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Research Article

Development and characterization of a novel missi roti multimix: exploring nutritional and sensory properties

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ABSTRACT

Healthy choices include a wide range of lifestyle modifications by adopting diverse and balanced foods that promote physical and mental well-being. World trends for healthy choices are changing day by day as most people are becoming more health conscious and prefer healthy foods over synthetic foods. Refined wheat flour is commonly used for making roti, but there is a need to make roti from composite flour for adding healthy food to the diet. Keeping in view the aspects mentioned above, the research was designed to develop a missi roti multimix in different ratios. Multimix foods included a blend of locally available, affordable, and commonly consumed food items that enhanced the nutritional value of the end product. The proposed study was focused on the addition of nutrient-rich ingredients such as chickpeas, wheat, and yellow lentils in the development of roti while maintaining its unique flavor and texture. Seven treatments were prepared and analyzed and among them, T4 (50% wheat flour, 10% chickpea flour, and 40% yellow lentil flour) exhibited the most favorable results. The proximate analysis revealed that T4 contained moisture 10.38%, ash 2.4%, crude fat 3.6%, crude protein 19.5%, and crude fiber 3.2%. Phytochemical analysis showed that T4 had a total phenolic content (TPC) of 332.782 mg GAE/100g and a total flavonoid content (TFC) 149.60 mg CE/g. All data were statistically analyzed, confirming the significant differences between treatments. The results showed that missi roti multimix made from 50% wheat flour, 10% chickpea flour, and 40% yellow lentil flour could serve as a nutritionally valuable food.

Keywords: Food multimix; missi roti multimix; wheat; lentils; chickpea.



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INTRODUCTION

In recent decades, with changes in people's dietary habits and lifestyle, there has been an increase in malnutrition (Ntentie et al., 2022). Most people consume single food groups and processed foods, which leads to a lack of diversification and ultimately leads to micronutrient deficiency (Fayama, 2022). Food Multi-Mix (FMM) is a cost-effective combination of ingredients that are culturally appropriate and commonly consumed as food or used in recipes. The constituents are blended in different proportions, taking into account the nutritional benefits of each component in the multimix. The objective is to preserve the nutritional composition of the FMM without incorporating any additional fortifying substances (Singh and Sharma, 2020). The FMM can be tailored to suit diverse communities and applied to a range of objectives, it can be formulated to support pregnant women by including nutrients like iron and folic acid, nutrition recovery in undernourished individuals and school feeding initiatives by including balanced energy, protein and essential micronutrients (Zotor et al., 2015). The Missi Roti Multimix was created in response to the urgent need to improve the nutritional profile of conventional flatbreads, to increase the micronutrient content by including a variety of flour sources, and to develop a food product that is adaptable to a range of dietary needs. Current dietary trends include growing consumer awareness of functional foods, nutrition, and the benefits of

consuming a variety of grains. Missi roti is a traditional Indian flat bread known for its unique flavour. Missi roti is a blend of wheat flour and chickpea flour. Our goal in creating a missi Roti multimix is to turn a conventional food item into a more nutrient-dense food item. To enhance the nutritional quality of missi roti, yellow lentil flour is used with wheat flour and chickpea flour.

Wheat (*Triticum aestivum*) is the main staple food of the global human population, including Pakistan, India, and some parts of Africa. It is a good source of carbohydrates, protein, and essential amino acids. Wheat is used in the production of different types of flatbreads. In India, there is almost 85% consumption of wheat in the form of chapatti (Kadam et al., 2012). Wheat consists of a significant amount of monosaccharide and oligosaccharide. The abundant oligosaccharides are polymers of fructose (fructo-oligosaccharide and fructans) (Shewry and Hey, 2015).

Legumes which are well known as “a poor man’s meat”. The addition of legumes to the diet provides fiber, complex carbohydrates, proteins, and necessary minerals and vitamins and has no cholesterol, low sodium, and fat. It is recognized as a food having a low glycemic index, which plays a crucial role in increasing satiety, dietary treatment of diabetes mellitus, and other health benefits (Kadam et al., 2012). Based on the composition of legumes, it has been widely used in different food products and is a vital food source in the human diet. The consumption of legumes helps to reduce the chances of cardiovascular disease and cancer (Carbas et al., 2023). Legumes including lentils may help to reduce the chances of type 2 diabetes by 33%. Moreover, the intake of legumes is also seen to reduce BMI and abdominal adiposity, the reason is the high fiber level and regulation of adiponectin in obese persons (Czerwonka et al., 2023).

Lentils (*Lens culinaris*) which are one of the oldest crop species are grown in the West of Asia, North America, and other parts of the world and are the most commonly consumed legumes in the world. The edible seeds of lentils are lens-shaped and contain most of the micronutrients and macronutrients. They have abundant protein and are good sources of fiber, minerals, and vitamins. Lentils show antioxidant, antibacterial, antifungal, antiviral, cardioprotective, antidiabetic, anticancer, and anti-obesity properties. These are cost-effective and have high nutritional properties (Ganesan et al., 2017). Bioactive compounds like flavonoids, total phenolics, phytates, tannins, and saponins are also present in lentils. Due to the presence of protein and high dietary fiber, the digestion of carbohydrates is slower, which may help lower glycemic index (Kaale et al., 2023).

Chickpea (*Cicer arietinum* L.) is a highly popular legume that is widely consumed worldwide, mainly due to its exceptional nutritional value, particularly its high protein content. Chickpea seeds are primarily consumed in their dehydrated state. Chickpea seeds consist of around 60-65% carbohydrates, with starch being the primary polysaccharide found in the cotyledons. Starch accounts for 30.8% to 37.9% of the dry weight. Chickpea peptides possess a range of bioactive characteristics, which include antioxidant, antihypertensive, anti-inflammatory, anti-carcinogenic, anti-obesity, antifungal, hypocholesterolemic, and hypoglycemic actions. Before ingestion or processing, chickpeas receive a range of pre-processing treatments to enhance their palatability, decrease processing duration, and enhance their nutritional content. After undergoing physical, biochemical, or thermal treatments, they are ingested in various forms that enhance digestibility and aid in the removal of anti-nutritional elements (Kaur and Prasad, 2021). The proposed study was designed to formulate multimix missi roti that includes traditional ingredients to improve nutritional value, to evaluate antioxidant activity, physicochemical and storage stability of missi roti multimix, and to know the consumer acceptability of multimix missi roti through sensory evaluation. Keeping in account all these attributes, the main objectives of this research are mentioned below:

- To formulate multimix missi roti that includes traditional ingredients to improve nutritional value.
- To evaluate antioxidant activity, physicochemical and storage stability of missi roti multimix.
- Consumer acceptability of multimix missi roti through sensory evaluation.

MATERIALS AND METHODS

The present research was carried out at different labs of the National Institute of Food Science and Technology at the University of Agriculture, Faisalabad.

Procurement of Raw Material

The wheat flour, yellow lentils, chickpea flour, and other ingredients were purchased from the local market of Faisalabad.

Preparation of Raw Material

The traditional recipe of missi roti included wheat flour and chickpea flour with added spices, green chillies, and onions. The formulated missi roti is made up of wheat flour, chickpea flour, yellow lentils, 3% dried spinach, 8% dried onion,

1% red chilli flakes, 2% salt, 0.2% haldi powder, 2.5% coriander powder, and 0.5% cumin powder. Wheat flour, chickpea flour, and yellow lentils were cleaned to remove unwanted residues. After the removal of residues, yellow lentils were ground to make flour. 3% of the spinach was washed and then cut into small pieces and dried for almost 48-72 hrs under sunlight. 8% of onions were cut into small pieces and then dried for 1-2 days under sunlight.

Preparation of Product

All the ingredients and spices were mixed in a dish and kneaded to make a smooth and soft dough, and were kept aside for almost 10-15 minutes. Seven different formulations were prepared for missi roti multimix along with a control group, as given in Table 1. The ratio of spices, water, dried spinach, and onion flakes remained constant. There is research on the utilization of fresh herbs for the development of missi roti to suit lifestyle diseases with emphasize on obesity as by Kumari and Dubey (2017).

Table 1. Treatment plan for the preparation of missi roti multi-mix.

| Treatment | Wheat flour % | Chickpea flour % | Yellow lentils % |
|----------------|---------------|------------------|------------------|
| T ₀ | 50 | 50 | - |
| T ₁ | 40 | 40 | 20 |
| T ₂ | 40 | 30 | 30 |
| T ₃ | 40 | 20 | 40 |
| T ₄ | 50 | 10 | 40 |
| T ₅ | 50 | 20 | 30 |
| T ₆ | 50 | 30 | 20 |
| T ₇ | 50 | 40 | 10 |

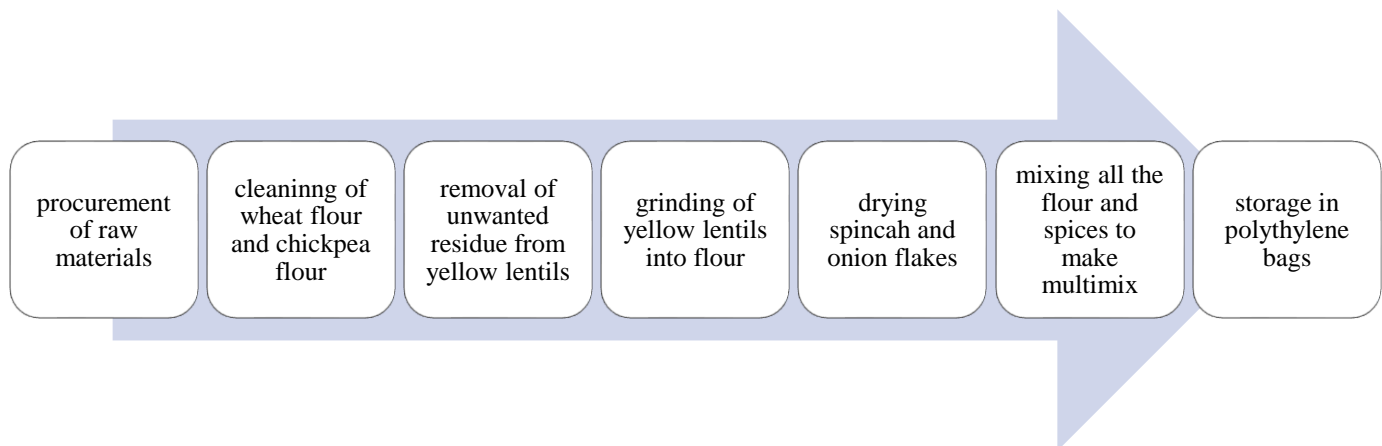


Figure 1. Flow chart for the preparation of missi roti multimix.

Analysis of Missi Roti Multimix

Proximate analysis

The proximate analysis of missi roti multimix was performed by following the protocol of AACC, (2015). AACC, (2015) method No. 44-15A was used to determine the moisture content. AACC, (2015) method no. 46-10 was used for the assessment of crude protein, which was carried out by the Kjeldahl method. AACC, (2015) Method No. 30-25 was used to determine the crude fat analysis. AACC, (2015) method no 32-10 was used to estimate the crude fiber content of fat-extracted samples. The Ash content of the samples was determined as outlined in AACC, (2015) method no. 08-01.

Fat rancidity

Peroxide value (PV) was determined by following the methods described by AOAC, (2023). The extracted fat was dissolved in 30ml acetic acid-chloroform solution, then 0.5mL saturated KI solution was added, then it was placed in the dark for 1 minute, and 30 ml distilled water was added. 0.01N Na₂SO₃ was used for titration until the yellow color disappeared, then 0.5mL 1%starch indicator was added and titration was done until the blue color disappeared.

$$\text{Peroxide Value (meq/kg)} = \frac{(S-B) \times N}{W} \times 1000$$

S = Volume (in mL) of sodium thiosulfate used for sample titration

B = Volume (in mL) of sodium thiosulfate used for blank titration

N = Normality of sodium thiosulfate solution

W = Weight (in grams) of the fat or oil sample taken for analysis

Antioxidant properties

AOAC, (2023) standard protocol was used to determine the antioxidant activity of missi roti based on stable 2, 2 - diphenyl 1-1 -picrylhydrazyl free radical scavenging activity. FRAP (Ferric Reducing Antioxidant Power) was analyzed by following the procedure of Arackal and Parameshwari, (2021).

Phytochemical analysis

The total phenolic content in the extracts was assessed using the Folin-Ciocalteu method as described by (Sharma and Gujral, 2014). The total flavonoid content of the samples was assessed using the methodology outlined by Arackal and Parameshwari, (2021).

Physicochemical analysis

Cooking yield is a parameter which is included in physicochemical analysis. Cooking yield was determined by the method of Huang et al. (2022). The dough prepared from each sample was weighed. A hot plate was used to cook roti at 180+5°C for 2-3 minutes. Then the cooked roti samples were cooled for 30 minutes and weighed.

$$\text{Cooking yield} = \frac{\text{Weight of cooked roti}}{\text{Weight of dough}} \times 100$$

Microbial analysis

AOAC, (2023) described a method used to assess the microbial quality of missi roti multimix by measuring total plate count. The shelf life of the product and the control sample was assessed through microbial analysis, measured in days. Plate count agar which is the commonly used culture medium, was used in the analysis at an interval of 0, 30, and 60 days.

$$\text{CFU/g} = \frac{\text{No. of colonies (Mean)} \times \text{Dilution factor}}{\text{Volume of sample used (0.1ml)}}$$

Physical analysis

Color

Kaur et al. (2022) conducted an analysis in which they determined the color of the product. The same procedure was followed to determine the color of the product through a colorimeter. Values of L*, a*, and b* were checked out by a colorimeter. Lightness was expressed by the L* value, and greenness and redness were expressed by a* respectively. Whereas blueness and yellowness were expressed by b* respectively.

Texture

The texture of the product was determined using a texture analyzer with slight modifications by the method described by Hemalatha et al. (2014). All analysis of the product was done in triplicates and their values in mean were determined.

Sensory evaluation

Meilgaard et al. (2016) procedure was followed for sensory evaluation of the product. It was performed by a panel of trained or experienced evaluators who were able to taste and smell well and knew the many flavors and features of roti or chapatti. A neutral, well-lit space free of unpleasant smells or other distractions should be used for the evaluation. Make a 9-point hedonic scale form for sensory evaluation that asks about attributes including look, color, flavor, texture, and preference.

Storage study

The storing durability of missi roti multimix was assessed by using the Total Plate Count Technique. The multimix was packed in a polyethylene bag and stored at room temperature. Microbial analysis was carried out at 0, 30, and 60 days.

Statistical Analysis

The significance level was estimated by applying an appropriate statistical approach to each factor. A two-way ANOVA technique was applied. After that, outcomes were elucidated at a probability level of 5% Montgomery (2017).

RESULTS AND DISCUSSION

Missi roti multimix was prepared. Sample made from 50% wheat flour and 50% chickpea flour was considered as control and the other seven treatments T1 (40% wheat flour, 40% chickpea flour, and 20% yellow lentils flour), T2 (40% wheat flour, 30% chickpea flour, and 30% yellow lentils flour), T3 (40% wheat flour, 20% chickpea flour, and 40% yellow lentils flour), T4 (50% wheat flour, 10% chickpea flour, and 40% yellow lentils flour), T5 (50% wheat flour, 20% chickpea flour, and 30% yellow lentils flour), T6 (50% wheat flour, 30% chickpea flour, and 20% yellow lentils flour) and T7 (50% wheat flour, 40% chickpea flour, and 10% yellow lentils flour) were prepared. Samples were stored at

room temperature. Sensory, physiochemical, and antioxidant tests of these samples were performed. Statistical analysis of these results was performed. The purpose of this study was the development and evaluation of missi roti multimix.

Analysis of Missi Roti Multimix

Proximate analysis

Proximate analysis is significant in estimating the grade of a product. In the present study, a proximate analysis was conducted to determine the ash, moisture, protein, fat, and fiber content in missi roti multimix. Treatments T0, T1, T2, T3, T4, T5, T6 and T7 expose to proximate analysis. The proximate composition of Missi Roti Multimix is presented in Table 2. The moisture content of missi roti was found to be 10.965% in T0 and 10.588% in T4. The protein content was highest in T4 (19.89%). The highest fat content was noted in T0 (4.8%).

Table 2. Effect of treatment and storage on the proximate composition (%) of missi roti multimix.

| Treatment | Storage duration (days) | Moisture | Crude Protein | Crude Fat | Crude Fiber | Ash |
|-----------|-------------------------|-------------------------|--------------------------|----------------------|---------------------|----------------------|
| T0 | 0 | 10.965 ^a | 16.524 ^{ij} | 4.896 ^a | 2.856 ^{fg} | 2.1420 ^f |
| | 30 | 10.455 ^{abcde} | 16.422 ^j | 4.794 ^{ab} | 2.652 ^{hi} | 2.244 ^{ef} |
| | 60 | 9.945 ^{efghi} | 16.32 ^j | 4.692 ^{abc} | 2.488 ^{ik} | 2.3460 ^{de} |
| T1 | 0 | 10.2 ^{cdefg} | 17.748 ^{defg} | 4.59 ^{bcd} | 3.162 ^{cd} | 2.3460 ^{de} |
| | 30 | 9.69 ^{ghij} | 17.646 ^{defgh} | 4.488 ^{cde} | 2.958 ^{ef} | 2.4480 ^{cd} |
| | 60 | 9.18 ^{kl} | 17.544 ^{defghi} | 4.386 ^{def} | 2.754 ^{gh} | 2.550 ^{bc} |
| T2 | 0 | 10.078 ^{defgh} | 18.156 ^{cdef} | 4.284 ^{efg} | 3.366 ^{ab} | 2.4480 ^{cd} |
| | 30 | 9.568 ^{hijk} | 18.054 ^{cdef} | 4.182 ^{fgh} | 3.06 ^{de} | 2.5500 ^{bc} |
| | 60 | 9.058 ^{kl} | 17.954 ^{cdef} | 4.08 ^{ghi} | 2.856 ^{fg} | 2.6520 ^{ab} |
| T3 | 0 | 9.945 ^{efghi} | 18.564 ^{bcd} | 3.978 ^{hij} | 3.468 ^a | 2.5500 ^{bc} |
| | 30 | 9.435 ^{ijkl} | 18.462 ^{bcd} | 3.876 ^{ijk} | 3.264 ^{bc} | 2.6520 ^{ab} |
| | 60 | 8.925 ^l | 18.36 ^{bcde} | 3.774 ^{jkl} | 3.06 ^{de} | 2.7540 ^a |
| T4 | 0 | 10.588 ^{abcd} | 19.89 ^a | 3.672 ^{klm} | 3.264 ^{bc} | 2.4480 ^{cd} |
| | 30 | 10.078 ^{defgh} | 19.686 ^a | 3.57 ^{lm} | 3.06 ^{de} | 2.5500 ^{bc} |
| | 60 | 9.568 ^{hijk} | 19.38 ^{ab} | 3.468 ^m | 2.856 ^{fg} | 2.6500 ^{ab} |
| T5 | 0 | 10.71 ^{abc} | 18.87 ^{abc} | 3.876 ^{ijk} | 3.06 ^{de} | 2.3460 ^{de} |
| | 30 | 10.2 ^{cdefg} | 18.564 ^{bcd} | 3.774 ^{jkl} | 2.856 ^{fg} | 2.4480 ^{cd} |
| | 60 | 9.69 ^{ghij} | 18.156 ^{cdef} | 3.672 ^{klm} | 2.652 ^{hi} | 2.5500 ^{bc} |
| T6 | 0 | 10.843 ^{ab} | 17.34 ^{efghij} | 4.182 ^{fgh} | 2.958 ^{ef} | 2.2440 ^{ef} |
| | 30 | 10.333 ^{bcdef} | 17.238 ^{ghij} | 4.08 ^{ghi} | 2.754 ^{gh} | 2.3460 ^{de} |
| | 60 | 9.823 ^{fghi} | 17.136 ^{fghij} | 3.978 ^{hij} | 2.55 ^j | 2.4500 ^{cd} |
| T7 | 0 | 10.965 ^a | 16.728 ^{ghij} | 4.488 ^{cde} | 2.754 ^{gh} | 2.1420 ^f |
| | 30 | 10.455 ^{abcde} | 16.626 ^{hij} | 4.386 ^{def} | 2.55 ^j | 2.2440 ^{ef} |
| | 60 | 9.945 ^{efghi} | 16.524 ^{ij} | 4.284 ^{efg} | 2.346 ^k | 2.3500 ^{de} |

The moisture content decreased over time across all treatments due to evaporation and loss of water during storage. There was a slight decrease in protein content during the storage period due to protein denaturation. Fat content decreases due to oxidation and fiber content also showed a reduction over storage duration due to microbial and enzymatic degradation. There was an increase in ash content due to the increase in mineral content during storage duration. The obtained results agreed with the results reported by Tangariya et al. (2018).

Fat rancidity

Peroxide value (PV) serves as an indicator of the degree of primary oxidation products, such as peroxides and hydroperoxides that develop during the rancidification of fats. Elevated PV readings signify a greater level of oxidation and a decline in fat quality. The interaction between the storage period and treatment was significant. The effect of treatment and storage is shown in Table 3. A higher peroxide value was seen in T0 with a mean of 2.5568%, and the lowest peroxide value was seen in T4 having a mean value of 3.5224%. The storage study showed a consistent increasing trend in all treatments. There was a consistent increase in peroxide value due to increase in unsaturated fat in legumes from day 0 to day 60. The obtained result was according to the results obtained from a study by Singh et al. (2020).

Antioxidant properties

The DPPH assay is used to predict antioxidant activity by determining the free radical scavenging capacity through the mechanism by which antioxidants operate to limit lipid oxidation and scavenge the DPPH radical. The DPPH test tells us how reactive flavonoids are to a stable free radical. The mean square values for the effect of substitution of different flours on the DPPH and FRAP content of missi roti multimix have been presented in Table 4. The interaction between

Table 3. Effect of treatment and storage on the peroxide value (meq/kg) of missi roti multimix.

| Treatment | Day 0 | Day 30 | Day 60 | Means |
|-----------|---------------------|--------------------|---------------------|---------------------|
| T0 | 0.83±0.01 | 2.49±0.04 | 4.33±0.08 | 2.5568 ^g |
| T1 | 0.99±0.01 | 2.9±0.05 | 4.91±0.09 | 2.941 ^e |
| T2 | 1.26±0.02 | 3.34±0.06 | 5.55±0.10 | 3.3898 ^c |
| T3 | 1.44±0.02 | 3.72±0.07 | 5.96±0.11 | 3.7128 ^a |
| T4 | 1.34±0.02 | 3.48±0.06 | 5.73±0.11 | 3.5224 ^b |
| T5 | 1.17±0.02 | 3.11±0.06 | 5.34±0.10 | 3.2096 ^d |
| T6 | 0.93±0.01 | 2.7±0.05 | 4.74±0.09 | 2.7948 ^f |
| T7 | 0.76±0.01 | 2.29±0.04 | 4.13±0.08 | 2.397 ^h |
| Means | 1.0965 ^c | 3.009 ^b | 5.0911 ^a | |

Means that do not share the same letters within columns or rows differ significantly ($p < 0.05$)

the storage period and treatment was non-significant. Higher DPPH values were observed in T4, with a mean of 76.071%, while the lowest DPPH value was recorded in T3, with a mean of 62.518%. The storage study showed a consistent decreasing trend in all treatments due to oxidation or degradation of antioxidant compounds. The results are in line with the findings of Przeor et al. (2016).

FRAP assesses the reducing capacity of antioxidants present in a sample. Elevated values signify enhanced antioxidant activity, attributed to the presence of compounds such as polyphenols, flavonoids, and other bioactive substances. The interaction between the storage period and treatment was non-significant. A higher FRAP value was seen in T₃ with a mean of 51.038%, the FRAP value was seen in T₀ having a mean value of 41.31%. The storage study showed a consistent decreasing trend in all treatments, which may be due to temperature exposure and oxidative stress. The results were in line with the findings of Przeor et al. (2016). There was a decrease in DPPH and FRAP during the storage duration. The results were in line with the findings of Przeor et al. (2016).

Table 4. Effect of treatment and storage on antioxidant activity of missi roti multimix.

| Treatment | Storage Duration (days) | DPPH | FRAP |
|-----------|-------------------------|-------------------------|-------------------------|
| T0 | 0 | 54.015 ^h | 43.35 ^{ijkl} |
| | 30 | 53.902 ^h | 41.616 ^{lmn} |
| | 60 | 53.798 ^h | 38.964 ⁿ |
| T1 | 0 | 71.71 ^{ab} | 46.512 ^{efghi} |
| | 30 | 71.506 ^{abc} | 44.574 ^{hijk} |
| | 60 | 71.302 ^{abcd} | 42.024 ^{klm} |
| T2 | 0 | 53.141 ^h | 49.164 ^{cde} |
| | 30 | 52.937 ^h | 47.022 ^{efgh} |
| | 60 | 52.733 ^h | 44.676 ^{hijk} |
| T3 | 0 | 62.722 ^{fg} | 53.448 ^a |
| | 30 | 62.518 ^{fg} | 51.102 ^{abc} |
| | 60 | 62.314 ^{fg} | 48.552 ^{cdef} |
| T4 | 0 | 76.275 ^a | 52.836 ^{ab} |
| | 30 | 76.071 ^a | 50.49 ^{bcd} |
| | 60 | 75.867 ^a | 47.838 ^{defg} |
| T5 | 0 | 66.554 ^{bcdef} | 48.246 ^{defg} |
| | 30 | 66.35 ^{cdef} | 46.104 ^{ghij} |
| | 60 | 66.146 ^{def} | 43.656 ^{ijkl} |
| T6 | 0 | 68.864 ^{bcde} | 45.594 ^{ghij} |
| | 30 | 68.66 ^{bcde} | 43.758 ^{ijkl} |
| | 60 | 68.456 ^{bcde} | 41.31 ^{lmn} |

| | | | |
|----|----|-----------------------|------------------------|
| T7 | 0 | 64.299 ^{efg} | 44.064 ^{ijkl} |
| | 30 | 60.429 ^g | 42.33 ^{klm} |
| | 60 | 63.891 ^{efg} | 39.882 ^{mn} |

Phytochemical analysis
Phenolic content in total

The method used to determine the sample's phenolic content is called TPC activity. Plant-based phenolic compounds possess redox characteristics that enable them to function as antioxidants. The interaction between the storage period and treatment was non-significant. Higher TPC was seen in T6 with a mean of 446.38%, and the lowest protein content was seen in T0 having a mean value of 173.62%. The storage study showed a consistent decreasing trend in all treatments. The results obtained were almost in line with the previous studies conducted by Tangariya et al. (2019). Flavonoids are essential for a healthy diet because they scavenge free radicals, chelate trace elements involved in the generation of free radicals, and enhance or safeguard antioxidant defenses. The mean values for the effect of substitution of different flours on the total flavonoid content of the paratha have been presented in Table 5. The interaction between the storage period and treatment was non-significant. Higher TFC was seen in T3 with a mean of 166.08%, and the lowest protein content was seen in T0 having a mean value of 129.04%. The storage study showed a consistent decreasing trend in all treatments. The results obtained were almost in line with the previous studies conducted by Przeor et al. (2016).

Table 5. Effect of treatment and storage on the phytochemical analysis of missi roti multimix.

| Treatment | Storage Duration (days) | TPC | TFC |
|-----------|-------------------------|---------------------|------------------------|
| T0 | 0 | 173.83 ^f | 129.24 ^g |
| | 30 | 173.62 ^f | 129.04 ^g |
| | 60 | 173.42 ^f | 128.84 ^g |
| T1 | 0 | 384.5 ^c | 141.59 ^{cdef} |
| | 30 | 384.3 ^c | 141.39 ^{def} |
| | 60 | 384.09 ^c | 141.18 ^{ef} |
| T2 | 0 | 415.1 ^b | 150.18 ^{bcde} |
| | 30 | 414.9 ^b | 149.98 ^{bcde} |
| | 60 | 414.69 ^b | 149.77 ^{bcde} |
| T3 | 0 | 408.97 ^b | 166.29 ^a |
| | 30 | 408.78 ^b | 166.08 ^a |
| | 60 | 408.57 ^b | 165.88 ^a |
| T4 | 0 | 339.67 ^d | 152.6 ^b |
| | 30 | 339.23 ^d | 152.39 ^b |
| | 60 | 339.03 ^d | 152.19 ^b |
| T5 | 0 | 268.15 ^e | 147.77 ^{bcde} |
| | 30 | 268.2 ^e | 147.56 ^{bcde} |
| | 60 | 268 ^e | 147.36 ^{bcde} |
| T6 | 0 | 446.12 ^a | 135.15 ^{fg} |
| | 30 | 446.61 ^a | 134.95 ^{fg} |
| | 60 | 446.21 ^a | 134.74 ^{fg} |
| T7 | 0 | 320.02 ^d | 150.45 ^{bc} |
| | 30 | 319.76 ^d | 150.26 ^{bcd} |
| | 60 | 319.56 ^d | 150.04 ^{bcde} |

Physicochemical analysis

Cooking yield denotes the weight of the final cooked product about its initial weight, serving as a crucial metric for assessing water absorption, texture, and overall consistency in food items such as missi roti. Various elements, including the composition of ingredients, the capacity for water absorption, and the method of cooking, play significant roles in determining cooking yield. Wheat flour, primarily made up of starch, has a notable capacity to absorb water, resulting in a higher cooking yield. The interaction between the storage period and treatment was non-significant. The higher cooking yield was seen in T3 with a mean of 175.47%, and the lowest cooking yield was seen in T0, having a mean value of 166.97%. The storage study showed a consistent decreasing trend in all treatments due to protein

denaturation, starch modification, and fiber hydration. The results were in agreement with the findings of Singh et al. (2020).

Microbial analysis

Total plate count

A technique for determining the overall amount of microorganisms (mold, yeast, and bacteria) in a substance is called total plate count, or TPC. The material is diluted in the first stage of the study until it reaches a 10-5 dilution. Finding out how many bacteria are in a food sample is the aim of the total plate count (TPC) test. It is employed to evaluate the food's general safety as well as any microbiological contamination. The mean square values for the effect of substitution of missi roti multimix have been presented in Table 7. The interaction between the storage period and treatment was non-significant. A higher total plate count was seen in T₃ with a mean of 3.57%, and the lowest total plate count was seen in T₇, having a mean value of 2.78%. The storage study showed a consistent increasing trend in all treatments.

Table 6. Effect of treatment and storage on the Cooking yield (%) of missi roti multimix.

| Treatment | Day 0 | Day 30 | Day 60 | Means |
|-----------|---------------------|----------------------|---------------------|----------------------|
| T0 | 168.50±3.30 | 167.07±3.27 | 165.34±3.24 | 166.97 ^d |
| T1 | 171.87±3.37 | 170.23±3.33 | 168.50±3.30 | 170.2 ^{bcd} |
| T2 | 174.72±3.42 | 172.99±3.39 | 171.15±3.35 | 172.9 ^{ab} |
| T3 | 177.27±3.47 | 175.54±3.44 | 173.60±3.40 | 175.47 ^a |
| T4 | 175.95±3.45 | 174.21±3.41 | 172.27±3.37 | 174.14 ^{ab} |
| T5 | 173.80±3.40 | 172.07±3.37 | 170.23±3.33 | 172 ^{abc} |
| T6 | 171.25±3.35 | 169.52±3.32 | 167.79±3.29 | 169.5 ^{bcd} |
| T7 | 169.62±3.32 | 167.89±3.29 | 166.05±3.25 | 167.8 ^{cd} |
| Means | 172.87 ^a | 171.19 ^{ab} | 169.36 ^b | |

Means that do not share the same letters within columns or rows differ significantly ($p < 0.05$)

Table 7. Effect of treatment and storage time on the total plate count (\log_{10} CFU/mL) of missi roti multimix.

| Treatment | Day 0 | Day 30 | Day 60 | Means |
|-----------|--------------------|---------------------|---------------------|--------------------|
| T0 | 2.14±0.04 | 2.85±0.05 | 3.67±0.07 | 2.89 ^g |
| T1 | 2.34±0.04 | 3.16±0.06 | 3.97±0.07 | 3.162 ^e |
| T2 | 2.55±0.05 | 3.36±0.06 | 4.18±0.08 | 3.366 ^c |
| T3 | 2.74±0.05 | 3.57±0.07 | 4.38±0.08 | 3.57 ^a |
| T4 | 2.65±0.05 | 3.46±0.06 | 4.28±0.08 | 3.468 ^b |
| T5 | 2.44±0.04 | 3.26±0.06 | 4.08±0.08 | 3.264 ^d |
| T6 | 2.24±0.04 | 3.06±0.06 | 3.87±0.07 | 3.06 ^f |
| T7 | 2.04±0.04 | 2.75±0.05 | 3.57±0.07 | 2.788 ^h |
| Means | 2.397 ^c | 3.1875 ^b | 4.0035 ^a | |

Means that do not share the same letters within columns or rows differ significantly ($p < 0.05$)

Physical analysis

Color

Food color is an important parameter that is appreciated by consumers and acceptance of products. It gives consumers an immediate impression of the freshness, flavor, and quality of the product. Color analysis is denoted in three values L^* , a^* , and b^* values. L^* value shows the brightness and darkness. It ranges from 0 to 100. AE is based on the L^* value. In the current study, different concentrations of wheat flour, chickpea flour, and yellow lentil flour were added for the preparation of missi roti and the samples were analyzed for L^* value. The highest L^* value was seen in T₀ having a mean of 86.19%, and the lowest L^* value was seen in T₇ with a mean of 75.48%. The highest a^* value was seen in T₄ with a mean of 3.298%, and the lowest a^* value was seen in T₇ with a mean of 1.224%. The highest b^* value was seen in T₇ with a mean of 23.46%, and the lowest b^* value was seen in T₀ with a mean of 9.962%. The L , a , and b values showed reduction over time and the results were in accordance with Yadav et al. (2020).

Texture

Food rheology can be directly correlated with the texture of the food, which is its physical and chemical contact in the mouth. Food texture includes thickness, smoothness, hardness, and other aspects of mouthfeel. Texture and other

physical characteristics are now frequently employed to describe the condition of the corresponding food product. A double mechanical compression test forms the basis for texture analysis, providing insights into the behavior of materials during the chewing process. The main advantage of Texture Profile Analysis (TPA) is that the double compression cycle produces a substantial array of parameters. Texture analysis for missi roti multimix was measured. The highest value was seen in T₇ with a mean of 5.5167% and the lowest value was seen in T₄ with a mean of 4.63%.

Sensory evaluation

Sensory analysis of the parameters of aroma, taste, color, texture, and overall acceptability was done of the missi roti. Sensory evaluation conducted by trained panelists. The texture of the product was evaluated for overall mouthfeel. Color evaluated for product appeal. The aroma was evaluated for freshness and unusual odors of the products. The results for sensory evaluation showed a decrease during storage duration. The results were in agreement with the study of Sharma et al. (2021).

Table 8. Effect of treatment and storage on the color of missi roti multimix.

| Treatment | Storage Duration (days) | L* | a* | b* |
|-----------|-------------------------|------------------------|----------------------|----------------------|
| T0 | 0 | 86.7 ^a | 1.5300 ^{jk} | 10.200 ^{lm} |
| | 30 | 86.19 ^{ab} | 1.4280 ^{kl} | 9.996 ^{lm} |
| | 60 | 85.68 ^{abc} | 1.3260 ^{lm} | 9.690 ^m |
| T1 | 0 | 84.66 ^{abcd} | 2.0400 ^g | 11.220 ^{jk} |
| | 30 | 84.15 ^{abcd} | 1.8360 ^h | 10.710 ^{kl} |
| | 60 | 83.64 ^{abcd} | 1.7340 ^{hi} | 10.200 ^{lm} |
| T2 | 0 | 83.64 ^{abcd} | 2.5500 ^e | 12.240 ^{hi} |
| | 30 | 83.13 ^{abcd} | 2.3460 ^f | 11.730 ^{ij} |
| | 60 | 82.62 ^{abcd} | 2.0400 ^g | 11.220 ^{jk} |
| T3 | 0 | 82.62 ^{abcd} | 3.0600 ^c | 13.260 ^{fg} |
| | 30 | 82.11 ^{abcde} | 2.8560 ^d | 12.750 ^{gh} |
| | 60 | 81.6 ^{bcdde} | 2.5500 ^e | 12.240 ^{hi} |
| T4 | 0 | 81.6 ^{bcdde} | 3.5700 ^a | 14.280 ^e |
| | 30 | 81.09 ^{cde} | 3.2640 ^b | 13.770 ^{ef} |
| | 60 | 80.58 ^{de} | 3.0600 ^c | 13.260 ^{fg} |
| T5 | 0 | 82.11 ^{abcde} | 3.0600 ^c | 13.770 ^{ef} |
| | 30 | 81.6 ^{bcdde} | 2.8560 ^d | 13.260 ^{fg} |
| | 60 | 81.09 ^{cde} | 2.5500 ^e | 12.750 ^{gh} |
| T6 | 0 | 83.13 ^{abcd} | 2.0400 ^g | 12.240 ^{hi} |
| | 30 | 82.62 ^{abcd} | 1.8360 ^h | 11.730 ^{ij} |
| | 60 | 71.4 ^g | 1.7340 ^{hi} | 22.440 ^c |
| T7 | 0 | 77.52 ^{ef} | 0.8160 ⁿ | 25.500 ^a |
| | 30 | 75.48 ^{fg} | 1.2240 ^m | 23.460 ^b |
| | 60 | 73.44 ^{fg} | 1.6320 ^{ij} | 21.420 ^d |

Table 9. Effect of treatment and storage on the texture of missi roti multimix.

| Treatment | Day 0 | Day 30 | Day 60 | Means |
|-----------|---------------------|---------------------|---------------------|---------------------|
| T0 | 4.91±0.09 | 5.34±0.1 | 5.98±0.12 | 5.4121 ^a |
| T1 | 4.65±0.09 | 5.08±0.1 | 5.63±0.11 | 5.12 ^b |
| T2 | 4.36±0.08 | 4.74±0.09 | 5.28±0.1 | 4.7944 ^c |
| T3 | 4.03±0.08 | 4.41±0.09 | 4.95±0.1 | 4.4633 ^e |
| T4 | 4.2±0.08 | 4.57±0.09 | 5.12±0.1 | 4.63 ^d |
| T5 | 4.44±0.09 | 4.81±0.09 | 5.36±0.11 | 4.8711 ^c |
| T6 | 4.73±0.09 | 5.14±0.09 | 5.69±0.11 | 5.1878 ^b |
| T7 | 5.02±0.1 | 5.47±0.11 | 6.06±0.12 | 5.5167 ^a |
| Means | 4.5437 ^c | 4.9458 ^b | 5.5088 ^a | |

Means that do not share the same letters within columns or rows differ significantly ($p < 0.05$)

Table 10. Effect of treatment and storage on the sensory evaluation of missi roti multimix.

| Treatment | Storage Duration (days) | Aroma | Color | Flavor | Taste | Overall acceptability |
|-----------|-------------------------|--------------------------|-------------------------|---------------------------|----------------------------|--------------------------|
| T0 | 0 | 7.1604 ^{defghi} | 7.4664 ^{cdef} | 7.599 ^a | 7.68 ^{bcde} | 7.548 ^{def} |
| | 30 | 9.9564 ^{fghi} | 7.2624 ^{defg} | 7.395 ^{abcd} | 7.4733 ^{cdefghi} | 7.34 ^{defghi} |
| | 60 | 6.7524 ⁱ | 7.0584 ^{fg} | 7.19 ^{abcdef} | 7.2717 ^{efghij} | 7.14 ^{fghi} |
| T1 | 0 | 7.3542 ^{cdefg} | 7.599 ^{bcde} | 7.5174 ^{abc} | 7.84 ^{abc} | 7.4664 ^{defg} |
| | 30 | 7.1502 ^{defghi} | 7.395 ^{cdefg} | 7.311 ^{abcdef} | 7.6333 ^{bcdefg} | 7.2624 ^{efghi} |
| | 60 | 6.9462 ^{ghi} | 7.191 ^{efg} | 7.1033 ^{cdefg} | 7.4358 ^{cdefghi} | 7.0584 ^{ghi} |
| T2 | 0 | 7.2114 ^{defgh} | 7.8438 ^{abc} | 7.293 ^{abcdef} | 7.5233 ^{bcdefghi} | 7.7622 ^{bcd} |
| | 30 | 7.0074 ^{efghi} | 7.6398 ^{bcde} | 7.089 ^{cdefg} | 7.32 ^{defghij} | 7.5582 ^{cdef} |
| | 60 | 6.8034 ^{hi} | 7.4358 ^{cdefg} | 6.8833 ^{fg} | 7.1133 ^{ij} | 7.3542 ^{defghi} |
| T3 | 0 | 7.395 ^{cdef} | 7.701 ^{abcd} | 7.3746 ^{abcde} | 7.6033 ^{bcdefgh} | 7.395 ^{defgh} |
| | 30 | 7.191 ^{defghi} | 7.395 ^{cdefg} | 7.1706 ^{abcdefg} | 7.4033 ^{cdefghij} | 7.191 ^{efghi} |
| | 60 | 6.987 ^{fghi} | 7.191 ^{efg} | 6.9633 ^{defg} | 7.2 ^{fghij} | 6.987 ^{hij} |
| T4 | 0 | 8.16 ^a | 8.16 ^a | 7.6092 ^a | 8.16 ^a | 8.313 ^a |
| | 30 | 7.956 ^{ab} | 7.956 ^{ab} | 7.4033 ^{abcd} | 7.9533 ^{ab} | 8.211 ^{ab} |
| | 60 | 7.752 ^{abc} | 7.752 ^{abc} | 7.2 ^{abcdef} | 7.75 ^{abcd} | 8.007 ^{abc} |
| T5 | 0 | 7.2114 ^{defgh} | 7.8438 ^{abc} | 7.14 ^{bcdefg} | 7.37 ^{defghi} | 7.293 ^{efghi} |
| | 30 | 7.0074 ^{efghi} | 7.6398 ^{bcde} | 6.9333 ^{efg} | 7.17 ^{hij} | 7.089 ^{ghi} |
| | 60 | 6.8034 ^{hi} | 7.4358 ^{cdefg} | 6.73 ^g | 6.9633 ^j | 6.579 ^j |
| T6 | 0 | 7.548 ^{bcd} | 7.395 ^{cdefg} | 7.5276 ^{abc} | 7.65 ^{bcdef} | 7.344 ^{defghi} |
| | 30 | 7.344 ^{cdefg} | 7.191 ^{efg} | 7.32 ^{abcdef} | 7.45 ^{cdefghi} | 7.14 ^{fghi} |
| | 60 | 7.14 ^{defghi} | 6.987 ^g | 7.1133 ^{cdefg} | 7.24 ^{efghij} | 6.936 ^{ij} |
| T7 | 0 | 7.4473 ^{cde} | 7.6704 ^{bcd} | 7.5587 ^{ab} | 7.5933 ^{bcdefgh} | 7.599 ^{cde} |
| | 30 | 7.242 ^{defgh} | 7.4664 ^{cdef} | 7.34 ^{abcde} | 7.3933 ^{cdefghij} | 7.395 ^{defgh} |
| | 60 | 7.038 ^{efghi} | 7.2624 ^{defg} | 7.14 ^{bcdefg} | 7.1907 ^{ghij} | 7.191 ^{efghi} |

CONCLUSION

Among the different treatments, the T4 formulation, which contained a specific blend of wheat flour, yellow lentil flour, and chickpea flour achieved the highest scores across most sensory parameters. T4 consistently outperformed other formulations in terms of texture, taste, aroma, and overall acceptability, indicating that it was the most favored by the sensory panel. This suggests that the combination of these particular flours not only enhances the nutritional content of the missi roti multimix but also improves its sensory qualities, making it a viable option for commercial production. Based on the comprehensive analysis, the T4 formulation emerged as the best treatment, offering a balance of high nutritional value, good sensory qualities, and stability over the 2-month storage period. This formulation, which includes wheat flour, chickpea flour, and yellow lentil flour, was particularly well-received in terms of taste and texture, and it maintained its quality throughout the storage period better than other treatments. The results of this research demonstrate the potential of missi roti multimix to be used in the development of nutritious, safe, and convenient food products, addressing the increasing consumer demand for healthy alternatives. The multimix made with T4 formulation can be used to develop protein-enriched food that is helpful to overcome nutritional deficiencies. It can be marketed as a convenient and ready to make food product that can overcome nutritional needs.

AUTHOR'S CONTRIBUTION

Malaika Tayyab prepared the manuscript; Muhammad Atif Randhawa done the proof reading of the manuscript; Muhammad Aamir and Ali Hassan cross checked the manuscript.

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All data of the research is available in the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable. This research did not involve human participants or animals.

CONSENT FOR PUBLICATION

All authors have consented to participate in the publication.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interest

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