

Original Research Article

Nutrient-Rich Red Rice-Based Pasta: Formulation, Processing and Comprehensive Nutritional Analysis

ABSTRACT

Modern Food industry is searching for food products with high nutritional value with great taste to satisfy the consumer needs. Red rice with good number of micronutrients and anti-oxidants properties is one such food to satisfy consumer's needs. A cold extruded products were developed using red rice flour (100 %,90%, 80 %, 70% and 60%) and wheat flour (10%, 20%,30 % and 40%). The blend was cold extruded at optimized extrusion conditions and the resultant pastaproducs were assessed for their sensory and cooking characteristics. Pastaincorporated with 60 percent of red rice flour with 40% percent of wheat flour had optimum cooking characteristics and adjudged as best compared to other levels of incorporation. The cooking studies of optimized product showed that cooking time of 6.15 min, swelling power of 1.46 gg⁻¹ and solid loss was found to be 9.94 per cent. The optimized product found to has 79.43 per cent of carbohydrate, 10.15 per cent of crude protein, 7.21 per cent of moisture, 1.52 per cent of crude fat, 1.93 per cent of crude fibre and 1.69 per cent of ash content. Formulation of such food products will add diversity to the diet and could be one of the ways for balancing nutrient deficiency in individuals.

Keywords: *Cooking time, swelling power, pasta, red rice.*

Introduction:

Nearly half of the world's population eats rice (*Oryza sativa* L.), a staple grain that is primarily consumed as a source of protein and carbohydrates. For Asians, rice is a symbol of food and is referred to as the grain of life. It has a medicinal value as well, which was fully understood by the medical systems centuries ago, in addition to being a staple food and an essential component of social rites, rituals, and festivals in practically all Asian countries. The colour of the rice is formed by differences in the genes that regulate the colour of aleurone, the colour of endosperm, and the composition of starch in the endosperm. In general, there are 2 types of rice based on their colour namely white rice and pigmented rice. There are two colours of pigmented rice; one of them is reddish-grain in colour is commonly called as red rice.

The pigmented rice contains phenolic compounds especially anthocyanin that also act as a colour pigment. The anthocyanin compounds in rice are in the form of cyanidin-3-O-glucoside, peonidine-3-O-glucoside and their derivatives (Escribano *et al.*, 2004; Wang *et al.*, 2008). Anthocyanins have been recognized as nutritious functional food ingredients, located in outer layers of the rice kernel which possess antioxidant activity, anticancerous, hypoglycemic and have anti-inflammatory effects. Coloured rice (black and red) consumption is rapidly growing due to their healthy functional food ingredients. However, fortification of this paddy with iron and other micronutrients to prevent malnutrition has to be attempted. This could be an optimal approach to reduce the high prevalence of Iron deficiency anaemia (Cook and Reusser, 1983).

Significant amounts of phenolics, such as anthocyanins, phenolic acids, and procyanidins, are present in red rice (Sompong *et al.*, 2011; Walter and Marchesan, 2011). Red rice contains proanthocyanins, which are single or polymerized units of flavan-3-ols like (+)-catechin and (-)-epicatechin. Proanthocyanins are absorbed in the small intestine differently depending on the degree of polymerization (DP), which impacts their bioactivity (Ou and Gu, 2014). Red rice contains 12.7% of moisture content, 1.81% of fat content, 2.71% of fibre content, 10.49% protein, 70.19% of carbohydrates along with micro nutrients like iron and zinc at 5.5 and 3.3 mg100 g⁻¹ respectively (Raghuvanshi *et al.*, 2017).

Red rice varieties with value added products like fenugreek and salt or sugar have been specially used in increasing milk secretion in lactating mothers. Red parboiled rice is the main staple food of the coastal belt of Southern Karnataka and its neighbouring district of Kerala. Products from red rice such as red rice cake, red rice sauce *etc.*, are available, however pasta from red rice are not yet explored. Development of food products that fulfills the consumer needs is the biggest challenge for food processing industry. Health and wellness are seen as a consumer trend by food formulators. With quick changes in the socio-economic landscape, increased female participation in the workforce, different views toward leisure activities, the time available for planning and cooking meals has drastically decreased. This has given boost to the manufacture and marketing of convenience foods (Kakde *et al.*, 2018).

Considering the importance of the ready to cook (RTC) snacks and the need to develop value added products, this investigation was undertaken to develop pasta product by using red rice flour and whole wheat flour. The present experiment was to develop cold extrudate with high nutritional value by red rice flour. This study aims to assess the impact of blending on physicochemical, texture and sensory attributes of obtained pasta targeting consumer acceptance for convenient food industry

application. The main objective of the present study is to develop Nutrient and mineral rich ready to cook pasta from red rice.

Materials and Methods:

Procurement of raw materials:

The major Raw material, red rice was procured directly from the Regional Cooperative Organic Farmer's Association Federation Limited, Davanagere, Karnataka, India. The other ingredients used in the study like wheat flour, sunflower oil, vegetables, pasta masala mix, salt *etc.*, were procured from a local super market.

Preparation of red rice flour for making cold extrudate:

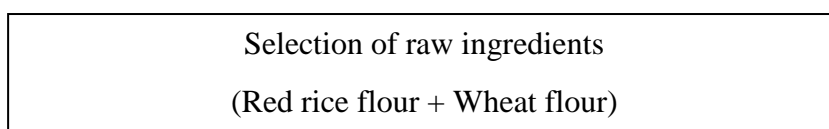
A domestic grain pulverizer was used to mill red rice grains into fine flour. The pulverizer was a complete stainless-steel construction and provided with detachable sieves to facilitate milling of the raw materials into appropriate sized flour. The pulverized flour was further grinded manually using kitchen grinder in order to obtain uniform particle sized flour mix. The flour was mainly used for developing the cold extruded pasta product from red rice after developing pasta it is kept in Dehydrator unit to dry cold extruded products to remove excess moisture content from pasta products.

Description of pasta making machine:

The pasta making machine was used to prepare pasta from red rice flour. It is an automatic and very reliable machine, suitable for working with any kind of flour and durum wheat (semolina) flours. It is powered by a 2.6 hp electrical motor and the rated capacity of this pasta machine was reported to be 25-35 kg hr⁻¹.

Formulation of red rice pasta:

Red rice pasta was standardized using 100%, 90%, 80%, 70% and 60% red rice combined with various levels of whole wheat flour (T₁ to T₄, shown in Table 1). Water was added to moistened the flour and mix was extruded from the Extruder. The procedure followed for preparation of pasta is shown in fig 1. Control pasta was extruded with 100 Per cent whole wheat flour.



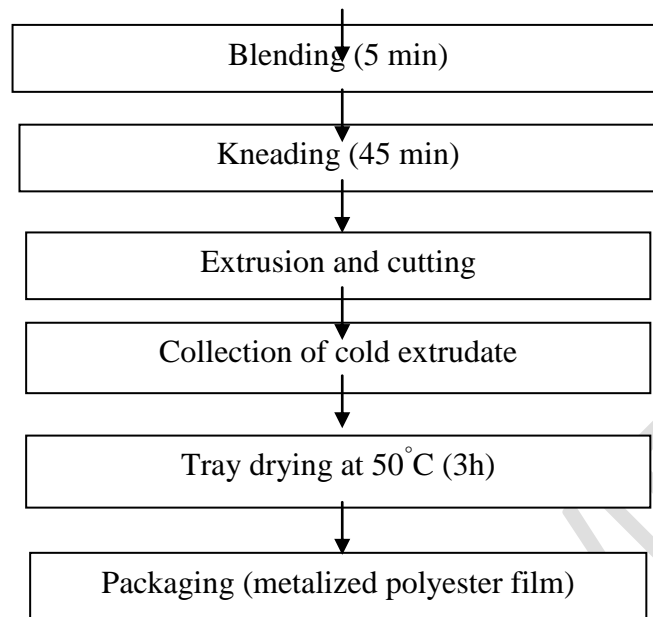


Fig. 1: Process flow chart for the development of pastaproducts

Table 1: Formulations used for the preparation of red rice based ready to cook pasta product:

Formulations	Level of flours in composite blend (RR + WF)		Composite blend (%)	Water (mLkg ⁻¹)
	RR (%)	WF (%)		
T ₁	90	10	100	450
T ₂	80	20	100	450
T ₃	70	30	100	450
T ₄	60	40	100	450

Cooking characteristics like solid loss, optimum cooking time, swelling power, water absorption index and Water solubility index were determined to find out developed pasta cooking quality.

Optimum cooking time: The cold extrudate pasta samples (5 g) were cooked in boiling water (100 mL) over a gas stove. The optimum cooking time of pasta was determined subjectively by pressing the product between fingers periodically at two-minute intervals. When the product was completely soft, the time was noted as optimum cooking time as per Jalgonkaret *al.* (2019).

Swelling power of cold extrudate samples were determined by the method proposed by Schoch (1964).

Solid loss:

Solid loss was determined by cooking pasta samples in boiling water for 20 minutes. After cooking, the cooked material was strained out and the whole filtrate was transferred quantitatively in to a pre-weighed petri dish. It was evaporated over a water bath followed by drying in a hot air oven maintained at $105\pm 2^{\circ}\text{C}$ for 1 hour. The petri dish was weighed again with the dried solids as per Jalgonkaret *al.* (2019). Then, the solid loss was calculated as:

$$\text{Solid loss (\%)} = \frac{m_2 - m_1}{m_0}$$

Where,

m_0 = Initial weight of pasta taken for cooking, g

m_1 = Weight of empty petri dish, g

m_2 = Weight of petri dish with dried solids after evaporation, g

The pasta products were optimally cooked just like regular commercially available pasta and were evaluated for sensory characteristics by a Semi trained panel of 10 members. The judges scored the cooked pasta for colour, texture, taste, flavour and overall acceptability on a 9-point hedonic scale from liked extremely (9) to disliked extremely. For each sample, the average score given by all the judges for different quality characteristics were computed and mean scores were reported.

Proximate composition like moisture content, protein, fat, crude fibre, ash content and for optimized product were determined by the method given by AOAC (1980) and carbohydrates using difference method.

The physical parameters like true density, bulk density, water absorption index, water solubility index were determined using Deshpande and Poshadri (2011), Launay and Lisch (1983), Anderson (1982), respectively and tristimulus colour was determined using spectrophotometer, textural properties were determined using texture analyser.

The optimum ingredient was extruded at optimum process parameters to produce the best nutritive and acceptable red rice based extruded food product was packed in selected packaging material. The developed product was stored in metalized polyester packaging cover ($50\ \mu\text{m}$) for three months. The quality parameters *i.e.*, moisture content, sensory scores, were measured after every fifteen days for a storage period up to three months which is shown in table 2.

Table 2: Experimental plan for storage study for optimized product:

Independent variable	Packaging material • Metalized polyester
Dependent variables	• Moisture content • Sensory quality (Colour, texture, taste, flavour and overall acceptability)
Interval (Storage days)	• 0, 15, 30, 45, 60, 75 and 90

Statistical Analysis:

Statistical analysis of experimental data was done using SPSS and OPSTAT software. The data of experiments were analysed using completely randomized design (CRD) and critical difference (CD) was to determine the significant difference among treatments.

Results and Discussion:

Development of red rice based cold extruded pasta products:

The pasta products were prepared from various formulations of composite flours containing red rice flour and whole wheat flour and extruded under constant extrusion conditions of the cold extruder. The developed pasta samples were evaluated for cooking and sensory characteristics for the optimization of best pasta product.

Cooking and sensory properties of pasta samples:

The developed pasta samples were evaluated for cooking characteristics in terms of cooking time, solid loss, swelling power and Sensory evaluation were assessed to optimization of the best accepted product; the results are shown in Table 3. Cooking characteristics revealed the perfect shape of the pasta samples were not retained by red rice flour as it is gluten free. As a result, in order to improve texture and retain shape during cooking, whole wheat flour at varying levels was added as presented in Table 1(In materials and methods).

Table 3: Cooking characteristics of developed pasta products:

Treatments	Cooking time (min)	Swelling power (gg ⁻¹)	Solid loss (%)
------------	--------------------	------------------------------------	----------------

T ₁	3.20	1.00	15.02
T ₂	4.00	1.09	13.23
T ₃	5.40	1.25	11.20
T ₄	6.15	1.46	9.94
Control	9.40	3.50	6.10
CD @ 5%	0.56	0.17	1.17
S.Em. ±	0.17	0.05	0.36

T₁: Red rice flour (90%): Wheat flour (10%)

T₂: Red rice flour (80%): Wheat flour (20%)

T₃: Red rice flour (70%): Wheat flour (30%)

T₄: Red rice flour (60%): Wheat flour (40%), Control: Whole wheat flour (100%).

Cooking studies revealed that, the swelling power, cooking time, solid loss of each treatment varied with the varying concentration of flour levels. This is due to the cooking process which caused the fibre to absorb more water as fibre content is more in red rice and is reported to have high affinity to water. Solid loss of the pasta products varied with the varying concentration of flour levels. It was observed that, with increasing level of red rice flour and decreasing level wheat flour, cooking loss increased. This might be attributed to the absence of gluten protein in composite blends. As the gluten protein network is responsible for maintaining pasta physical integrity during cooking, a weaker structure leaches more solids from pasta samples into the cooking water, resulting in greater cooking residues (Savita *et al.*, 2013; Gull *et al.*, 2015).

Sensory qualities of developed pasta products:

The sensory quality characteristics which included appearance, colour, texture, flavour, taste and overall acceptability of the pasta products prepared using red rice flour and wheat-based flour formulations were evaluated. The formulations of ingredients (*i.e.*, red rice flour and wheat flour) to be incorporated in pasta was evaluated in two stages namely, preliminary and final stage. During preliminary selection, pasta products made from wider range of concentration of red rice flour (100, 90, 80, 70, 60 and 50 %) incorporated with wheat flour (10, 20, 30 and 40 %) were evaluated in order to know the optimum concentration of flour levels in the composite blend. Colour, texture, flavour, taste and overall acceptability were all evaluated using a 9-point hedonic scale. Fig 2, show the mean scores for all sensory parameters.

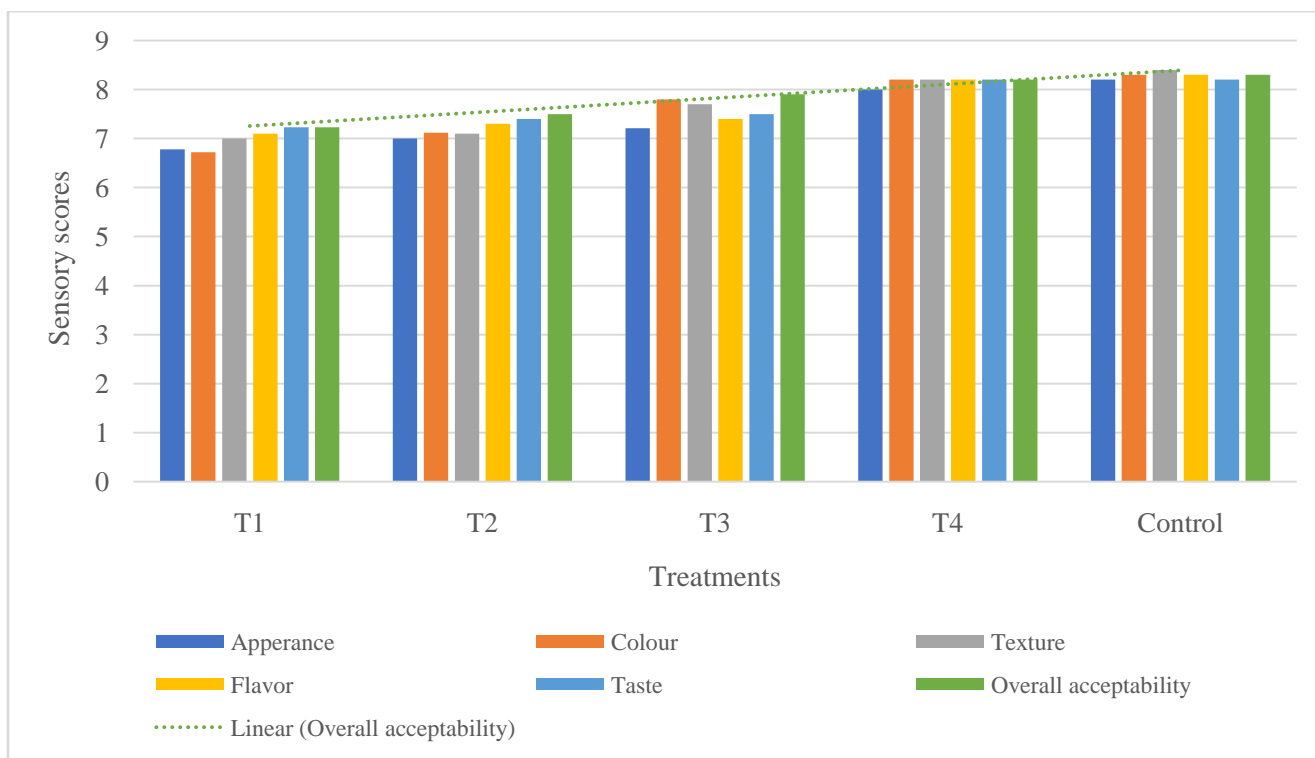


Fig. 2. Sensory scores of developed red rice pasta samples for optimization

T₁: Red rice flour (90%): Wheat flour (10%)

T₂: Red rice flour (80%): Wheat flour (20%)

T₃: Red rice flour (70%): Wheat flour (30%), T₄: Red rice flour (60%): Wheat flour (40%), Control: Whole wheat flour (100%)

Sensory scores for all the treatments look alike, but they vary in cooking characteristics which were depicted in (Fig 2). During final selection (*i.e.*, for optimization) cooking characteristics and organoleptic properties of different flour blends were selected and evaluated. Based on the cooking characteristics and sensory scores, the product was optimized.

Analysis of nutritional and physical properties of the optimized pasta product:

The nutritional composition of optimized red rice pasta product (Treatment-T₄) in terms of moisture content, crude protein, crude fat, crude fibre, total ash and carbohydrates are presented in Table 4.

Physical properties such as density, colour, WAI and WSI of the optimized pasta product is presented in Table 4. It was observed that, the water absorption index and water solubility index of the pasta product were about 0.54 g/g and 0.1 g/g, respectively. The difference in WAI and WSI might be due to the hydrophilic polysaccharides present in their respective flour (Oninawo and Asugo, 2004). Similar observations have been made by Dayakar Rao *et al.* (2015) in case of sorghum pasta blended with wheat semolina, reported that WAI of extrudates increased with an

increase in sorghum semolina in the blend and WSI of the extrudates increased with an increase in wheat semolina in the blend.

Table 4: Proximate composition, physical and functional parameters of optimized red rice-based pasta product:

Parameters	Quantity
Moisture	7.21%
Crude Protein	10.15%
Crude Fat	1.52%
Total ash	1.69%
Crude fibre	1.93%
Carbohydrate	79.43%
True density	1.03 (g/ mL)
Bulk density	0.54 (g/ mL)
Colour	$L^*=68.92, a^*= 5.91, b^*=11.60$
Water absorption index (WAI)	0.54 g/g
Water solubility index (WSI)	0.1 g/g

Textural properties of optimized un cooked red rice pasta product:

The textural characteristics of optimized pasta products are presented in Table 5. The results of Krishnan and Prabhasanka (2010) also depicts the similar kind of values in pastas incorporated with green banana flours and sprouted finger millet.

Table 5: Textural properties of optimized un cooked red rice based cold extruded products:

Parameters	Pasta
Hardness (g)	1711.73
Fracturability (g)	9524.84
Adhesiveness (g. sec)	0
Springiness	0

Storage studies of red rice based optimized pasta product:

The findings of a storage study done on the optimized product, which were kept in a metalized polyester packing film (50 μm) at room temperature for three months are mentioned below.

Effect of packing type on cold extrudates shelf life:

To maximize the shelf life of processed foods, they must have good storage qualities. Food is physically shielded from outside influences by packaging. Therefore, the stability of packing materials is essential for improving food quality and safety as well as extending the shelf life of foods. Therefore, it is crucial to evaluate how the packaging material affected the product's quality characteristics and storage stability.

Packaging type and storage days effects on extrudates properties:

The effects of packaging material on the extrudate characteristics were investigated. The 90-day study on storage stability was conducted in Bengaluru, Karnataka, India, under ambient conditions (at temperature: $24 \pm 3^\circ\text{C}$, humidity: $65.2 \pm 12\%$). The quality of the extruded product was seen to be significantly impacted by storage time and packaging type.

Effect of storage days on moisture content of red rice-based pasta product:

The moisture content of the pasta samples packed in metalized polyester packaging film was determined after every 15 days interval for three months storage period and data are presented in fig 3. Initially, the moisture content was about 7.21 per cent. During the storage period, a steady increase in moisture content was recorded. It was found to be increased from 7.21 to 10.20 per cent at the end of three months of storage period. Analysis of variance for moisture indicated that, packaging material and storage period had significant ($P \leq 0.05$) effect on the moisture content of cold extruded products.

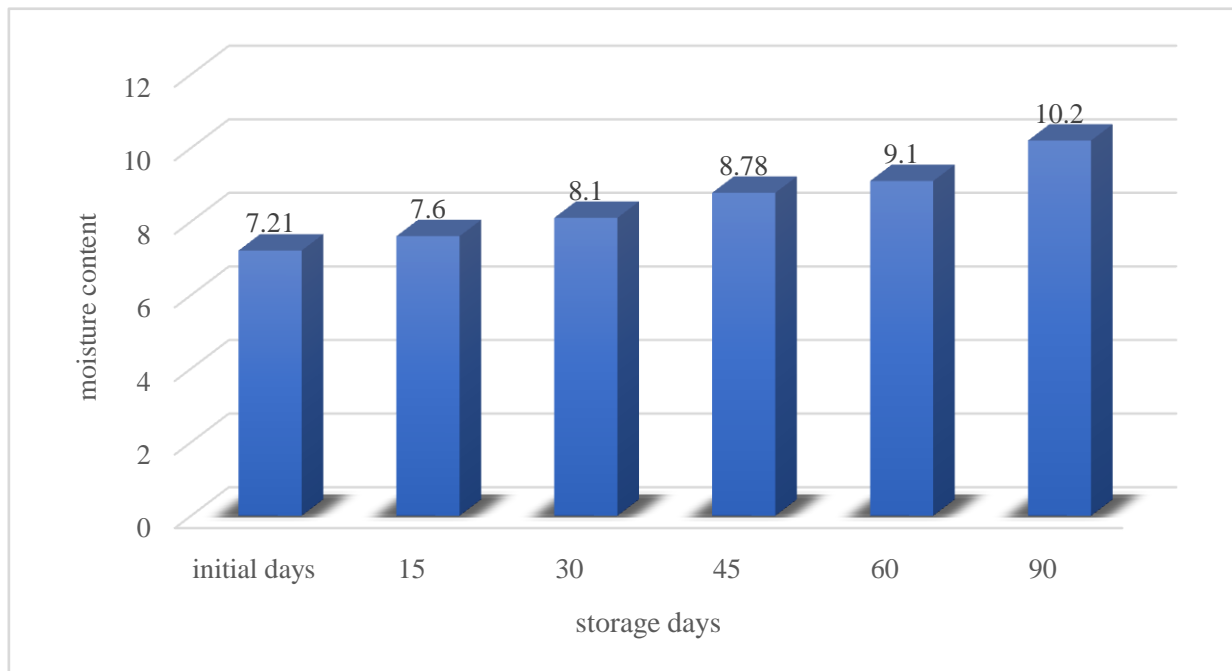


Fig.3. Effect of storage on moisture content of red rice pasta sample stored in metalized polyester film

This rise in moisture content was due to hygroscopic nature of the extruded product which causes an increase in moisture content of the product during storage period (Kocherlaet *et al.*, 2012). Or this might be attributed to the migration of water vapours inside the packaging material from the storage environment (temperature and relative humidity changes) as reported by Nagi *et al.* (2012). Several authors have reported similar patterns of results during storage studies of cereal-based food products in different packaging materials and storage conditions (Amir *et al.*, 2017; Kriti *et al.*, 2017).

Effect of packaging material and storage days on sensory characteristics

The sensory acceptability of the ready-to-cook pasta product were assessed on each withdrawal for 15 days interval and recorded in terms of appearance, colour, flavour, texture/mouth feel, taste and overall acceptability for three months storage period.

Effect of storage on sensory scores of red rice pasta samples stored in metalized polyester film:

The sensory scores for the optimized red rice-based pasta product stored in metalized polyester packaging cover are presented in fig4. It was observed that with increasing storage period, mean sensory scores for overall acceptability of the pasta product declined from 8.20 to 6.80. At the end of the storage period, the sensory scores for appearance, colour, texture, flavour, taste and overall acceptability of cold extruded products were rated as 6.90, 6.80, 6.80, 6.70, 6.60 and 6.80, respectively. The highest average overall acceptability was observed at 0, 1 and 2 months of storage indicated that pasta were acceptable up to two months of storage. Decreasing trends ($p \leq 0.05$) were observed for all the sensory attributes like appearance, colour, taste, texture and overall acceptability of products during storage.

The overall change in the sensory acceptability of the products during storage could be due to change in colour, texture, flavour and taste that contributed more to overall acceptability of the samples. This might be due to the minor biochemical changes (moisture intake, water activity, colour, FFA, peroxide and microbial growth) that took place during storage resulting in lowering of sensory scores.

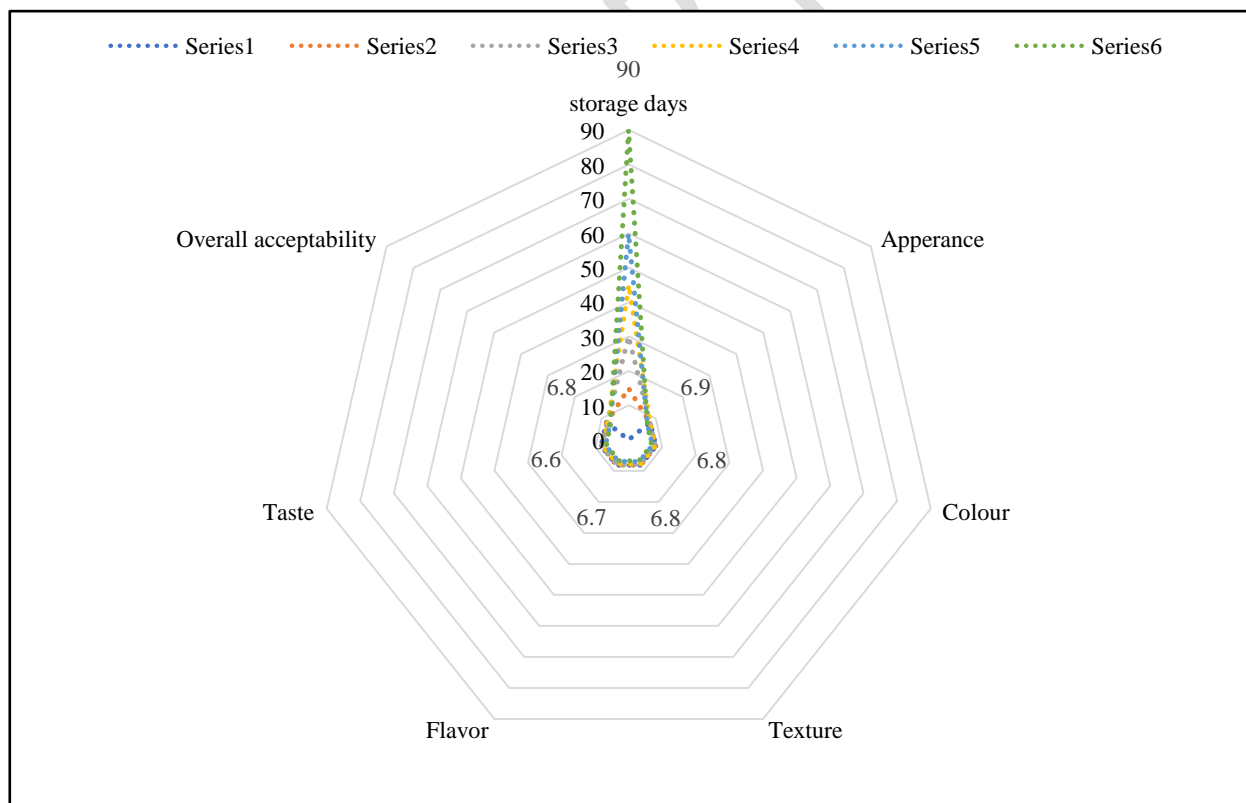


Fig.4. Effect of storage on sensory scores of red rice pasta samples stored in metalized polyester film

Conclusion:

Red rice has numerous important effects on human health, both as a diet and as a medication. With the usage of red rice in the development of ready to cook (RTC) products add variety to the diet and increases its popularity in producing the higher yield of economy with nutrition. RTC products are produced to meet various needs of the population, using a combination of cereals like red rice with the other ingredients can add the higher nutrition in the food products. High protein products can be produced by combining red rice with higher protein sources or preferably with cheaper and more affordable millet sources. Extrusion technology provides many advantages over conventional methods and is one of the most flexible and energy-efficient methods currently offering solutions to the world's hunger and healthy diet.

References:

- Amir Gull, Kamlesh Prasa and Pradyuman Kumar, 2017, Quality changes in functional pasta during storage in two different packaging materials: LDPE and BOPP. *J. Food Process. Preserv.*, 41: 13115.
- Anderson, R. A., 1982, Water absorption and solubility and amylograph characteristics of roll-cooked small grain products. *Cereal chem.*, 59: 265-269.
- AOAC, 1980, Official Methods of Analysis. 13th edition, Association of Official Analytic Chemists, Washington, DC.
- APHA, 1984, Compendium of methods for the microbiological examination of foods (ed. Speck, M.L.). 2nd edn, American Public Health Association, Washington, DC.
- Cook, J.D. and Reusser, M.E., 1983, Iron fortification. *Am J Clin Nutr.*, 38: 648–659.
- Dayakar Rao Benhur, Bhargavi, Kalpana, Vishala, Ganapathy, K. N. and Patil, J. V., 2015, Development and standardization of sorghum pasta using extrusion technology. *J. Food Sci. Technol.*, 52(10): 6828–6833.
- Deshpande, H. and Poshadri, A., 2011, Physical and sensory characteristics of extruded snacks prepared from foxtail millet based composite flours. *Int. Food Res. J.*, 18: 730-735.

- Dinkar B. Kamble, Savita Rani, Rakhi Singh and Barjinder Pal Kaur, 2020, Storage stability and shelf-life prediction of multigrain pasta under different packaging material and storage conditions. *J. Food Process. Preserv.*
- Escribano-Bailon, M.T., Santos-Buelga, C. and Rivas Gonzalo, C., 2004, Anthocyanins In Cereals *J. Chromatogr A*,1054 (1-2): 129-141.
- Gull, A., Prashad, K. and Kumar, P., 2015, Effect of millet flours and carrot pomace on cooking qualities, colour and texture of developed pasta. *J. Food Sci. Technol.*, 63: 470-474.
- Jalgaonkar, K., S. K. Jha, M. K. Mahawar and D. N. Yadav., 2019, Pearl millet-based pasta: Optimization of extrusion process through response surface methodology. *J. Food Sci. Technol.*, 56: 1134-1144.
- Kakde, S. B., Masih, D. and Sonkar, C., 2018, Utilization of moringa leaves powder as valuable food ingredients in pasta preparation. *J. Pharmacogn. Phytochem.*,7 (4): 1053-1056.
- Kirti Jalgaonkar, S. K., Lata Nain and Mir Asif Iquebal, 2017, Quality changes in pearl millet-based pasta during storage in flexible packaging. *J. Agric. Eng.*,54 (3): 22-31.
- Kocherla, P., Aparna, K. and Lakshmi, D. N., 2012, Development and evaluation of RTE (Ready to Eat) extruded snack using egg albumin powder and cheese powder. *Int. J. Agric. Eng.*, 14(4): 179-187.
- Krishnan, M. and Prabhasankar, P., 2010, Effect of pasting, microstructure, sensory and nutritional profile of pasta influenced by sprouted finger millet (*Eleucina coracana*) and green banana (*Musa paradisiaca*) flours. *J. Texture Stud.*, 41(6): 825-841.
- Launay, B. and Lisch, L. M., 1983, Twin screw extrusion cooking of starches: Flow behavior of starch pastes, expansion and mechanical properties of extrudates. *J. Food Eng.*, 2: 259-280.
- Nagi, H. P. S., Kaur, J., Dar, B. N. and Sharma, S., 2012, Effect of storage period and packaging on the shelf life of cereal bran incorporated biscuit. *American J. Food Technol.*, 7 (5): 301-310.
- Oninawo, I. A. and Asugo, S., 2004, Effects of germination on the nutrient content and functional properties of pigeon pea flour. *J. Food Sci. Technol.*,41(2): 170-174.

- Raghuvanshi, R.S., Dutta, A., Tewari, G. and Suri, S., 2017, Qualitative characteristics of red rice and white rice procured from local market of Uttarakhand: a comparative study. *Rice Res.*, 10(1): 49-53.
- Savita, S., Arshwinder, K., Gurkirat, K. and Vikas, N., 2013, Influence of different protein sources on cooking and sensory quality of pasta. *Int. J. Eng. Sci.*, 3 (2): 1757-1763.
- Schoch, T. J., 1964. Swelling power and solubility of granular starches. In: Carbohydrate Chemistry, R.L. Whistler, R.J. Smith, N.J. Millerand M.I. Wolform (Eds.), Academic Press, New York, pp. 106-108.
- Sompong, R., Siebenhandl-Ehn, S., Linsberger-Martin, G. and Berghofer, E., 2011, Physicochemical and antioxidative properties of red and black rice varieties from Thailand, China and Sri Lanka. *Food Chem.*, 124(1):132.
- Walter, M. and Marchesan, E., 2011, Phenolic compounds and antioxidant activity of rice. *Brazilian Archives of Biology and Technology.*, 54:371-377.
- Wang, L. S. and Stoner, G. D. 2008, Anthocyanins and their roles in cancer prevention. *Cancer Letters*, 269: pp.281- 290.