Original Research Article

Assessment of microbial and physicochemical properties of pasta prepared using buckwheat, chickpea flour

Abstract

Exploring beyond traditional varieties, the present study focused on innovative approaches to pasta production, with a particular emphasis on the utilization of alternative ingredients and novel processing techniques. The pasta using buckwheat and chickpea flourwas prepared and analyzed with respect to storage and packaging conditions for optimal targeting cold pasta extrudates. Therefore, the developed pasta extrudates from buckwheat, chickpea and xanthan gum were packed in two different packaging materials viz; low density polypropylene (LDPE) and Aluminium laminate (AL) and kept under ambient and accelerated conditions for a storage period of 90 days. All the samples were evaluated for moisture content, free fatty acids, water activity (a_w), sensory analysis and total plate count (TPC) and found that in both the packaging materials , effect of moisture content increased significantly ($p<0.05$) from 5.71 % to 7.31 % in LDPE and 5.71 % to 6.35 % in Aluminium laminate. Water activity also showed significant ($p<0.05$) increase from 0.33 to 0.49 in LDPE and 0.33 to 0.47 in AL.

Keywords: Buckwheat, chickpea, xanthan gum , pasta , LDPE, Aluminium laminates, storage stability

1. Introduction

In today's scenario, food being the most demanding and challenging sector in terms of value addition which refers to the process of enhancing the nutritional content, taste, shelf life and appeal of food products will remain in continuation in future as well because of the drastic changes in the economic status of people and more concern with their diet and nutrition. Value addition utilizes the advanced techniques like high pressure processing or freeze drying, extrusion technology in order to improve the texture, nutritional profile and overall quality of food products. Among various value-added products of different food groups, especially in cereals and pulses, snacks and pasta are the most acceptable products in children and adultsgaining popularity being rich in nutritive value and ability to provide a choice of variety of food products for diabetic and cealic patients (Rawat et al., 2023).

Buckwheat (Fagopyrum *esculentum*) is a pseudocereal from the family Polygonaceae as it resembles cereal (Aufhammer, 2000). In Hindi and local language, buckwheat is named as *"Kutu Ka Aatta"*. It is an ancient crop of India and is commonly cultivated in the Himalayan region from Jammu and Kashmir to Arunachal Pradesh. It bears neutraceutical properties and due to which its incorporation into food products is gaining popularity in the development of healthy and nutritious food products (Woo et al., 2016). Buckwheat is being used for the development of bread, cookies, pies, pancakes and macaroni products (Haros and Sanz- Penella, 2017).On the other hand, raw buckwheat groats have been reported to contain 33.5% resistant starch, because of which it is considered to be a good source to develop a value added food product with low glycemic index. About 30% buckwheat flour in combination with other flours offers best results for the preparation of biscuits, girdle cakes, cracknuts, pancakes and noodles with low glycemic index (Sofi et al., 2023). Chickpea (Cicer *arietinum.* L) is the third most important pulse crop rich in protein content, dietary fiber, essential minerals, vitamins and have low glycemic index. Intake of chickpea proves beneficial effects in terms of lowering the glucose level, cardio-vascular diseases, cancer, hypertension, cholesterol (Begum et al. 2023). These beneficial effects can be better utilized for the development oflow cost food products for overall good health (Meng et al. 2010). The positive effects of its incorporation further supported by the study made by (Wang et al., 2019) exploring the physical, functional and nutritional properties of extruded chickpea based products. The development of instant ready to eat chickpea snacks prepared by extrusion cooking ideally exhibit the optimum characteristics. Xanthan gum, CMC, tragacanth, and other gums have been studied as additives to control moisture content, texture, and porosity in gluten-free pasta products (Ahmed et al., 2024; Squeo et al., 2021). Gums and thickeners such as CMC and guar gum helps in thickening, gelling, improving water holding capacity, texture (Jayakody et., 2023) and also overall acceptability in the development of healthy pasta. The incorporation of fiber –rich ingredients enhances the nutritive value of pasta. These additives play a vital role in enhancing the sensory and textural attributes of gluten-free pasta (Gao et al., 2018). Premalatha et al. (2010) studied the changes in chemical constituents of high fiber noodles packed in different packaging materials analyzed periodically during the storage period of 180 days and found that moisture content increased gradually. There was gradual loss of proteins predominantly from 90 days of storage. Also, a very slight reduction in fat content was noted after 180 days of storage in all the treatments of noodles. Process variables, such as ingredient concentrations (buckwheat, chickpea, and xanthan gum), significantly influence pasta quality attributes like glycemic index, glycemic load, resistant starch, solid gruel loss, and cooking time. Incorporation of buckwheat, chickpea and xanthan gum in the pasta formulation can serve as a better option for developing pasta with shelf stability. Cold extrusion involves the process of shaping raw materials at a temperature below 100 ^{0}C by applying compressive forces. Thus, it enables the development of pasta with varied choice of shapes with high precision and consistency. The dough is passed through an extruder where it is forced through dies with desired shapes (Anjali et al., 2016). Cold extrusion act as a suitable way for the production of gluten free pasta by maintaining the integrity of dough. It also provides an efficient alternative of incorporating the choice of different ingredients such as spinach, amaranth, beetroot, and also allows the addition of flavours including herbs, spices in improving the taste of pasta.The aim of the present study was to developbuckwheat and chickpea flour based pasta using xanthan gum as a additive and determine its storage stability.

2. Material and Methods

2.1 Raw materials and sample preparation

Buckwheat (Fagopyrum *esculentum*) and chickpea (Cicer *arietinum*) grains were washed and sundried for 5 days for 7-8 hours per day to sun. Sorting was done to remove the unwanted particles.The dried and cleaned samples were then ground into flour in mill so that they can pass through 200 µ sieve. The flour obtained was kept in an airtight container until further use.

2.2 Preparation of pasta

The pasta was prepared with buckwheat, chickpea flours and xanthan gum using a cold extruder (Pasta and Noodle Maker, Model 16009 Make, Kent). Water and salt concentration were kept constant at 40% and 1.5%, respectively (as per the method suggested by Solta-Civelek et al., 2019).

Blending

↓

Optimum water

↓

Mixing (10 min.)

↓

Extrusion

↓

Cutting (into desired shape)

↓

Drying (40-50ºC, 5-6% moisture)

↓

Dried product → packaging

Figure 1. Flow sheet for preparation of Pasta

2.3 Water activity

Water activity is free or available water in the food that supports microbial growth. The sample was filled (3/4th) in a cup of water activity meter. Instrument was calibrated as perthe instruction manual calibration. Sample was kept in a cup till constant reading wasobtained (Jalgaonkar et al., 2017).

2.4 Moisture content

The moisture content was determined by using an electronic moisture analyzer (Citizen MB 50 C). 2 g of sample was placed on an aluminium sample holder and inserted into the analyzer. The sample was heated to 105 ^{0}C and the evaporative moisture losses were automatically calculated as percent of moisture content (Jalgaonkar et al., 2017).

2.5 Free fatty acids

Standard AOAC procedure wasfollowedfor determination of freefattyacids(FFA)in pasta extrudates duringstorage. 5gsamplewastakeninaflasktowhich 50 ml benzenewasaddedandkept for 30minforextractionofFFA. 5 ml extract, 5-ml benzene, 10 ml alcohol,andphenolphthalein as indicatorsweretakeninaflaskandtitrated against0.02N, KOHtillcolourdisappeared (Allai et al., 2022). TheFFAvaluewascalculatedbyusingthefollowingequation:

$$\text{FFA (as oleic acid)} = \frac{282 \text{x} 0.02 \text{ N KOH x ml of alkali x D.F}}{1000 \text{ x weight of sample (g)}} \text{x } 100 \qquad (1)$$

2.6 Total plate count

Total plate count was determined according to the standard method of Palczar and Chan (1993). One gram (1 g) of sample was placed aseptically into a test tube containing 9 ml of sterile water and vigorously mixed. After mixing, 1 ml of the mixture was transferred to a test tube containing 9 ml sterile water for further dilution. The procedure was repeated until the sixth dilution (10^{-6}). Spread plating technique was used to inoculate nutrient agar (NA) with 0.1 ml of diluted sample (10^{-6}) and incubate at 37^{0}C for 24 hours. The colonies were enumerated and multiplied by the dilution factor. The results of total plate count were expressed as log colony forming unit (log cfu) of sample.

$$\text{Microbial load} = N \times \frac{1}{V} \times D$$

Where,

N= No. of colonies counted

V= Volume of inoculums

D= Dilution factor

2.7 Sensory evaluation

A sample of cooked pasta extrudates prepared using various formulations was evaluated with an experienced and pre-trained panel of 10 judges of age group between 21-55 years including faculty members, research scholars and students. The panel has been asked to evaluate the pasta extrudates for the parameters such as appearance, color, texture, taste, and overall acceptability). For such case, 9-point hedonic scale with extreme values i.e., 1 and 9 indicating dislike and like extremely respectively.

3. Results and Discussion

The developed pasta from buckwheat, chickpea flour and xanthan gum were packed in two different packaging materials *viz.* Low-density polypropylene (LDPE) and Aluminium laminate (AL) and kept under ambient and accelerated conditions for a storage period of 90 days. The stored samples were evaluated for moisture content, water activity, free fatty acid (FFA), total plate count (TPC) and Sensory Analysis, every 30 days Significant effect ($p<0.05$) of both the packaging materials LDPE and HDPE as well as the storage period was recorded for the all the parameters *viz*. moisture content, water activity (a_w), free fatty acids, sensory analysis and total plate count (TPC) of developed pasta product.

3.1 Moisture content (%) of extrudates

Water activity and moisture content are considered as crucial factors for determining the storage life of pasta products. In both the packaging materials the effect of moisture content increased significantly ($p<0.05$) from 5.71 % to 7.31 % in LDPE and 5.71 % to 6.35 % in AL at ambient conditions whereas, at accelerated conditions, significant increase of moisture content was found in LDPE from 5.71 % to 7.98% as compared to AL (5.71 % to 7.11). Being hygroscopic in nature, moisture is gained by the pasta which depends upon the storage conditions and type of packaging material used. Relatively lesser moisture gain was found in pasta due to good barrier protection of Aluminium laminates (Kamble et al., 2020)(Table 1).

Table 1. Effect of storage conditions and packaging materials on moisture content of pasta

Storage period	**Ambient**		**Accelerated**	
	LDPE	**AL**	**LDPE**	**AL**
0 day	5.71 ± 0.75	5.71 ± 0.75	5.71 ± 0.75	5.71 ± 0.75
30 days	6.01 ± 0.07	5.91 ± 0.04	6.36 ± 0.02	6.15 ± 0.05
60 days	6.93 ± 0.12	6.12 ± 0.09	7.06 ± 0.05	6.91 ± 0.08
90 days	7.31 ± 0.15	6.35 ± 0.12	7.98 ± 0.11	7.11 ± 0.10

Values are shown as mean ± standard deviation

LDPE, Low density polyethylene; AL, Aluminium laminate

3.2 Water activity

Water activity showed significant ($p<0.05$) increase from 0.33 to 0.49 in LDPE and 0.33 to 0.40 in AL at ambient conditions and at accelerated conditions, water activity increases from 0.33 to 0.45 in LDPE and 0.33 to 0.47 in AL (Table 2). Water activity values recorded towards the end of storage period demonstrate that developed product was stable from microbial deterioration.

Table 2.Effect of storage conditions and packaging materials on water activity of pasta

Storage period	Ambient		Accelerated	
	LDPE	**AL**	**LDPE**	**AL**
0 day	0.33 ± 0.02	0.33 ± 0.02	0.33 ± 0.02	0.33 ± 0.02
30 days	0.38 ± 0.01	0.35 ± 0.02	0.39 ± 0.02	0.0.36 ± 0.05
60 days	0.41 ± 0.03	0.38 ± 0.01	0.43 ± 0.0	0.41 ± 0.08
90 days	0.49 ± 0.03	0.40 ± 0.03	0.45 ± 0.11	0.47 ± 0.10

3.3 Free fatty acid

During storage, free fatty acid (FFA) content showed a significant ($p<0.05$) increase, from 0.120% to 0.30% in LDPE and 0.25 % in AL pouches at ambient conditions. FFA increased significantly from 0.12 to 0.34% and in LDPE and 0.27 % in AL pouches at accelerated conditions (Table 3).The increase in free fatty acid content during storage is due to hydrolysis of lipids (Dussert et al., 2006). FFA values recorded in this study at the end of storage period were within the permissible limits of FAO (1986) in processed products. Naseer*et al*. (2021) reported that rancidity test becomes noticeable, when FFA exceeds 1 %.

Table 3.Effect of storage conditions and packaging materials on free fatty acids of pasta

Storage period	Ambient		Accelerated	
	LDPE	**AL**	**LDPE**	**AL**
0 day	0.12 ± 0.12	0.12 ± 0.12	0.12 ± 0.12	0.12 ± 0.12
30 days	0.20 ± 0.11	0.16 ± 0.09	0.23 ± 0.08	0.19 ± 0.10
60 days	0.240 ± 0.16	0.20 ± 0.11	0.31 ± 0.09	0.22 ± 0.12
90 days	0.30 ± 0.19			

		0.25 ± 0.14	0.34 ± 0.21	0.27 ± 0.17

3.4 **Total plate count**

Total plate count was too few to count (TFTC) for extrudates stored at ambient and accelerated conditions in LDPE and Al until 120 days of storage (Table 4). However, at 90th days of storage, total plate count was recorded as 0.81 × 10^2 cfu/g for extrudates packed and stored at ambient conditions in LDPE and 0.52 × 10^2cfu/g in AL. For snacks stored at accelerated conditions in LDPE was recorded as 0.99 × 10^2 cfu/g and 0.61 × 10^2cfu/g in AL till the end of storage period. Furthermore, at the end of storage period, the TPC recorded in pasta products was within the safe limits of 50,000 prescribed by Indian standard for high protein extrudates (Nagi *et al*., 2012).

Table 4.Effect of storage conditions and packaging materials on total plate count (cfu/g) (×10^2**) of pasta**

Storage period	**Ambient**		**Accelerated**	
	LDPE	**AL**	**LDPE**	**AL**
0 day	ND	ND	ND	ND
30 days	ND	ND	ND	ND
60 days	ND	ND	ND	ND
90 days	0.81 ± 0.02	0.52 ± 0.01	0.99 ± 0.04	0.61 ± 0.01

ND: Not detected

3.5 Effect of storage on sensory evaluation (Overall acceptability) of extrudates.

During storage significant ($p<0.05$) changes were recorded for overall acceptability (OAA) of pasta products packed and stored in LDPE and AL respectively (Table 5). Overall Accessibility decreased from 8.23 to 6.54 for pasta products packed in LDPE and 8.28 to 7.35 for developed products packed in AL, respectively. The decrease in OAA could be attributed to colour deterioration during storage. At the same time, the moisture gain during storage may have decreased the crispness of pasta. Due to permeation of air through the packaging material, lipid hydrolysis may have taken place in pasta, which possibly reduced the flavor and mouthfeel scores of pasta products after 30 days of storage period (Jalgaonkar et al., 2017). Since OAA were determined from other sensory attributes, therefore, the decrease in these sensory attributes may have led to decrease in OAA as well. At the end of storage period, OAA was recorded as 7.35, which indicated that the developed product was liked moderately even after 90 days of storage.

Table5. Effect of storage conditions and packaging materials on over all acceptability of pasta.

Storage period	Ambient		Accelerated	
	LDPE	AL	LDPE	AL
0 day	8.23±0.23	8.23±0.23	8.23±0.23	8.23±0.23
30 days	8.0 ± 0.19	8.13 ± 0.21	7.99 ± 0.17	8.02 ± 0.17
60 days	7.23 ± 0.23	7.89 ± 0.20	7.01 ± 0.19	7.21 ± 0.16
90 days	6.54 ± 0.18	7.35 ± 0.17	6.09 ± 0.12	6.21 ± 0.17

4. Conclusion

In conclusion, the present research investigated the effect of storage and packaging conditions on the quality attributes of cold pasta extrudates made from buckwheat, chickpea, and xanthan gum. It has been demonstrated that both packaging materials, low density polypropylene (LDPE) and Aluminium laminate (AL), influenced the moisture content and water activity of the pasta significantly over a 90-day storage period under ambient and accelerated conditions suggesting a potential compromise in the product's shelf stability. Furthermore, the sensory analysis and total plate count (TPC) provided valuable insights into the overall quality and microbial safety of the pasta samples. These analyses contribute to understanding the acceptability and microbiological safety of the product during storage. Thus, the research underscores the importance of selecting appropriate packaging materials and storage conditions to maintain the quality and safety of buckwheat and chickpea flour-based pasta extrudates.

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