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Storage Stability of Pseudocereal-based Carrot Pomace enriched Bakery Products

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ABSTRACT: Psuedocereals are gluten free grains, including buckwheat, amaranth and quinoa, known for their high quality protein and outstanding phytochemical composition. Present study was conducted with an objective of exploiting these underutilized crops for development of nutritionally superior gluten-free products, with an additional aim of utilizing carrot juice processing by-product. In this study, bakery products (biscuits and cake) were prepared using buckwheat, amaranth and quinoa flour and also by replacing some quantity of flour with carrot pomace powder (CPP). Three types of biscuits (buckwheat-based, quinoa-based and amaranth-based) were prepared and stored in polyethylene pouches under ambient conditions for 90 days and were subjected to chemical analysis at 0, 30, 60 and 90 days. Likewise, buckwheat-based, quinoa-based and amaranth-based cakes were prepared and stored in polyethylene pouches under ambient conditions. Prepared cakes were analyzed every 10 days for 1 month and it was observed that cakes remained acceptable up to only 20 days of storage and deteriorated on further storage, however, biscuits were microbiologically safe at the end of 90 days period. During storage there was non-significant increase in moisture, total sugar and reducing sugars of the biscuits, while the carotenoids, phenols and antioxidant activity decreased significantly. In case of cakes, ash, fat, crude fiber and protein content of stored products decreased non-significantly, while moisture content, phenols, carotenoids and antioxidant activity decreased significantly. It was found that partial replacement with CPP improved nutritional value of the products and CPP enriched products were comparatively more stable during storage than respective control. Therefore, the developed products are the perfect example of bio-waste utilization as well as hold the potential for solving the problem of protein energy malnutrition and diet restriction in celiac disease.

Keywords: Psuedocereals, phytochemical composition, carrot pomace powder, bio-waste utilization.

INTRODUCTION

Pseudocereals are a class of foods known as "sub-exploited foods" that include non-grass plant species which are not members of the cereal family but have characteristics and functions similar to those of cereals. Pseudocereals are dicotyledonous, which makes them different from cereals (monocotyledonous) in terms of their botanical characteristics (Ciudad-Mulero *et al*. 2019; Schoenlechner *et al.,* 2008), but the term "pseudocereals" is used because of the similarities between their grain's starch content, texture, palatability, and cooking method. The most widely grown and researched pseudocereals are buckwheat (*Fagopyrum* spp.), amaranth (*Amaranthus* spp.), and quinoa (*Chenopodium quinoa*). Pseudocereals may offer an alternative with potential advantages in terms of nutrition in nations lacking biologically useful protein sources, as well as from a socioeconomic standpoint in times of constrained food supply. Pseudocereals can also enhance and broaden the diversity of natural resources from an environmental perspective. The importance of pseudocereals is economic, social, ecological, nutritional, and functional due to their agronomic traits, ecological resilience to challenging situations, and high nutritional content (Rodríguez *et al*., 2020). In the past 10 years, excellent nutritional content and agro-food potential of pseudocereals have been presumed.

The nutritive value of pseudocereal grains is chiefly associated to the presence of high-quality protein and dietary fiber. The protein fraction of pseudocereal flour is primarily composed of albumin and globulin, while the prolamin and glutelin-like proteins are present in small quantities. Moreover, gluten forming prolamins such gliadins and related protein fractions are completely absent, rendering these grains essentially gluten-free. The high concentration of vitamins B_1 and B_2, as well as the substantial amount of essential amino acids in its proteins, make buckwheat a nutritional powerhouse. It contains a lot of soluble carbohydrates, phytosterols, flavonoids, and other nutrients including thiamine-binding proteins, fagopyritols and D-chiro-inositol (Przybylski and Gruczynska 2009). Compared to other conventional cereal crops, amaranth (*Amaranthus* L.) has greater protein content (14-19%) and almost an adequate percentage of essential amino acids, which are abundant in lysine and methionine (Narwade and Pinto 2018). Flavonoids and tocotrienols are also abundant in amaranth along with minerals such as magnesium, potassium, phosphorus and zinc. Squalene molecules, which make up 6-7 per cent of it, can improve the immune system, manage lipid metabolism and have anti-aging benefits on the skin (Nascimento *et al*., 2014). Likewise, Quinoa is also a rich source of various macronutrients as well as high quality proteins and unsaturated fatty acids. Additionally, it has high levels of fiber, minerals, and low-glycemic index carbohydrates like polysaccharides. Moreover, antioxidants like tocopherols and flavonoids like quercetin and kaempferol renders quinoa a phyto-chemical rich grain (Wang and Zhu 2016).

Carrots are a ubiquitous cool-season root vegetable that are grown in temperate regions mostly in the spring and summer and in tropical regions in the winter. Despite the fact that the carrot's greens can also be eaten, the taproot is the component that is most frequently consumed (Di Donato *et al.,* 2014). Carrot can be consumed raw as salad or can be processed into products such as pickles, juices, candy, preserve etc. Consumer demand for nutritious fruit and vegetable juices has led to an increment in juice production, as a consequence to which an ample quantity of pomace is produced. The food industry produces a lot of by-products, so it's important to properly dispose of them in order to minimise environmental pollution. However, significant amounts of polysaccharides, polyphenols, carotenoids, and other useful components are present in these residual components (Stolarczyk and Janick 2011), which can be recovered and then used to create variety of functional foods. The aim of the present study was to investigate the storage stability of bakery products (biscuits and cake) developed from pseudocereals (buckwheat, amaranth and quinoa) and fortified with carrot pomace.

MATERIAL AND METHODS

A. Raw materials

Carrots were procured from the fruit and vegetable market in Solan, Himachal Pradesh, while pseudocereal grains, such as buckwheat, quinoa, and amaranth, were acquired from the National Bureau of Plant Genetic Resources (NBPGR) Research Station, Shimla. The raw material was transferred to the Fruit Processing Laboratory at the Dr. Yashwant Singh Parmar University of Horticulture and Forestry in Nauni, Solan, Himachal Pradesh, for further use.

B. Development of pseudocereal-based bakery products

Preparation of pseudocereal-based biscuits supplemented with carrot pomace powder (CPP). Method standardized by Thejasri *et al*. (2017) for making biscuits was used, although with a few minor adjustments. Powdered sugar and fat (refined oil) were combined and beaten until the mixture was creamy. The above-prepared creamy mixture was added to the correctly combined other components (22-34% CPP and 66-78% pseudocereal flour), and the necessary amount of water was used to turn the combination into dough. After being well mixed for 10 minutes, the resulting dough was wrapped in aluminium foil and left at room temperature for 30 minutes. A consistent sheet of dough with a thickness of 0.5 cm was hand sheeted using a rolling pin. A cookie or biscuit cutter was used to cut the sheet into the desired shapes. The cut pieces were placed on baking sheets covered with parchment paper and cooked for 25 minutes at 150°C. Before packing, the processed product was allowed to cool to room temperature.

Preparation of pseudocereal-based cake supplemented with CPP. The cake was made using a modified version of the standard recipe published by Kaur *et al*. (2018). In several experiments, different combinations of the components were tested, and the recipe that performed best in terms of the sensory metrics was chosen. Powdered sugar and fat (refined oil) were combined and stirred until the mixture was light and fluffy. Separately beaten eggs were added, along with the aforesaid combination, after they had already been mixed. CPP (28-34%) and pseudocereal flours (66-72%) along with other dry components (baking powder) were well combined and added to the foamy mixture. To produce a batter with the correct consistency, the entire mixture was repeatedly whisked. The prepared batter was placed onto a baking pan that had been oiled, and after being properly leveled and set, it was cooked for 30 minutes at 200°C in a preheated oven.

C. Packaging and storage of developed products

To assess the quality of the biscuits throughout a 90-day storage period, they were packaged in polyethylene pouches (0.75 mm gauge), heat sealed, and stored at room temperature (1.9 - 29.7°C). The prepared cakes were also stored in polyethylene pouches (0.75 mm gauge) under ambient conditions and were subjected to evaluation of storage stability at regular intervals during 30 days storage period.

D. Chemical Characteristics

The moisture and ash content of samples was determined using the method suggested by Ranganna (2009). Fat content of the sample was estimated using the automatic SoxTron fat extraction instrument (Model: Sox-2 version 0.1), protein content using semi-automatic instrument i.e. KjelTRON (KDIGB 6M & KjelDISTEA) and crude fiber content using FibroTRON-FRB-2 instrument by referring to the method given in AOAC (2012). The total carbohydrate content was determined by subtraction method explained by Ranganna (2009). Reducing and total sugar content was determined by volumetric method described by Lane and Eynon (1923). The total carotenoids content of products was estimated by solvent extraction method described by Ranganna (2009) and total phenol content of samples by the method given by Bray & Thorpe (1954). The optical density for above parameters of the samples was measured at using UV-VIS spectrophotometer (Shimadzu, Japan) and the concentration was determined as per the standard procedure from the standard curve. Antioxidant potential of raw materials as well as products developed was estimated using the DPPH radical scavenging method described by Brand-Williams (1995). Using methanol as blank, the optical density of sample was measured at 515 nm (till absorbance became steady) with UV-VIS spectrophotometer and remaining DPPH concentration was calculated.

RESULTS AND DISCUSSION

A. Storage stability of developed bakery products

Buckwheat-based biscuits. Optimization of concentration of buckwheat flour and carrot pomace powder for development buckwheat-based biscuit was done on sensory basis and treatment containing 78 per cent buckwheat flour (BF) and 22 per cent CPP was selected for evaluation during storage.

Changes in chemical characteristics during storage. Data pertaining to changes in nutritive value of buckwheat-based biscuits containing CPP is shown in Table 1. Results indicated that the moisture content, total sugars and reducing sugars content of biscuits increased during the storage, however, the effect was non-significant, while the total phenols, carotenoids and antioxidant activity of biscuits decreased significantly. Similar trend was observed in the findings of Nagarajaiah and Prakash (2015), Divyashree *et al.* (2016) and Soni (2019).

Microbiological characteristics during storage. The microbiological analysis of a biscuit made of buckwheat and CPP revealed no microbial growth on day zero. The microbiological investigation showed a marginal rise in total plate count (TPC) under ambient settings after 90 days. However, the growth observed was within the safe limits and the product was safe for consumption.

B. Quinoa-based biscuits

Quinoa-based biscuits were prepared using 72 per cent quinoa flour (QF) and 28 per cent CPP, as this combination was found most acceptable in terms of its organoleptic properties. The developed product was compared with control (100% QF) for changes in its chemical composition during storage period of 90 days.

Changes in chemical characteristics during storage. Data related to the effect of storage on chemical characteristics of quinoa-based carrot pomace enriched biscuit is presented in Table 2. It is clear from the data that there was an increment in moisture content, total sugars and reducing sugars content of developed products. However, the phyto-chemical composition of products reduced significantly resulting in reduced antioxidant activity of the products. The results are in accordance with findings of Pasha *et al*. (2002) and Kausar *et al.* (2018).

Table 1: Effect of storage on chemical characteristics of buckwheat-based carrot pomace enriched biscuit.

Parameter	Buckwheat-based Biscuit							
	0 day		30 days		60 days		90 days	
	BB_1	BB_2	BB_1	BB_2	BB_1	BB_2	BB_1	BB_2
Moisture (%)	3.01	4.82	3.28	5.13	3.77	5.54	4.15	5.84
Ash (%)	1.01	2.05	0.94	1.97	0.86	1.87	0.80	1.82
Fat (%)	19.85	18.79	19.32	18.26	19.04	17.80	18.58	17.27
Protein (%)	8.85	7.91	8.69	7.78	8.54	7.67	8.43	7.58
Crude fiber (%)	3.24	5.76	3.06	5.61	2.86	5.40	2.69	5.17
Reducing sugars (%)	0.34	2.65	0.40	2.74	0.48	2.87	0.53	2.97
Total sugars (%)	9.25	10.23	9.53	10.41	9.74	10.56	9.91	10.67
Carotenoids (mg/ 100 g)	0.46	4.02	0.25	3.61	0.19	3.26	0.10	2.90
Total phenols (mg GAE/ 100 g)	97.87	90.53	93.69	86.37	89.45	83.08	86.23	79.87
Antioxidant activity (% DPPH scavenging activity)	77.93	71.23	76.39	70.23	75.28	68.08	74.15	67.50

BB_1: 100% Buckwheat flour biscuit (Control)
BB_2: 78% BF and 22% CPP

Table 2: Effect of storage on chemical characteristics of quinoa-based carrot pomace enriched biscuit.

Parameter	Quinoa-based biscuit							
	0 day		30 days		60 days		90 days	
	QB_1	QB_2	QB_1	QB_2	QB_1	QB_2	QB_1	QB_2
Moisture (%)	3.08	4.97	3.36	5.32	3.85	5.80	4.13	6.01
Ash (%)	2.03	2.63	1.97	2.57	1.91	2.49	1.86	2.43
Fat (%)	22.39	18.32	21.80	17.75	21.46	17.28	20.95	16.68
Protein (%)	9.87	8.62	9.73	8.50	9.57	8.39	9.48	8.31
Crude fiber (%)	3.25	6.55	3.09	6.42	2.92	6.24	2.68	6.01
Reducing sugars (%)	0.41	3.33	0.52	3.42	0.60	3.53	0.69	3.62
Total sugars (%)	9.37	10.73	9.71	10.92	10.00	11.07	10.21	11.20
Carotenoids (mg/ 100 g)	0.40	5.06	0.24	4.62	0.16	4.23	0.09	3.83
Total phenols (mg GAE/ 100 g)	41.97	34.40	39.79	31.21	36.90	28.08	34.39	25.96
Antioxidant activity (% DPPH scavenging activity)	55.81	53.49	53.29	51.99	52.72	50.44	51.15	49.87

QB_1: 100% Quinoa flour biscuit (Control)
QB_2: 72% QF and 28% CPP

Microbiological characteristics during storage. The total plate count (TPC) of the product was measured at mentioned intervals during storage in order to evaluate the microbial composition of quinoa-based biscuits. No microbiological growth was seen on the first day of storage, however during the course of the storage period in ambient conditions, TPC gradually increased. Results from the microbiological investigation of the product held in ambient conditions after 90 days showed that QB_2 had a higher TPC of 5×10^3 cfu/ mL and QB_1 had a lower TPC of 4×10^3 cfu/ mL.

C. Amaranth-based biscuits

Treatment combination containing amaranth flour (AF) at the concentration of 66 per cent and CPP at the concentration of 34 per cent was found best in terms of sensory characteristics. The developed product was evaluated for changes in its nutritional properties during storage and was compared to control (100% AF).

Changes in chemical characteristics during storage. Perusal of data in Table 3 indicates that ash, fat, crude fiber and protein content of stored products decreased during 90 days storage period, accompanying the decrease in carotenoids content, total phenols and resultant antioxidant activity. Decrease in former components was found non-significant, while the later reduced significantly. The results obtained are in agreement with findings of Kumar and Barmanray (2007) and Wani and Sood (2014).

Microbiological characteristics during storage. Microbiological quality of amaranth-based biscuit was measured as TPC of the product at regular intervals during storage. There was absence of microbial growth at the beginning of storage period (0 day), but, with the advancement of storage period, a gradual increase in TPC of the product was recorded. At the end of 90 days, microbial analysis of product stored under ambient condition indicated higher TPC of 5×10^3 cfu/ mL in AB_1 and relatively lower TPC of 4×10^3 cfu/ mL in AB_2.

D. Buckwheat-based cake

Buckwheat-based cake was developed by replacing BF with 28 per cent CPP in the standardized recipe. Thus, BF: CPP ratio of 72:28 was employed for making buckwheat-based cake and developed combination was compared with control (100% BF cake) during storage period of 30 days at regular intervals.

Changes in chemical characteristics during storage. An appraisal of results presented in Table 4 shows that moisture content, ash, fat, crude fiber and protein content of developed products decreased during storage. It is also evident from the table that there was significant reduction in total carotenoids, total phenols and antioxidant activity of products with the advancement of storage period up to 20 days. Nagarajaiah and Prakash (2015) and Mittal (2018) also reported a decline in carotenoid content in their studies on carrot pomace enriched cookies and pumpkin based-bakery products, respectively. Also, it was observed that storage beyond 20 days increased the microbial counts beyond acceptable levels and products was discarded and was not evaluated further.

Table 3: Effect of storage on chemical characteristics of amaranth-based carrot pomace enriched biscuit.

Parameter	Amaranth-based biscuit							
	0 day		30 days		60 days		90 days	
	AB_1	AB_2	AB_1	AB_2	AB_1	AB_2	AB_1	AB_2
Moisture (%)	3.09	5.11	3.40	5.46	3.92	5.95	4.14	6.20
Ash (%)	2.09	3.09	2.02	3.01	1.95	2.94	1.89	2.87
Fat (%)	22.47	17.23	21.98	16.67	21.52	16.17	21.00	15.54
Protein (%)	10.58	9.00	10.43	8.88	10.30	8.75	10.17	8.64
Crude fiber (%)	4.47	8.04	4.29	7.91	4.09	7.74	3.93	7.53
Reducing sugars (%)	0.28	3.85	0.35	3.98	0.44	4.09	0.51	4.25
Total sugars (%)	9.14	11.09	9.51	11.30	9.76	11.46	9.94	11.59
Carotenoids (mg/ 100 g)	0.33	5.97	0.21	5.54	0.15	5.18	0.09	4.81
Total phenols (mg GAE/ 100 g)	9.79	28.15	7.08	25.99	5.67	23.11	3.49	22.21
Antioxidant activity (% DPPH scavenging activity)	11.33	21.49	9.77	19.97	7.48	18.42	6.17	17.85

AB_1: 100% Amaranth flour biscuit
AB_2: 66% AF and 34% CPP

Table 4: Effect of storage on chemical characteristics of buckwheat-based carrot pomace enriched cake.

Parameter	Buckwheat-based cake							
	0 day		10 days		20 days		30 days	
	BC_1	BC_2	BC_1	BC_2	BC_1	BC_2	BC_1	BC_2
Moisture (%)	22.13	23.19	21.48	22.51	19.80	20.94	-	-
Ash (%)	1.39	2.53	1.32	2.43	1.27	2.34	-	-
Fat (%)	19.11	17.83	18.26	16.65	18.00	16.42	-	-
Protein (%)	13.34	12.26	13.16	12.07	13.03	11.92	-	-
Crude fiber (%)	3.36	6.68	3.30	6.53	3.23	6.37	-	-
Reducing sugars (%)	0.32	3.03	0.39	3.11	0.48	3.18	-	-
Total sugars (%)	13.13	14.05	13.26	14.21	13.43	14.37	-	-
Carotenoids (mg/ 100 g)	0.57	5.29	0.34	4.79	0.28	4.48	-	-
Total phenols (mg GAE/ 100 g)	100.05	89.19	97.13	86.98	94.38	84.16	-	-
Antioxidant activity (% DPPH scavenging activity)	78.13	70.65	77.34	69.63	76.62	68.55	-	-

BC_1: 100% Buckwheat flour cake (Control)
BC_2: 72% BF and 28% CPP

Microbiological characteristics during storage. A total plate count was used to conduct a microbial study of the cake. The zero-day microbiological quality test confirmed that the cakes were microbiologically sterile. However, as the storage time progressed, a few colonies started to form. Up to 20 days of storage, the microbiological growth under ambient conditions was within acceptable limits (11×10^3 cfu/ mL in BC_2 and 8×10^3 cfu/ mL in BC_1). However, when the storage period extended over 20 days, visible growth began to emerge, and the product quality as well as safety was diminished.

E. Quinoa-based cake

For evaluating the storage stability of quinoa-based cake, the treatment containing 72 per cent QF and 28 per cent CPP was taken and compared with the control (100% QF cake) for changes in chemical composition and microbiological quality during storage.

Changes in chemical characteristics during storage. Table 5 shows the effect of storage on chemical characteristics developed products. The addition of CPP increased the moisture, ash, fiber and carotenoid contents of cake in comparison to control. Increasing and decreasing trend in chemical composition of quinoa-based cake was similar to buckwheat-based cake.

Microbiological characteristics during storage. On day zero, a total plate count of the product showed that it was completely free of microorganisms, but as the storage days progressed on, a few colonies started to form in the cakes. Up to 20 days of storage, the microbiological growth under ambient conditions was within tolerable limits (15×10^3 cfu/ mL in QC_2 and 12×10^3 cfu/ mL in QC_1). However, when the storage period extended over 20 days, microbial numbers increased considerably resulting in deterioration of products and the product was discarded.

F. Amaranth-based cake

Amaranth flour at the concentration of 66 per cent and CPP at the concentration of 34 per cent was selected for the development of CPP enriched amaranth-based cake.

Changes in chemical characteristics during storage. Data pertaining to storage stability of developed products is shown in Table 6. Products were evaluated only up to 20 days of storage and were discarded later due to increase in microbial numbers beyond safe limits. Supplementation with CPP improved the crude fiber, total phenols, total carotenoids and antioxidant activity of the product. Storage stability of developed products greatly reduced during storage resulting in loss of its nutritive potential.

Table 5: Effect of storage on chemical characteristics of quinoa-based carrot pomace enriched cake.

Parameter	Quinoa-based cake							
	0 day		10 days		20 days		30 days	
	QC_1	QC_2	QC_1	QC_2	QC_1	QC_2	QC_1	QC_2
Moisture (%)	22.83	23.95	22.20	23.28	20.54	21.69	-	-
Ash (%)	1.99	3.06	1.93	2.95	1.87	2.86	-	-
Fat (%)	20.58	17.13	19.71	16.22	19.54	15.97	-	-
Protein (%)	13.87	12.61	13.69	12.41	13.55	12.24	-	-
Crude fiber (%)	3.41	6.83	3.34	6.67	3.26	6.50	-	-
Reducing sugars (%)	0.39	3.08	0.46	3.16	0.55	3.26	-	-
Total sugars (%)	13.18	14.12	13.44	14.27	13.58	14.39	-	-
Carotenoids (mg/ 100 g)	0.53	5.21	0.32	4,75	0.24	4.42	-	-
Total phenols (mg GAE/ 100 g)	42.13	34.57	40.00	31.39	38.75	28.65	-	-
Antioxidant activity (% DPPH scavenging activity)	56.03	54.55	55.21	53.59	54.20	52.54	-	-
QC_1: 100% QF biscuit QC_2: 72% QF and 28% CPP								

Table 6: Effect of storage on chemical characteristics of amaranth-based carrot pomace enriched cake.

Parameter	Amaranth-based cake							
	0 day		10 days		20 days		30 days	
	AC_1	AC_2	AC_1	AC_2	AC_1	AC_2	AC_1	AC_2
Moisture (%)	20.07	21.16	19.45	20.49	17.80	18.94	-	-
Ash (%)	2.47	3.58	2.40	3.47	2.34	3.36	-	-
Fat (%)	20.87	15.61	20.00	14.51	19.72	14.29	-	-
Protein (%)	15.55	13.89	15.34	13.71	15.17	13.56	-	-
Crude fiber (%)	4.56	8.40	4.49	8.22	4.42	8.04	-	-
Reducing sugars (%)	0.24	3.58	0.39	3.73	0.47	3.89	-	-
Total sugars (%)	13.06	14.23	13.36	14.37	13.49	14.50	-	-
Carotenoids (mg/ 100 g)	0.47	6.08	0.29	5.64	0.21	5.39	-	-
Total phenols (mg GAE/ 100 g)	10.32	27.41	8.02	25.89	5.57	23.15	-	-
Antioxidant activity (% DPPH scavenging activity)	11.79	21.57	10.98	20.57	10.21	19.46	-	-
AC_1: 100% Amaranth flour biscuit AC_2: 66% AF and 34% CPP								

Similar effects of storage were reported by Antoniewska *et al.* (2018) in muffins made from amaranth, buckwheat and wheat flour blends and Soni (2019) in bakery products made from apple pomace and oat flour.

Microbiological characteristics during storage. Microbial evaluation of amaranth-based cake indicated the absence of growth of micro-organisms at the beginning of storage period (0-day analysis). However, as the storage period progressed, few colonies were observed in the stored product. The cakes became unacceptable at the end of 30 days but were safe for consumption up to 20 days having TPC of 21×10^3 cfu/ mL in AC_1 and 18×10^3 cfu/ mL in AC_2, which was within the safe limits.

DISCUSSION

Some of the important properties when assessing the nutritional quality and stability of baked products during storage are moisture content, crude protein, ash content, crude fat, antioxidant activity and microbial load. This study showed how nutritional characteristics can be significantly affected during storage period of baked products. An increase in moisture content of biscuit during storage was probably because of the hygroscopic nature of the biscuits and the higher moisture content of biscuits containing CPP might be due to high moisture absorbing capacity of fiber present in CPP. Similar increasing trend in moisture during storage of gluten free biscuit prepared by using rice flour, soya flour and BF was reported by Gogoi *et al*. (2020). In contrast, the decrease in moisture content of the cake was noticed during storage, which was probably due to retro-degradation of starch during storage and is greatly affected by the storage temperature and packaging material used. This could be confirmed by results reported by Li (2022) in his study on determination of quality characteristics of sponge cakes made from rice flour. Likewise, the changes in ash content might be correlated to biochemical activities occurring in the product and the decline in fat content of biscuit might be related to hydrolysis of triglycerides during storage or due to oxidation of unsaturated fatty acids with atmospheric oxygen and moisture uptake. A similar decreasing trend in ash and fat content of biscuits during 12 weeks storage was observed in biscuits made from composite flour containing 60 per cent sprouted sorghum flour, 30 per cent soybean flour and 10 per cent finger millet (Kumarasiri *et al*., 2018). Similar observations have also been reported by Nwabueze and Atuonwu (2007) while assessing organoleptic and nutritional properties of wheat biscuits supplemented with African bread fruit seed flour. The decrease in protein during storage may be due to splitting of protein molecules owing to the hydrolysis of peptide bonds by protease enzyme. Similar behaviour of crude protein was observed by Nwabueze and Atuonwu (2007) in African bread fruit seeds incorporated biscuits which confirm our findings.

An increment in total sugars during storage was probably due to partial hydrolysis of starch during storage and increment in reducing sugars might be due to the disintegration of polysaccharides to form reducing sugars. Similar trend was found in biscuits incorporated with buckwheat flour in study of Jan *et al*. (2015). DPPH inhibition potential (antioxidant activity) of the products decreased during storage period, which was probably due to oxidative degradation of phytochemicals such as phenols and carotenoids during storage, owing to their heat and light sensitive nature. These results are in accordance with the findings of Slima *et al.* (2022) where comparable decrease in antioxidant activity of cake formulated from *Lepidium sativum* polysaccharide was observed during 15 days storage at room temperature. The loss of carotenoids in the stored product was probably due to heat sensitive nature of carotenoids and their oxidative degradation during storage. Microbial study determined that initially, the pseudocereal based bakery products did not have any microbial contamination. However, as the storage period progressed, few colonies were observed in the stored product. The increase in microbial count might be due to the increase in moisture content during storage. Microbial studies indicated that the biscuits stored at room temperature up to 90 days and cake up to 20 days had better stability as the microbial count remained within permissible limits. The findings of Nagi *et al*. (2012) in cereal bran included biscuits and Hussain *et al*. (2018) in barley and buckwheat based cookies were supported our study's findings.

CONCLUSION

This work showed that it is possible to use pseudocereals flour for complete replacement of wheat flour in the preparation of bakery products with improved nutritional and health benefits. Nevertheless, the substitution of carrot pomace in pseudocereal flour improved the nutritional parameters of bakery products as well as their storage stability. In addition it has been observed that minimal changes occurred in nutritional characteristics of pseudocereal based cakes and biscuits during storage study. Furthermore, the use of pseudocereals and carrot pomace in bakery products pursued the objectives of study *i.e*., improving nutritional quality, gluten-free products, special organoleptic characteristics, and storage stability of pseudocereal-based bakery products.

FUTURE SCOPE

Bakery industry is one of the largest growing food industries in the world as their products are consumed by almost all age and economic groups of the society. However, these are rich in fats and sugars and are generally prepared from refined wheat flour leading to various life threatening diseases, if consumed on daily basis. As the consumption of bakery products still remains at rise it is important to generate healthier as well as economic products for the consumers. This can be achieved by preparing these products from high value underutilized grains such as amaranth, buckwheat and quinoa in order to incorporate their high bioactive compounds and nutrients into the products. Moreover, the addition by products such as carrot pomace can provide both a viable economic solution and substantial health aid through its nutritional and functional values. Further, this present research showed that carrot pomace and these underutilized grains can be successfully utilized to improve the overall nutritional profile of bakery products and it also opens an area of exploration on bioactive compounds quantification in by products and under-utlized grains to create novel, value added products for the emerging market in future times.

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