Development of red rice-based pastas: physicochemical, cooking and sensory properties and shelf life

ABSTRACT

Aim: To develop red rice-based pasta and to assess their physico-chemical, sensory and cooking properties.

Study design: Completely randomized design.

Place and Duration of Study: Department of Processing and Food Engineering, College of Agricultural Engineering, UAS, GKVK, Bengaluru, between 2021 to 2022 (2 years).

Methodology: Cold extruded pastas were developed by incorporation of red rice flour and wheat flour at varying levels and physical parameters and proximate were analysed according to Deshpande and Poshadri (2011), Launay and Lisch (1983), Anderson (1982), AOAC (1980) respectively and 9-point hedonic scale was used to adjudge the sensory characteristics and also studied cooking characteristics according to standard methodologies for optimized pasta.

Results: Pasta incorporated 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 varied from 3.20-6.15 min, swelling power varied from 1.00-1.46 gg^{-1} and solid loss was found to be 15.02-9.94%. The optimized product found to has 79.43% of available carbohydrate, 10.15% of crude protein, 7.21% of moisture, 1.52% of crude fat, 1.93% of crude fibre and 1.69% ash content.

Conclusion: The developed red rice pasta underwent a comprehensive analysis encompassing physicochemical, cookingand textural evaluations. The study revealed key insights into the unique characteristics of the pasta, highlighting its nutritional attributes and cooking performance. The observed textural properties contribute to its overall appeal, making it a promising and health-conscious alternative in the realm of pasta products.

***Keywords**: Cooking time,crude protein, swelling power, Solid loss,*

1. 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. in addition to being a staple food and an essential component of social rites, rituals, and festivals in practically all Asian countries (Ahuja*et al*., 2007).

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(Ahuja*et al*., 2007)

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). It has a medicinal value as well, which was fully understood by the medical systems centuries ago.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 (Bhat*et al*., 2015)

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.his 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 pastaproduct by using red rice flour and whole wheat flour. In order to obtain a food product with viable functional and technological characteristics and sensory acceptance, the aim of this study was to standardize formulations for the development of cold extruded pastas based on red rice, evaluate the physicochemical, cooking and sensory properties of the formulated pastas and then assess the shelf life of the pasta made with the ingredients in optimum quantities according to the parameters analyzed.

2. MATERIALS AND METHODS

2.1 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.

2.2 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(25μm)flour mix. The flour was mainly used for developing the cold extruded pasta product from red rice after developing pasta it is kept in Dehydratorunit to dry cold extruded products to remove excess moisture content from pasta products.

2.3Description of pasta making machine:

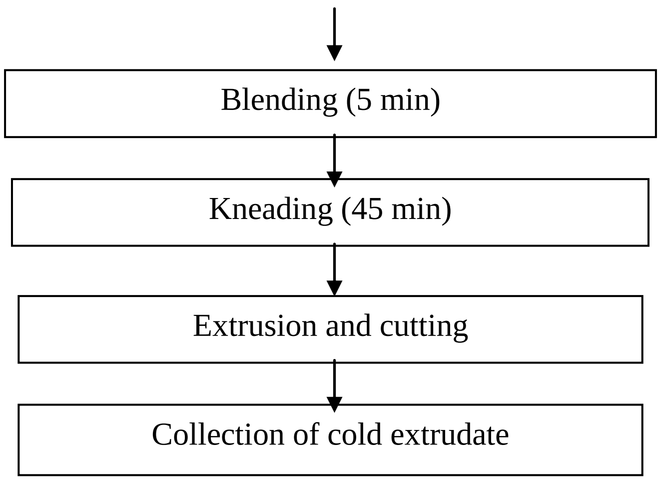
The pasta making machine was used to prepare pasta from red rice flour. It is an automatic and very reliable machine, suitable for working with any kind of flour and durum wheat (semolina) flours. It is powered by a 2.6 hp electrical motor and the rated capacity of this pasta machine was reported to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

2.4 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

2.5 Formulation of red rice pasta

Red rice pasta was standardized using 100%, 90%, 80%, 70% and 60% red riceflour (RRF)combined with various levels of whole wheat flour (WWF),Water was added to moistened the flousand mix was extruded from the extruder.(Table 1). The procedure followed for preparation of pasta.



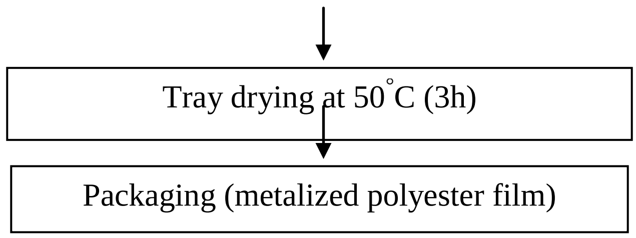


Fig. 1: Process flow chart for the development of pasta product

Table 1: Formulations based on different levels of red rice flour (RRF) and whole wheat flour (WWF) used to develop cold extrusion pasta.

Formulations	Level of flours in composite blend (RRF + WWF)		Composite blend (%)	Water (mLkg^{-1})
	RRF (%)	WWF (%)		
T_1	90	10	100	450
T_2	80	20	100	450
T_3	70	30	100	450
T_4	60	40	100	450

Note:Each analysis was performed in triplicates

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.

Tri-stimulus colour measurements of the pasta and vermicelli products were made using a Spectrophotometer (Make: Konica Minolta Instrument, Osaka, Japan; Model-CM5),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), respectivelyand The textural properties of extruded products were investigated using a Textural Analyzer (Make: Stable Microsystems Ltd, UK; Model – HDi). The textural characteristics were determined in a single test, where the extrudate was penetrated using a 25 mm stainless metal blade probe. The real-time force of compression during the test was recorded.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 Jalgonkar*et 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±2°C for 1 hour. The petri dish was weighed again with the dried solids as per Jalgonkar*et al*. (2019). Then, the solid loss was calculated as:

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

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(with age group between 20-35 years). 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.

The ideal ingredients were extruded at optimal process parameters to produce a red rice-based cold extruded pasta with highest functional value and most acceptable. The developed pasta was stored in metallized polyester packaging (50 µm). The moisture content and sensory parameters (colour, texture, taste, flavour and overall acceptability) were evaluated every 15 days of storage for a period of 90 days.

2.6Statistical 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

3 RESULTS AND DISCUSSION

3,1 Cooking and sensory properties of pasta samples:

The pasta samples developed in the study underwent a comprehensive evaluation for cooking characteristics, including cooking time, solid loss, and swelling power. Additionally, a sensory evaluation was conducted to optimize the production of the most well-received product, with detailed results provided in Table 2.

The analysis of cooking characteristics indicated that the perfect shape of the pasta samples was not maintained when using red rice flour, given its gluten-free nature. To address this, whole wheat flour was incorporated at various levels, as outlined in Table 1 (Materials and Methods), with the aim of enhancing texture and preserving the pasta's shape during the cooking process.

Table 2: 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

T_1: Red rice flour (90%): Wheat flour (10%)

$T_{2:}$ Red rice flour (80%): Wheat flour (20%)

T_3: Red rice flour (70%): Wheat flour (30%)

$T_{4:}$ Red rice flour (60%): Wheat flour (40%), Control: Whole wheat flour (100%)

Note: CD: Critical difference; S.Em.±: Standard error of mean

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).

3.2 Sensory properties of pasta

The sensory quality characteristics which included appearance, colour, texture, flavour, taste and overall acceptability of the pasta products prepared usingred 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.

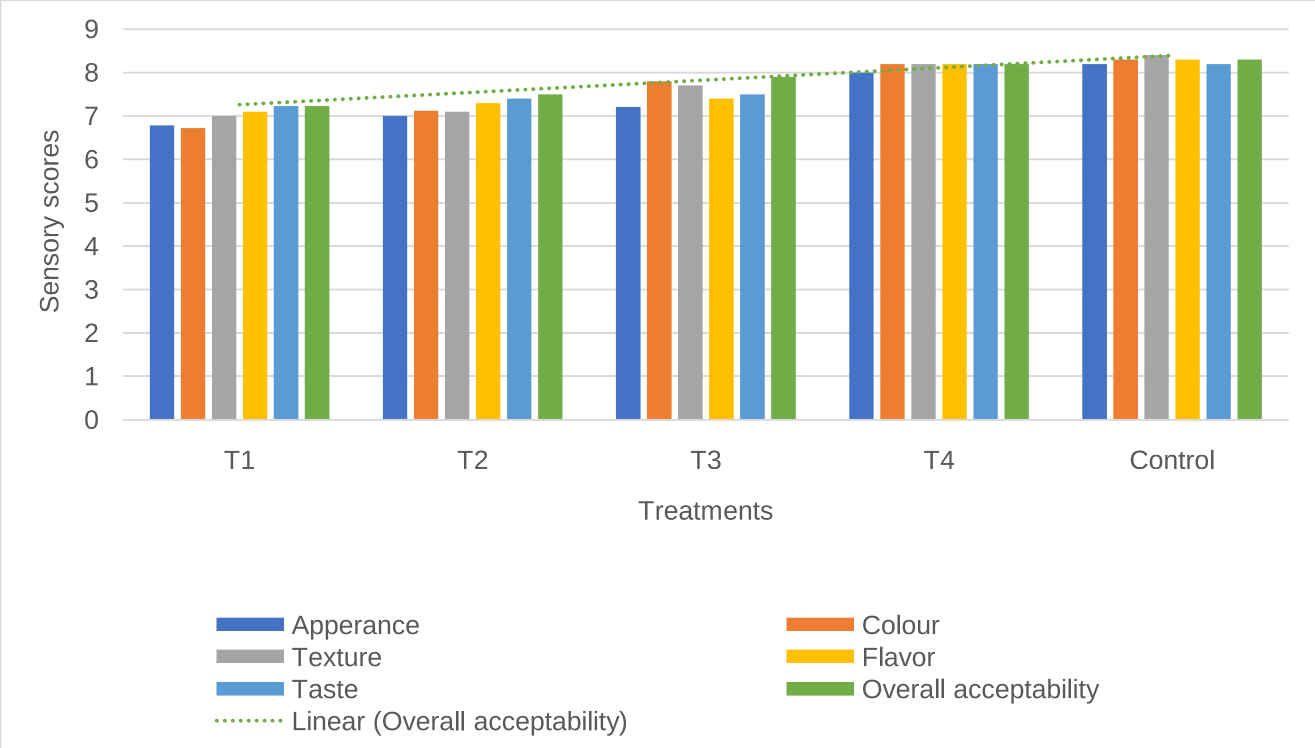


Fig. 2. Sensory scores of developed red rice pasta samples

T_1: Red rice flour (90%): Wheat flour (10%)

$T_{2:}$ Red rice flour (80%): Wheat flour (20%)

T_3: Red rice flour (70%): Wheat flour (30%), $T_{4:}$ 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.

3.3 Physico-chemical properties of pasta

The nutritional composition of optimized red rice pasta product (Treatment-T_4) in terms of moisture content, crude protein, crude fat, crude fibre, total ash and carbohydrates are presented in Table 3.

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 3: 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%
Available 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

3.4 Textural properties of optimized un cooked red rice pasta product

The textural characteristics of optimized pasta products are presented in Table 4. 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 4: Textural properties of optimized un cooked red rice based cold extruded products:

Parameters	**Optimized pasta**
Hardness (g)	1711.73
Fracturability (g)	9524.84
Adhesiveness (g. sec)	0
Springiness	0

3.5 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.

3.5.1 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.

3.5.2 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 ± 3°C, humidity: 65.2 ± 12%). The quality of the extruded product was seen to be significantly impacted by storage time and packaging type.

3.5.3Effect 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≤ 0.05) effect on the moisture content of cold extruded products.

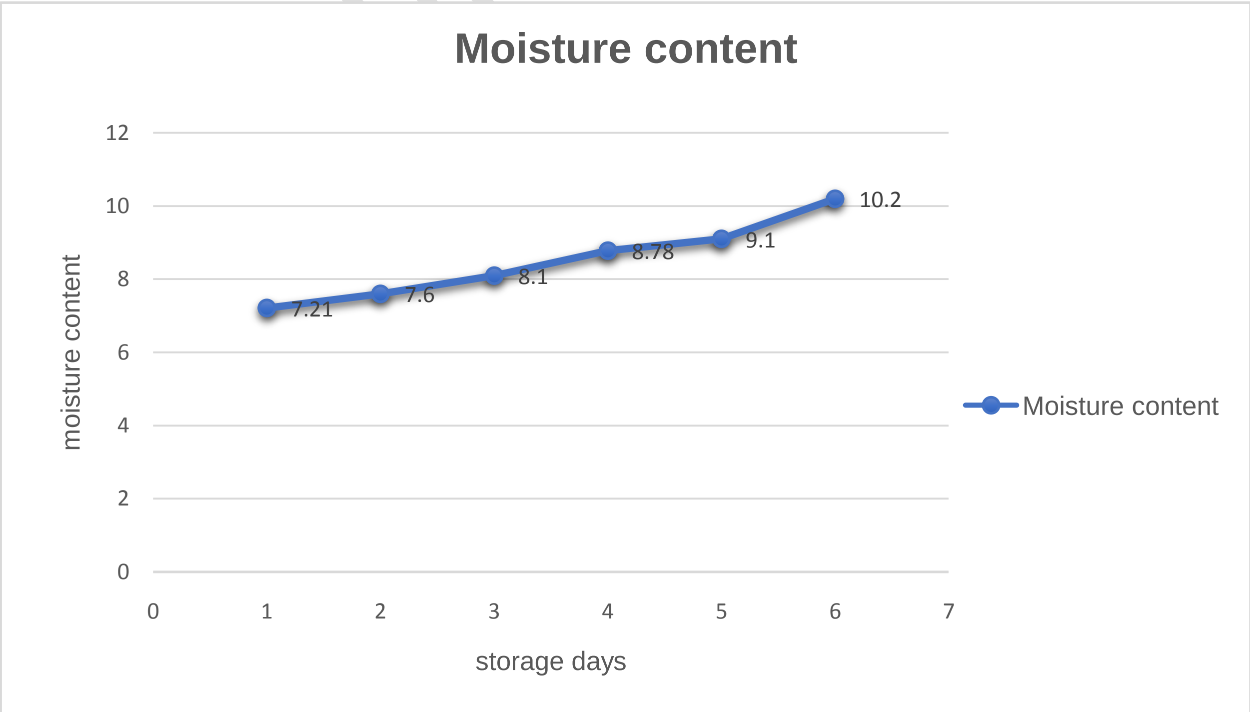


Fig.3. Effect of storage on moisture content of red rice pasta sample stored in metalized polyester film

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 (Kocherla*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).

3.5.4Effect 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.

3.5.5Effect 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 sores 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.

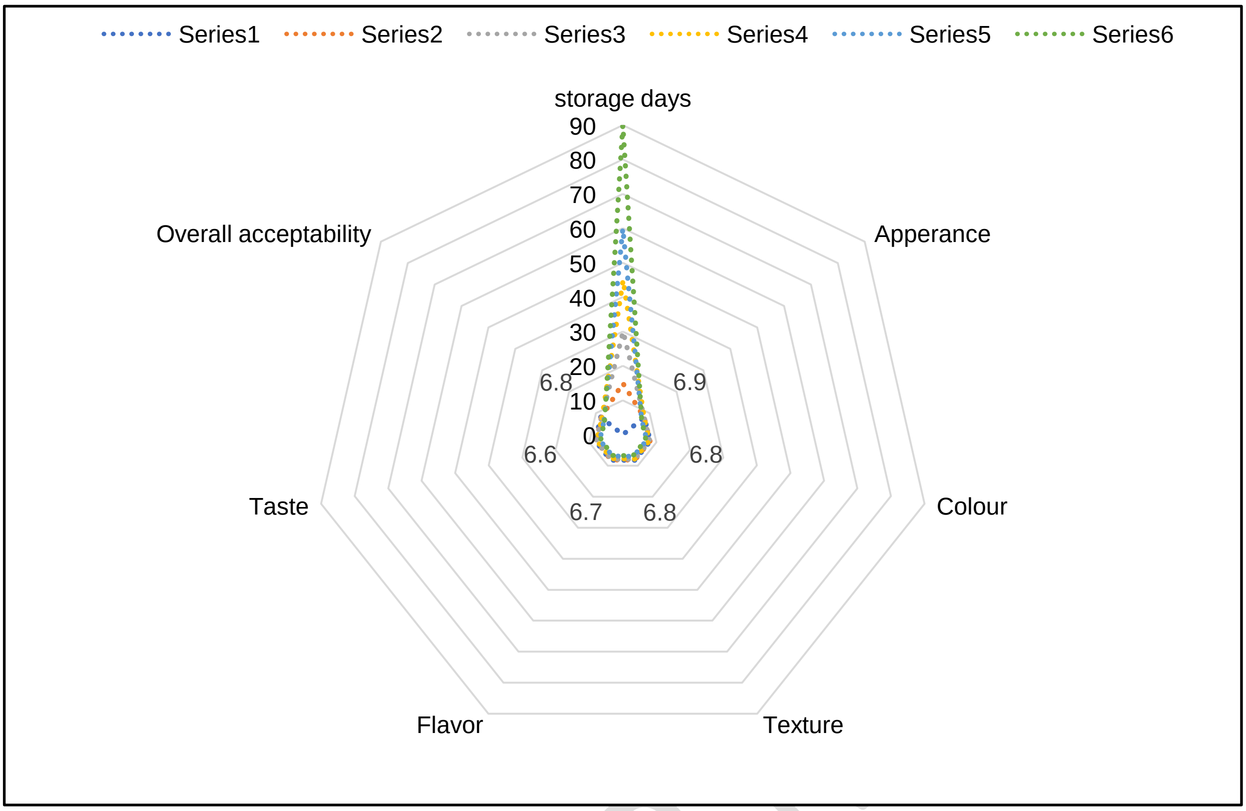


Fig.4. Effect of storage on sensory scores of red rice pasta samples stored in metalized polyester film

4CONCLUSIONS

The development of red rice-based pasta was investigated with a focus on enhancing its cooking characteristics. The evaluation encompassed crucial parameters such as cooking time, solid loss, swelling power, and sensory attributes. The findings revealed that the use of red rice flour, being gluten-free, posed a challenge in retaining the ideal pasta shape during cooking. To overcome this limitation and improve overall texture, varying levels of whole wheat flour were introduced into the formulation. This study not only sheds light on the limitations associated with red rice flour in pasta development but also provides a practical solution by incorporating whole wheat flour for better shape retention and enhanced sensory qualities. These results offer valuable insights for the optimization of red rice-based pasta, addressing both technical and sensory aspects for improved consumer acceptance.

ACKNOWLEDGEMENTS

I express my sincere gratitude to all individuals and institution that contributed to the successful completion of this research endeavour. First and foremost, I extend my appreciation to Viresh Kumargouda and Suresha, K. B, Assistant Professor (Processing and Food Engineering) Dept. of Processing and Food Engineering, College of Agricultural Engineering, UAS, GKVK, Bengaluru and Associate Professor (Dairy Technology) andInchargeCoE-Nutricereals, AICRP on PHET (ICAR), UAS, GKVK, Bengaluru for their support and guidance throughout the project. Special thanks are due toMohithkumar, G.V and Shobha, D., Associate

Professor (Processing and Food Engineering) Dept. of Processing and Food Engineering, College of Agricultural Engineering, UAS, GKVK, Bengaluru and Associate Professor (Food science and Nutrition), Post-harvest Engineering and Technology, AICRP on PHET (ICAR), UAS, GKVK, Bengaluru for their invaluable expertise and insightful suggestions.

Abbreviations

RRF: Red rice flour

WWF: Wheat flour

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