 to 5 and 0 to 10 g/100 g) to wheat flour increased the total dietary fiber content of fortified bread (Tolve *et al*., 2021).

Fat content

The fat content of the samples ranged from 19.22 to 24.90 g/100 g (Table 3). The S_5 cookies recorded higher fat content (24.90 g) and cookies fortified with grape must comparatively recorded higher fat content than other cookies. The grape seed is a rich source of fat and it contains 90% monounsaturated fatty acid (Sousa *et al*., 2014). An average healthy adult who is aiming to maintain the current weight requires 40 to 60 g of fat consumption per day. The fat content has a direct relation to the calorific value. The USDA reports that 35% of the calories are obtained from fat which states that 97 g of fat per day is to be consumed in a 2500 calorie diet and up to 66 g of fat consumption per day is required in a 2000 calorie diet.

Free fatty acids (FFA)

The free fatty acid content of the cookies ranged from 0.79% to 1.16%. The FFA content in cookies fortified with (S_6) registered the highest value (1.16 %) and lowest in S_1 (0.79). Free fatty acids speed up the rate of hydroperoxide decomposition, acting as pre-oxidants in oils. Thus, high FFA content in the food may cause further oxidation and leads to development of offensive taste and flavour. If the free fatty acid content of food is high, rancidity takes place quickly. The quality deterioration of cookies is due to

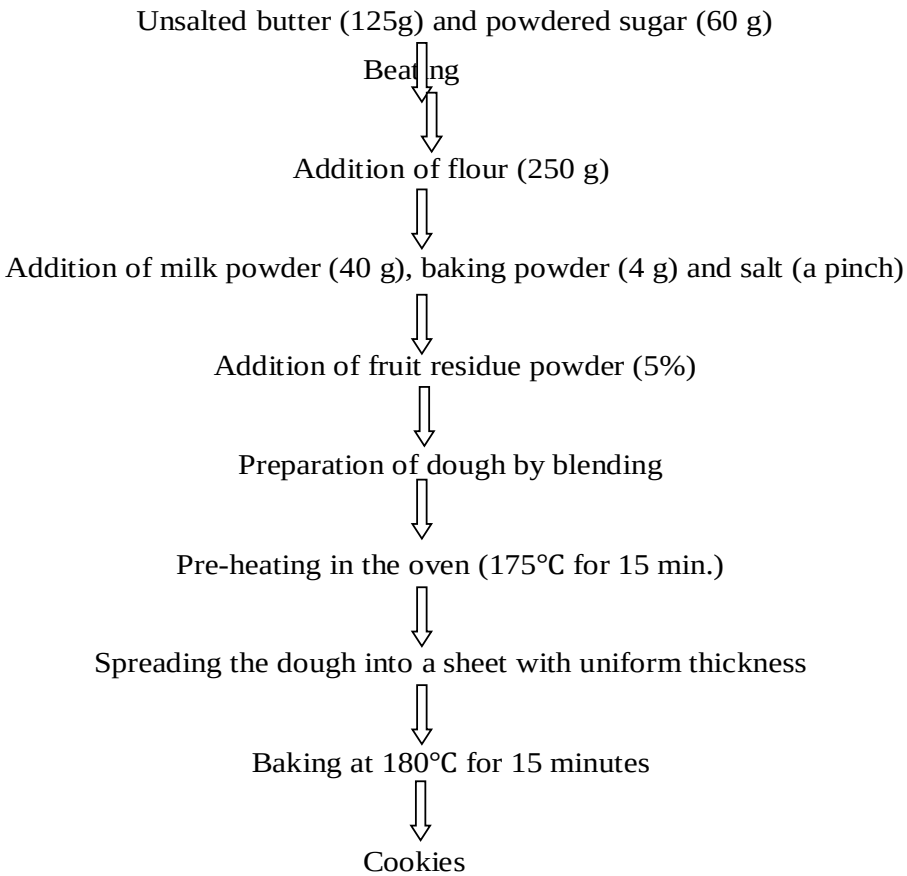

Fig 1: Flow chart for preparation of cookies.

moisture loss, oxidation, textural alteration and spoilage during prolonged storage (Adegoke *et al*., 1998). During storage, development of off-flavours is the indicator of product oxidation that can be identified by measuring FFA levels. Cookies possess higher risk of oxidative changes because of higher fat contents due to the addition of butter. Incorporation of antioxidant prevents quality degradation by retarding or inhibiting oxidative reactions (Reddy *et al*., 2005). It has been noted that there is controversy about the use of synthetic antioxidants in terms of their safety for human health (Nanditha and Prabhasankar, 2008). Pomegranate peel powder is a plentiful source of phytochemicals more specifically ellagitannis that impart characteristic free radical scavenging properties.

Total protein

Significantly higher protein (14.6 g) was found in treatment S_5 and the minimum protein content (8.1 g) was recorded in the treatment (S_1). This is due to the incorporation of grape must powder which is rich in protein (11%) as compared to conventional cookies. Increase in the protein content in the fortified cookies with increase in the level of fortification was reported by Paul and Bhattacharyya (2015) in cookies fortified with pomegranate juice and peel powder. Though the protein content of residue powder is higher, the protein content of cookies was reduced. This may be due to denaturation of protein that takes place during baking of cookies (Nakov *et al*., 2020).

Calorific value

The calorific value is reported to be higher in S_1 which is 492.73 kcal and found to be lower in S_7 (385.84 kcal). More percent of carbohydrate in S_1 is responsible for the highest calorific value whereas comparatively lower calorific value in cookies prepared from wheat flour, pearl millet flour and fortification with pomegranate peel powder and grape must powder might be due to more ash and crude fibre which do not add any calories. The findings of the present study were well supported by El-Sharnouby *et al*. (2012) in nutritional quality of biscuits supplemented with wheat bran and date palm fruits.

Moisture content

The moisture content was high in S_5 (9.36%) and it was reported to be low in S_8 (4.65%). The moisture content has its direct influence in the storability. Generally, cookies have less moisture content when compared to other value-added products. Cookies will have better shelf-life conditions if they possess low moisture content and are packed and stored properly (*i.e*., packaging in moisture and vapour proof material). The grape must incorporated cookies are having high moisture content and decreased hardness. Water absorption increased with the addition of grape must at the level of 5% as it contains more fibre. Addition of mango peel powder, apple fibre, lemon and orange peel to the wheat dough produced the similar effect (Ajila *et al*., 2008; Kohajdová *et al*., 2011; Kohajdová *et al*., 2014). Increased water absorption is due to the higher number of hydroxyl

Table 3: Comparison of nutritional attributes of conventional cookies and fortified cookies.

Treatments	Total CHO (g/100 g)	Crude fibre (g/100 g)	Fat content (g/100 g)	FFA (%)	Total protein (g/100 g)	Calorific value (Kcal)	Moisture content (g/100 g)	Ash content (g/100 g)	Total phenols (mg/g)	Antioxidants (%)
S_1 (Maida flour)	66.38	2.09	19.22	0.79	8.1	492.73	6.59	0.95	90	9.03
S_2 (Wheat flour)	63.30	3.00	21.14	0.95	10.6	448.18	8.09	1.65	108	8.84
S_3 (Pearl millet flour)	60.62	3.03	20.30	1.03	8.0	464.38	8.30	2.15	128	29.15
S_4 (WF+PPP)	55.45	3.66	22.53	0.94	11.4	479.32	7.46	2.80	160	44.73
S_5 (WF+GM)	52.23	4.03	24.90	0.90	14.6	472.64	9.36	3.20	150	45.59
S_6 (PMF+PPP)	54.37	3.21	21.35	1.16	10.10	446.11	8.43	2.75	146	61.39
S_7 (PMF+GM)	53.28	3.62	22.15	1.08	11.30	385.84	8.55	2.75	140	79.13
S_8 (WF+PMF+PPP+GM)	60.17	3.78	24.27	0.94	12.60	485.75	4.65	2.30	136	90.75
Sed	1.22	0.08	0.40	0.07	0.46	4.38	0.13	0.45	4.72	3.87
CD (p=0.05)	2.42	0.17	0.82	0.15	0.94	8.75	0.27	0.94	9.55	7.56

Table 4: Mean value obtained from organoleptic evaluation by 15 panelists.

Treatments	Sensory parameters				
	Colour	Texture	Flavour	Taste	Overall acceptability
S_1	8.03	8.00	8.07	8.23	8.69
S_2	7.76	8.10	7.70	7.80	7.23
S_3	7.23	7.38	7.23	7.23	7.15
S_4	7.23	7.23	7.07	6.92	6.92
S_5	7.50	8.00	7.60	7.60	8.07
S_6	7.23	7.15	7.07	6.69	7.07
S_7	7.07	7.00	6.76	7.15	7.15
S_8	7.23	7.30	7.07	7.15	7.60
SEd	0.20	0.21	0.20	0.21	0.21
CD (p=0.05)	0.41	0.42	0.40	0.42	0.42

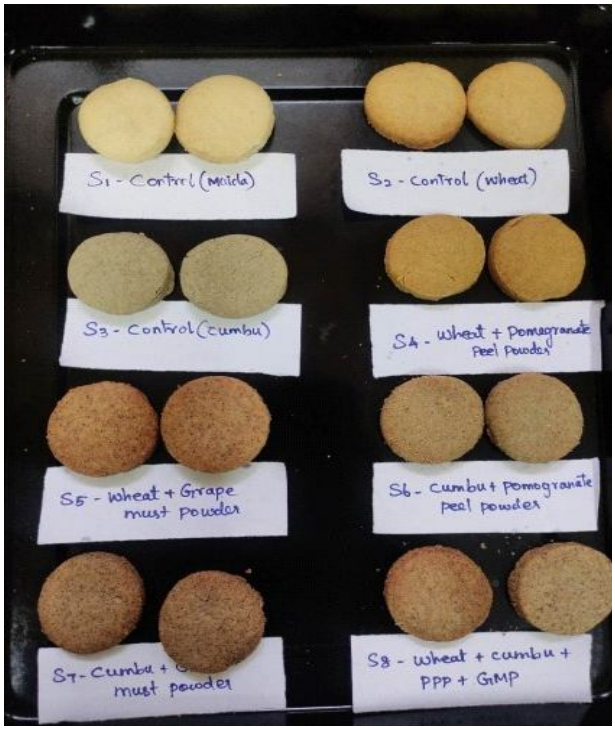

Fig 2: Physical appearance of cookies from different treatments.

groups in the structure of dietary fibre, which enables more water interactions through hydrogen bonding (Kohajdová *et al*., 2011).

Ash content

The average ash content of the cookies was reported to be high in S_5 (3.20 g/100 g) and found to be low in S_1 (0.95 g/ 100 g). The ash content of grape must powder (GMP) was 3.70 g/100 g and the ash content increases with the addition of GMP. Higher ash content indicates that the flour contains more of the germ, bran and outer endosperm. Lower ash content means that the flour is more highly refined and so the ash content of refined maida is 0.95 g. The higher ash content in the fortified cookies may be due to higher mineral content present in fruit residue powder (Bello *et al*., 2022).

Total phenol and antioxidants

The total phenolic content ranged from 90 mg to 160 mg. The presence of phenolics on account of their ability to donate hydrogen atom is one of the reported reasons for high free radical scavenging properties of fruit waste powder. Correlation between phenolics concentration and antioxidant activity has been previously justified by Chidambara *et al*. (2002) and Zahin *et al*. (2010). Due to fruit residue powder's high level of bioactivity, there was a simultaneous rise in the total phenolic content and antioxidant activity of cookies after the concentration of fruit powder was increased (Zlatanoviæ *et al*., 2019). In the present study, wheat flour cookies fortified with 5% pomegranate peel powder recorded the highest total phenol content. The antioxidants content also ranged from 8.84% and 90.75%. The cookies prepared from combination of wheat flour and pearl millet flour and fortified with pomegranate peel powder and grape must powder resulted in the highest antioxidant content.

Sensory analysis

Addition of pomegranate peel powder at 5% level did not manifest any undesirable organoleptic response and the product remained acceptable. S_1 ranked first in terms of colour, texture, flavour and taste and S_5 ranked second in overall acceptability (Table 4 and Fig 2). Gayas *et al*. (2012) observed the mean overall sensory acceptability scores of more than 8.50 for biscuit samples incorporated up to 5% carrot pomace powder indicated the commercial scope for manufacturing good quality vegetarian biscuits with carrot pomace powder and defatted soy flour. The colour of control cookies made of maida flour was found to be brighter and those made with pomegranate peel powder and grape must powder contributed dark colour as they possess anthocyanin which on baking leads to formation of dark colour on reaction with reducing sugars present (Nakov *et al*., 2020).

CONCLUSION

In this study, pomegranate peel powder and grape must powder incorporated cookies were prepared with different combination of wheat and pearl millet flour and analysed for various nutritional parameters along with cookies made

from maida flour. The fortified cookies have more nutritional properties than conventional cookies. From the experimental results, cookies prepared from wheat flour fortified with grape must powder (S_5) was found acceptable when compared to other fortified cookies. Sensory evaluation of the cookies by 15 panelists also revealed that the conventional maida cookies (S_1) are widely accepted by the people because of their taste and followed by S_5 (wheat flour + grape must powder) cookies and S_8 (wheat flour + pearl millet flour + pomegranate peel powder + grape must powder) cookies. Nowadays, people are more conscious about diet, nutrition of the food consumed and the ill effects of junk foods. Considering the nutritional qualities, wheat cookies fortified with grape must powder proved to be the best alternative in the market.

Conflict of interest

All authors declared that there is no conflict of interest.

REFERENCES

Adegoke, G.O., Kumar, M.V. , Gopal Krishna, A.G., Varadaraj, M.C., Sambaiah, K. and Lokesh, B.R. (1998). Antioxidants and lipid oxidation in foods: A critical appraisal. J. Food Sci Technol. 35: 283-298.

Ajila, C.M., Leelavathi, K.U.J.S. and Rao, U.P. (2008). Improvement of dietary fiber content and antioxidant properties in soft dough biscuits with the incorporation of mango peel powder. Journal of Cereal Science. 48(2): 319-326. doi: 10.1016/j.jcs.2007.10.001.

Akhtar, S., Anjum, F.M., Rehman, S.U., Sheikh, M.A. and Farzana, K. (2008). Effect of fortification on physico chemical and microbiological stability of whole wheat flour. Food Chem. 110: 113-119. doi: 10.1016/j.foodchem.2008.01.065.

Antonisamy, A.J., Marimuthu, S., Malayandi, S., Rajendran, K., Lin, Y.C. andaluri, G., Lee, S.L. and Ponnusamy, V.K. (2023). Sustainable approaches on industrial food wastes to value added products- A review on extraction methods, characterizations and its biomedical applications. Environmental Research. 217:114758. doi: 10.1016/j.envres.2022.114758.

AOAC International, (2000). Official Methods of Analysis, Official Method 999.11 (17th ed.). Gaithersburg (MD): AOAC International.

Bello, F.A., Bassey, V.I. and Edet, M.O. (2022). Optimization of cassava, mungbean and coconut pomace flour levels in the production of fiber-rich cookies using response surface methodology. Journal of Culinary Science and Technology. 20(6): 498-517. doi: 10.1080/15428052.2020.1871147.

Bertagnolli, S.M.M., Silveira, M.L.R., Fogaça, A.O., Umann, L. and Penna, N.G. (2014). Bioactive compounds and acceptance of cookies made with Guava peel flour. Food Sci. Technol. 34(2): 303-308. https://doi.org/10.1590/fst.2014.0046.

Chidambara, M.K.N., Jayaprakasha, G.K. and Singh, R.P. (2002). Studies on antioxidant activity of pomegranate (*Punica granatum*) peel extracts. J. Food Agric Chem. 50: 4791-4795. doi: 10.1021/jf010865b.

Cox, H.E. and Pearson, D. (1962). The chemical analysis of foods chemical. Publishing Campus. Inc New York, 420.

El-Sharnouby, G., Aleid, S. and Al-Otaibi, M. (2012). Nutritional quality of biscuit supplemented with wheat bran and date palm fruits (*Phoenix dactylifera* L.). Food and Nutrition Sciences. 3(3): 322-328. doi: 10.4236/fns.2012.33047.

Gayas, B., Shukla, R.N. and Khan, B.M. (2012). Physico-chemical and sensory characteristics of carrot pomace powder enriched defatted soyflour fortified biscuits. International Journal of Scientific and Research Publications. 2(8): 1-5.

Gullón, P., Astray, G., Gullón, B., Tomasevic, I. and Lorenzo, J.M. (2020). Pomegranate peel as suitable source of high added value bioactives: Tailored functionalized meat products. Molecules. 25(12): 2859. doi: 10.3390/molecules 25122859.

Ikuomola, D., Otutu, O. and Oluniran, D. (2017). Quality assessment of cookies produced from wheat flour and malted barley (*Hordeum vulgare*) bran blends. Cogent Food Agric. 3: 1293471. doi: 10.1080/23311932.2017.1293471.

Kearney, J. (2010). Food consumption trends and drivers. Philos Trans R Soc Lond B Biol Sci. 365(1554): 2793-807. doi: 10.1098/rstb.2010.0149.

Kohajdová, Z., Karovicova, J., Jurasová, M. and Kukurová, K. (2011). Effect of the addition of commercial apple fibre powder on the baking and sensory properties of cookies. Acta Chimica Slovaca. 4(2): 88-97.

Kohajdová, Z., Karovièová, J., Magala, M. and Kuchtová, V. (2014). Effect of apple pomace powder addition on farinographic properties of wheat dough and biscuits quality. Chemical Papers. 68:1059-1065. https://doi.org/10.2478/s11696-014-0567-1.

Kushwaha, S.C., Bera, M.B. and Pradyuman, K. (2013). Nutritional composition of detanninated and fresh pomegranate peel powder. J Environmental. Sci, Toxi. Food Techno. 7(1): 38-42.

Li, Y., Guo, C., Yang, J., Wei, J., Xu, J. and Cheng, S. (2006). Evaluation of antioxidant properties of pomegranate peel extract in comparison with pomegranate pulp extract. Food Chem. 96: 254-260. https://doi.org/10.1016/j.foodchem.2005.02.033.

Malik, M., Singh, U. and Dahiya, S. (2002). Nutrient composition of pearl millet as influenced by genotypes and cooking methods. Journal of Food Science and Technology. 39(5): 463-468.

Moura and Vialta, A. (2022). Use of fruits and vegetables in processed foods: Consumption trends and technological impacts. Food Sci. Technol. 42. https://doi.org/10.1590/fst.66421.

NABCONS, (2022). Study to determine post-harvest losses of agri produces in India. Ministry of Food Processing Industries, Government of India. p.no. 3.

Nakov, G., Brandolini, A., Hidalgo, A., Ivanova, N., Stamatovska, V. and Dimov, I. (2020). Effect of grape pomace powder addition on chemical, nutritional and technological properties of cakes. Lwt. 134: 109950. DOI: 10.1016/j.lwt.2020.109950.

Nanditha, B. and Prabhasankar, P. (2008). Antioxidants in bakery products: A review. Critical Reviews in Food Science and Nutrition. 49(1):1-27. doi: 10.1080/10408390701764104.

Ning, X., Wu, J., Luo, Z., Chen, Y., Mo, Z., Luo, R., Bai, C., Du, W. and Wang, L. (2021). Cookies fortified with purple passion fruit epicarp flour: Impact on physical properties, nutrition, *in vitro* starch digestibility and antioxidant activity. Cereal Chemistry. 98(2): 328-336. doi: 10.1002/cche.10367.

Okpala, L. and Akpu, M. (2014). Effect of orange peel flour on the quality characteristics of bread. Br J. Appl Sci Technol. 4: 823. doi: 10.9734/BJAST/2014/6610.

Pattnaik, M., Pandey, P., Martin, G.J., Mishra, H.N. and Ashokkumar, M. (2021). Innovative technologies for extraction and microencapsulation of bioactives from plant-based food waste and their applications in functional food development. Foods. 10(2): 279. https://doi.org/10.3390/foods10020279.

Paul, P. and Bhattacharyya, S. (2015). Antioxidant profile and sensory evaluation of cookies fortified with juice and peel powder of fresh pomegranate (*Punica granatum*). International Journal of Agricultural and Food Science. 5: 85-91.

Perez, P. M. P. and Germani, R. (2007). Elaboração de biscoitos tipo salgado, com alto teor de fibra alimentar, utilizando farinha de berinjela (*Solanum melongena*, L). Food Science and Techonology. 27(1): 186-192. https://doi.org/10.1590/S0101-20612007000100033.

Rai, K.N., Gowda, C.L.L., Reddy, B.V.S. and Sehgal, S. (2008). Adaptation and potential uses of sorghum and pearl millet in alternative and health foods. Comprehensive Reviews in Food Science and Food Safety. 7(4): 320-396.

Ranjitha, J., Bhuvaneshwari, G., Deepa, T. and Kavya, K. (2018). Nutritional composition of fresh pomegranate peel powder. Int. J. Chem. Stud. 6: 92-696.

Reddy, V., Urooj, A. and Kumar, A. (2005). Evaluation of antioxidant activity of some plant extracts and their application in biscuits. Food Chemistry. 90(1-2): 317-321. https://doi.org/10.1016/j.foodchem.2004.05.038.

Reshmi, N.P., Mandal, G. and Thokchom, R. (2018). Effect of pre-treatment of salt solution and drying methods on the quality of processed Aonla (*Emblica officinalis* Gaertn.). Int. J. Curr. Microbiol. App. Sci. 7(8): 1438-1446. https://doi.org/10.20546/ijcmas.2018.708.165.

Shukla, F.C., Shilpa, M. and Thind, S.S. (2000). Bakery industry in India-Present quality control and future scenario: A review. Beverage Food World. 27: 11-15.

Singh, G., Sehgal, S. and Kawatra, A. (2006). Mineral profile, anti nutrients and *in vitro* digestibility of biscuit prepared from blanched and malted pearl millet flour. Nutrition and Food Science. 36(4):231-239. doi: 10.1108/00346650610676802.

Sousa, E.C., Uchôa-Thomaz, A.M.A., Carioca, J.O.B., Morais, S.M.D., Lima, A.D., Martins, C.G., Alexandrino, C.D., Ferreira, P.A.T., Rodrigues, A.L.M., Rodrigues, S.P. and Silva, J.D.N. (2014). Chemical composition and bioactive compounds of grape pomace (*Vitis vinifera* L.) Benitaka variety, grown in the semiarid region of Northeast Brazil. Food Science and Technology. 34: 135-142. https://doi.org/10.1590/S0101-20612014000100020.

Theagarajan, R., Narayanaswamy, M. L., Dutta, S., Moses, J.A. and Chinnaswamy, A. (2019). Valorisation of grape pomace (cv. Muscat) for development of functional cookies. International Journal of Food Science and Technology. 54(4): 1299-1305. https://doi.org/10.1111/ijfs.14119.

Tolve, R., Simonato, B., Rainero, G., Bianchi, F., Rizzi, C., Cervini, M. and Giuberti, G. (2021). Wheat bread fortification by grape pomace powder: nutritional, technological, antioxidant and sensory properties. Foods. 10: 75. doi: 10.3390/foods10010075.

Torres-León, C., Ramírez-Guzman, N., Londoño-Hernandez, L., Martinez-Medina, G.A., Díaz-Herrera, R., Navarro-Macias, V., Alvarez-Pérez, O.B., Picazo, B., Villarreal-Vázquez, M., Ascacio-Valdes, J. and Aguilar, C.N. (2018). Food waste and byproducts: An opportunity to minimize malnutrition and hunger in developing countries. Frontiers in Sustainable Food Systems. 2: 52. doi: 10.3389/fsufs.2018.00052.

Zahin, M., Aqil, F. and Ahmad, I. (2010). Broad spectrum antimutagenic activity of antioxidant active fraction of *Punica granatum* L. peel extracts. Mutation Research/Genetic Toxicology and Environmental Mutagenesis. 703(2): 99-107. doi: 10.1016/j.mrgentox.2010.08.001.

Zlatanović, S., Kalušević, A., Micić, D., Laličić-Petronijević, J., Tomić, N., Ostojić, S. and Gorjanović, S. (2019). Functionality and storability of cookies fortified at the industrial scale with up to 75% of apple pomace flour produced by dehydration. Foods. 8(11): 561. https://doi.org/10.3390/foods8110561.