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Effect of Different Packaging Materials on Storage Quality of Grain Amaranth Based Pasta

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***Abstract*:** The purpose of this study was to observe the effect of packing material and storage duration affected the qualitative features of pasta prepared from grain amaranth flour and amaranth leaf powder by extrusion. The developed extrudates were packed in 50 µm metalized polyester covers and kept at room temperature for three months to study storage induced changes in quality attributes such as moisture content, colour, sensory, texture, and microbial properties, with all quality parameters analyzed every 15 days. The moisture content and L* value dropped with time. The a* and b* values, on the other hand, were raised during storage. The hardness value of the pasta grew considerably with time when compared to the cohesiveness, springiness, gumminess, and chewiness. TPC of the pasta was enhanced with time in which yeast, mould, and E-coli development was not observed until 45 days of incubation. As the storage period progressed, there was a consistent and noticeable increase in deteriorative quality parameters. This indicates that the extrudates underwent a gradual decline in their overall quality over time. Despite these changes, the pasta remained within an acceptable range for consumption for duration of up to 45 days of storage.

***Keywords*:** Pasta, Storage quality, Packaging material, Amaranth

Recently, pasta has emerged among the trending foods in India with the consumption rate growing at a rapid pace. There are more than 30 pasta brands available in the country (Anonymous 2016), and most of them are made of durum wheat (*Triticum durum*) semolina, which contains gluten protein. The disorders related to gluten namely, celiac disease, wheat allergy, and non-celiac gluten sensitivity are becoming an epidemiological phenomenon with a global prevalence of about 5 per cent (Elli et al 2015) deficiencies of essential micronutrient ions or excesses of toxic ions are of concern in wheat (Abecassis et al 2000). Hence, research efforts are continuing on replacing wheat either fully or partially in pasta and similar products. Many studies targeted the improvement of pasta quality by mainly focusing on replacing the gluten network in pasta by additives and texturizing ingredients and components that enhance the nutritional value or exert a beneficial effect on health. Several authors have attempted fortification of pasta by partially or completely substituting durum wheat with diverse sources such as legume flours, dietary fibres and protein isolate with the purpose of improving the nutritional content of pasta. Pasta made with these flours could be a good diet option for persons on a low-calorie diet. The present study was aimed to evaluate the qualitative changes in grain amaranth based pasta at ambient condition. Various deterioration indicators of food products as moisture content, colour values, microbial load, textural properties and sensory quality were determined as a function of storage period.

MATERIAL AND METHODS

Raw material: The main raw materials used for the development of extruded product were grain amaranth flour and amaranth leaf powder (ALP). Amaranth flour was prepared by using domestic grain pulverizer. Amaranth leaf powder was prepared by drying clean and blanched leaves (70-100°C, <5 min) in a dehydrator unit at 45°C for 6-8 hours and fine powder of dried leaves were made using kitchen grinder.

Pasta product manufacture: The amaranth based pasta products were manufactured by following the systematic procedure (Nagi et al 2012). The sieved (BS 44 mesh size) amaranth flour and amaranth leaf powder were first blended in the extruder for 5 min and then kneaded for about 45 min after adding required quantity of water. When the dough characteristics was optimum, it was extruded using appropriate 'dies' (in all the available shapes i.e., macaroni, ribbed tube, twisted ribbons). The cutter speed was set to optimum level and then dried in a tray drier at 50°C for about 3 hours. The dried pasta was then packed in metalized polyester bags (50µ), heat sealed and stored at ambient

conditions. The complete flow chart for the production of Amaranth based cold extruded ready-to-cook pasta (Fig. 1).

Storage stability of pasta: Storage analysis of pasta sample was carried out by packaging in metalized polyester (50 µm) packaging material and stored at ambient conditions (temperature: 24±3°C; relative humidity: 65.2±12%). Analyses of moisture content, colour, sensory evaluation, textural properties and microbial analysis were conducted for every 15 days' interval during the three-month storage period.

Moisture content (%): Five grams of samples in triplicates were dried in a clean, dry and pre-weighed moisture dish at 105± 2°C for 24 hours were dried to constant weight in an oven, cooled in the desiccators and weighed (Hall 1957). The moisture loss was calculated and expressed in percentage.

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

Where, W_1 and W_2 = Initial & Final weight of the sample, g

Instrumental color analysis: Tri-stimulus colour measurements of the samples was made using a Spectrophotometer (Make: Konica Minolta Instrument, Osaka, Japan; Model-CM5). The colour of the sample was measured in *L* a* b** coordinate system where *L** indicated lightness of the sample; *a** value indicated greenness (-) or redness (+) of the sample; and *b** value indicated blueness (-) or yellowness (+) of the sample.

Textural properties: Textural properties of cooked pasta were measured using the Texture Analyzer (Make: Stable Microsystems Ltd, UK; Model –HD_i)) equipped with a metal blade probe (25 mm). Texture analyzer settings used were: Mode: return to start; pre-test speed: 1.0 mm/s; test speed: 1.0 mm/s; post-test speed: 10.0 mm/s; distance: 12 mm; data acquisition rate: 200 pps. From the TPA curve, hardness (maximum peak force during the first compression).

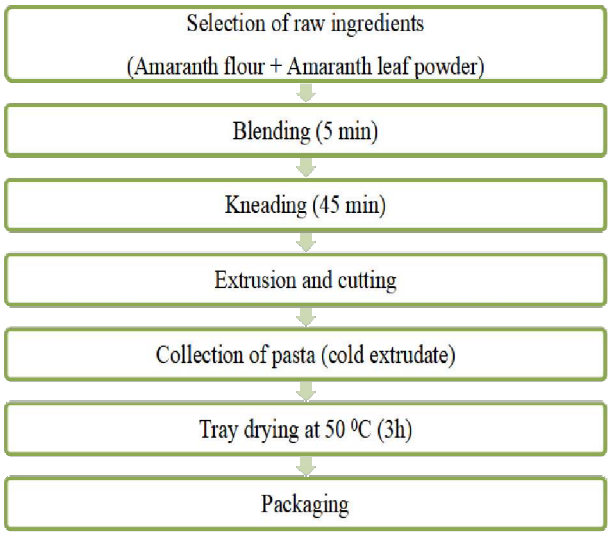

Fig. 1. Process flow chart for production of pasta products

Sensory evaluation: Sensory evaluation of the pasta product was carried out by a panel of ten members. The products was evaluated for individual characters as colour, texture, taste, flavor and overall acceptability using a 9-point hedonic scale, where 9=Like extremely, 8=Like very much, 7=Like moderately, 6=Like slightly, 5=Neither like nor dislike, 4=Dislike slightly, 3=Dislike moderately, 2=Dislike very much, 1=Dislike extremely (Ranganna 1986, Rathi et al 2004).

Microbial analysis: Prepared pasta samples were subjected to microbial analysis in terms of total plate counts (TPC) and yeast and mold count (YMC) and *E. coli*. For determination of total plate count, nutrient agar media was used. YEPD agar media was used for yeast, Potato dextrose agar media was used for mold count and EMB agar media was used for coli forms. The microbial study was conducted under a sterile environment using laminar airflow. The microbial load of the pasta samples was determined initially and after every 15 days of storage interval up to three months. The microbial growth was shown as CFU/g of the sample weight.

Pour plate technique was used to determine the microbial load of samples. One gram of sample was added to 9 ml sterile distilled water and mixed thoroughly for the first dilution i.e., $1/10^{th}$concentration of origin sample. Subsequent dilution was obtained by transferring 1ml of previous dilution to 9 ml of sterile distilled water solution in cotton plugged test tubes. The samples were serially diluted up to 10^{-1}-$10^{-2}$for yeast and mold, 10^{-3}-$10^{-4}$for TPC and 10^{0}-10^{-1} for *E. Coli*. 1 ml of appropriate dilution was inoculated into sterile petri-dishes and molten agar media was added and left to solidify. The petri-plates with samples were allowed to cool and then, placed in an incubation period of 27±2 hr at 37℃ for TPC, 48 hr at 37 ℃ for coli forms, 70-90 hr at 30°C for yeast and mold growth. After incubation period, counts of visible colonies were recorded.

Statistical analysis: Statistical analysis of experimental data was done using OPSTAT software.

RESULTS AND DISCUSSION

Moisture content of extrudates: As per the Indian standard [BIS: 1485-(2010)], the moisture content of pasta should not be more than 12 per cent. During the storage period, a consistent increase in moisture content of pasta was recorded, but was limited within 12 per cent. Initially, the moisture content was about 6.73 per cent (w.b) (Table 1). During the storage period, a steady increase in moisture

content of pasta sample was recorded. It increased from 6.73 to 9.73 per cent at the end of three months of storage period. The storage period and packaging material had significant effect on the moisture content of pasta.

This rise in moisture content was due to hygroscopic nature of the extruded product which resulted in the increase in moisture content of the product during storage period (Kocherla et al 2012). This rise in moisture content is attributed to the migration of water vapors inside the packaging material from the storage atmosphere (temperature and relative humidity changes) (Nagi et al 2012). Butt et al (2004) observed increase in moisture content of breakfast cereals during a storage period of 6 months and in barnyard millet cookies (Surekha et al 2013). Gull et al (2017) observed that for millet fortified pasta samples stored in LDPE and BOPP pouches at accelerated temperature, significant increase in moisture content was observed during the 6-months storage study. Jalgaonkar et al (2017) have reported an increase in the moisture (8.87 -11.90 %) content of pasta samples after six months of accelerated storage (32.95 ± 8.75℃ and 79 ± 19 % RH) in BOPP pouches.

Tri-stimulus color value of extrudate: According to International Commission on Illumination (CIE), *L**, *a**, *b** are the three color coordinates, in which "*L**" represents the lightness (*L** = 0, absolute black/no lightness, *L** = 100 diffuse white), "*a**," varied between negative green to positive red/magenta, and "*b**," corresponds to blueness when negative and yellow when positive score. These color parameters correspond to complete color space or describe all the colors visible to the human eye; therefore, they were designed to use in the form of an independent device model as a reference (Swer et al 2019). The changes in color characteristics of pasta samples were expressed as *L**, *a**, *b** values. It was observed that lightness value (*L**) of pasta samples decreased continuously from 62.77 to 54.63 (Table 1). Both *a** and the *b** value of pasta product increased with storage period indicating that there was a greater change in color of the product with increased storage days the extrudate were significantly affected by both packaging material and storage time individually and their interaction.

The *L** value of the pasta product was decreased significantly with storage time. This decreased lightness scores of pasta products is due to Maillard browning reaction and might be lower barrier properties of packaging material. Similar observations were also reported by Kamble et al (2020) after 4 months storage of multigrain pasta by packaging in HDPE and BOPP films. Redness (*a**) of optimized pasta product increased significantly during a storage period of 3 months. This increased *a** of the products might be the result of the formation of non-enzymatic browning components at the storage time was also observed by Kumar et al (2017) in case of storage study of the cereal-based food product. The yellowness (*b**) of the pasta sample was increased significantly during storage y. This increase in *b** might have been due to the occurrence of non-enzymatic browning. Similarly, Gull et al (2017) found a similar pattern of increase in yellowness score for millet pomace based functional pasta after the storage period of 4 months at accelerated condition (40 ± 1 ℃ and 90 ± 1 % RH).

Sensory characteristics: The storage conditions had a significant effect on the sensory quality of the pasta by judges after 3 months of storage (Table 2). The sensory acceptability of the ready- to- cook pasta product were assessed on each withdrawal for 15-day interval. For optimized pasta sensory score for color, texture, flavor, taste and overall acceptability were rated as 7.90, 7.60, 7.80, 7.60, and 7.70, respectively, at 0 day of storage time. Decreasing trends were observed for all the sensory attributes like color, texture, flavor, taste and overall acceptability at ambient condition.

With increasing storage period, mean sensory scores for overall acceptability of the pasta product declined from 7.7 to 5.3. At the end of the storage period, the sensory scores for colour, texture, flavour, taste and overall acceptability of pasta was rated as 5.8, 4.2, 5.5, 5.8 and 5.3 respectively. The highest average overall acceptability was observed at 0, 1 and 2 months of storage indicated that pasta was acceptable up to 45 days of storage. Decreasing trends were observed for all the sensory attributes like color, taste, texture, appearance and overall acceptability of product during storage. Sensory evaluation of the pasta revealed significant effect of storage period and packaging material on the liking of pasta by the panelists in terms of color, texture, flavor, taste, and overall acceptability. The overall change in the

Table 1. Effect of storage on moisture content and colour values of pasta sample stored in Metalized Polyester (MP) film

Storage period (days)	Moisture content (%)	Mean Tri-stimulus colour value		
		L*	a*	b*
0	6.73 ±0.033	62.77	1.98	19.33
15	6.90 ± 0.058	61.72	2.80	19.57
30	7.63 ±0.033	60.19	3.32	19.98
45	8.03 ± 0.033	59.65	3.98	20.18
60	8.80 ± 0.058	57.80	4.52	20.52
75	9.16 ± 0.033	56.67	4.87	20.85
90	9.73 ± 0.033	54.63	5.33	21.07
CD (p=0.05)	-	0.333	0.084	0.137

L*: Lightness, a*: Greenness or redness, b*: Blueness or yellowness

sensory acceptability of the products could be due to change in color, texture, flavor and taste that contributed more to overall acceptability of the samples. This might be due to the minor biochemical changes (moisture intake, a_w, color, FFA, peroxide and microbial growth) takes place during storage resulted in lowering of sensory scores. Puyed et al (2010) and Shoba et al (2015) also reported that overall acceptability of noodles made from composite flours affected significantly over the storage duration of 4 months, which may be the result of alternative biochemical changes like increase in moisture.

Textural properties of extrudate product: During the entire storage period of three months, hardness values of pasta stored in metalized polyester packaging film was varied from 11.83 to 10.64 N (Table 3). Textural attributes decreased with storage period. Both storage period and packaging material individually and their interaction had significant) effect on the textural qualities of pasta during storage up to 90 days. Hardness values decreased with increase in the storage days. This may be due to moisture intake of the product from the storage environment. Moisture migration and redistribution, product composition, physical changes of the main components and the interactions between them which become highly heterogeneous and exhibits significant effect on product texture Wang et al (2002). Similar results were reported by Charunuch et al (2008) in rice snacks stored for four month. Variation in the texture of the pasta products during storage may be attributed to the variation in gluten strength as it is reduced due to the substitution of different flours. Incorporation of fibre rich flours exhibit decreased textural attributes as they have high affinity for water. Similarly, Krishnan and Prabhasankar (2010) also reported the same results in pastas incorporated with sprouted finger millet and green banana flours.

Microbial load: Microbial quality of optimized pasta sample was analyzed in terms of TPC and yeast mold count during storage at ambient conditions (Table 4). The packaging material and storage environment had a significant influence on the TPC of pasta samples. During the storage period of three months, bacteria, yeast and mold were detected and *E.coli* was absent . Bacterial count were in the range of 0.3×10^4 to 4.3×10^4 CFU/g. Yeast count were increased from 60^{th} day of storage period in the range of 0.6×10^1 to 3×10^1 CFU/g and mould count were increased from 75^{th} day of storage period in the range of 1.3×10^1 to 2.6×10^1 CFU/g. bacterial count and fungal count be increased with storage days. The packaging material and storage time significantly affects the product quality. The TPC load of the pasta kept in

Table 2. Effect of storage on sensory scores of pasta sample stored in metalized polyester film

Storage period (days)	Colour and appearance	Texture/mouth feel	Flavor/aroma	Taste	Overall acceptability
0	7.9	7.6	7.8	7.6	7.7
15	7.6	7.4	7.6	7.6	7.5
30	7.4	6.7	7.2	7.1	7.1
45	7.2	6.5	7.0	7.0	7.0
60	6.4	5.1	7.0	6.5	6.3
75	6.0	4.6	6.4	6.2	5.9
90	5.8	4.2	5.5	5.8	5.3
CD (p=0.05)	0.26	0.26	0.28	0.28	0.20

Table 3. Effect of storage on textural characteristics of pasta sample stored in metalized polyester film

Storage period (Days)	Hardness (N)	Cohesiveness	Springiness (mm)	Gumminess (N)	Chewiness (N.mm)
0	11.83	0.60	1.23	6.01	6.27
15	11.65	0.61	1.21	6.11	6.15
30	11.52	0.62	1.17	6.27	6.17
45	11.46	0.63	1.19	6.40	6.45
60	10.97	0.64	1.20	6.45	6.36
75	10.85	0.60	1.17	5.95	6.27
90	10.64	0.61	1.26	5.98	6.45
CD (p=0.05)	0.01	0.02	0.02	0.02	0.02

Table 4. Effect of storage on microbial load of pasta sample stored in metalized polyester film

Storage period (days)	Total plate count (10^4 CFU/g)	Yeast (10^1 CFU/g)	Mold (10^1 CFU/g)	*E. coli* (10^0 CFU/g)
0	0.3	ND	ND	ND
15	1.3	ND	ND	ND
30	2.0	ND	ND	ND
45	2.6	ND	ND	ND
60	3.3	0.6	ND	ND
75	4.0	2.3	1.3	ND
90	4.3	3.0	2.6	ND
CD (p=0.05)	0.28	0.11	0.06	-

ND: Not detected

metalized polyester pouches at ambient storage conditions increased significantly from 0.3×10^4 to 4.3×10^4 CFU/g. This higher bacterial count could be due to the adverse conditions of storage environment (temperature and relative humidity), which facilities the rapid entry of moisture inside the pasta sample and subsequently enhance the bacterial count of product. Kamble et al (2020) in multigrain pasta products reported a significant increase in TPC that might be due to higher moisture and water activity of the products during storage. Other researchers also specified increasing trends of TPC during the storage study of food products (Yadav et al 2014, Verma et al 2015, Gull et al 2017). The fungal count of stored pasta increased more rapidly under ambient conditions (25°C – 28°C). This may be due to yeast and molds grow luxuriantly at an optimum temperature of around 25°C – 37°C. Hence, the microbial load of the packed pasta samples was satisfactory up to 2 months of storage. Yadav et al (2014) observed in pasta prepared from a blend of wheat, pearl millet with vegetable paste during 90 days storage in polyethylene bags (50 µm) at ambient condition.

CONCLUSION

The quality attributes of the extrudates were significantly influenced by both the packaging material used and the duration of storage. As the storage period progressed, there was a consistent and noticeable increase in deteriorative quality parameters. This indicates that the extrudates underwent a gradual decline in their overall quality over time. Specifically, there was an observed rise in moisture content and total plate count (TPC), which are indicative of potential spoilage and microbial growth. In contrast, the color parameter, sensory scores, and textural properties exhibited a reduction, suggesting a decline in visual appeal, taste, and overall texture. Despite these changes, the pasta remained within an acceptable range for consumption for duration of up to 45 days of storage.

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