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# Development and Evaluation of Multigrain Flour for Traditional Recipes

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## Abstract

In the past few years, the people have shown more attention towards eating the multigrain food products made from multigrain flour. Eating multigrain flour recipes helps in prevention and better management of different types of chronic diseases. Multigrain flour is the rich source of protein, fiber, vitamins, minerals and energy. Not just nutrient rich it's a tasty, digestive, affordable, locally available and energetic ingredient used for making the various value-added recipes. Therefore the major objective of the study was to Develop and Evaluate the Multigrain flour for making various Indian traditional recipes. Total three traditional recipes were prepared from 14 multigrain flour treatments. Sensory evaluation of these recipes was done by using composite rating scale. Data obtained during study were statistically analyzed using completely randomized design(CRD). Shelf life of the flour was up to 3 months. All the 14 treatments were orgenoleptically acceptable. However, the developed multigrain flour consisted of wheat flour (65%) and bajara, amaranth, oats, soyabean and ragi (each grain 5%) along with blackgram dhal flour (10%) was highly acceptable, also improved the taste and nutritional quality of the traditional Indian recipes especially puri and paratha. Rheologically, the dough also showed good extensibility which is desired quality for all these recipes. It was also accepted for making chapatti.

**Key words**: Multigrain flour, sensory evaluation, traditional recipes, shelf life, nutrients

## INTRODUCTION:

- Multi-grain flour is a combination of different flours including cereals and pulses. Pulse is the important food crop due to the high protein and essential amino acid content. Pulses are 20-25% protein by weight. The digestibility of protein is quite high. Due to lack of methionine, consuming it with grains which are deficient in lysine provides a complete diet of protein. It also provides complete carbohydrates, several vitamins, iron, magnesium, phosphorus and zinc. Ragi provide high amount of amino acid methionine, calcium, vitamins and fiber. Legumes are a rich source of protein and form a major component of a vegetarian diet. Now a days demand of multigrain food have increased in the market as people are more aware regarding the facts that multigrain food helps in reducing and managing chronics diseases (Niu M, Hou G G, KindelspireJ, et al. (2017) and Zhang N, Xiu L, Min W H, et al (2014). Some researcher also have found that consuming multigrain food is linked with the decreasing risks in cardiovascular diseases and metabolic risk factors Ahn Y, Park S, Kwack H, *et al.* (2013), and Anderson J W (2003). In view of the facts regarding nutritional quality of cereal, pulses and oil seeds, combination of different ratio of various ingredients (ICMR, 2002) were mixed to develop acceptable multigrainflour. Therefore, along with wheat and bajara, soybean, ragi, oat, black gram dal flour and amaranth was added in the flour.

**OBJECTIVES**:

1. To develop and standardize the multigrain flour from locally available food grains
2. Toe valuate the multigrain flour for preparation of Indian recipes, i.e. Chapati, Puri, Paratha and its sensorial quality
3. To assess the nutritional profile of multigrain flour
4. To analyze the multigrain flour for its shelf life
5. To measure rheological properties of the developed multigrain flour.

**MATERIALS AND METHODS**

Grains selected for the study viz. wheat, bajara, amaranth, oat, soybean, ragi, black gram dhal, were purchased from the local market in Sardarkrushinagar, Gujarat. Grains were selected on the basis of nutritional profile (Gopalan et al.1989.), price and local availability.Multigrain flours were prepared by substituting the wheat flour with all other grain flours as shown in Table 1**.** Total three recipes were prepared namely Chapati, Paratha and Puri.Sensory evaluation was carried out using composite rating scale. Consumer acceptance was also carried out to check the acceptability of the multigrain flour for making and eating qualities of chapati, puri and paratha. More than 25 respondents were provided the best rated multigrain flour and were asked to prepare the chapati, puriand paratha at home and they were asked to rate the quality of each product after testing on 9 point hedonic scale rating. The prepared composite flours were stored in airtight glass bottles and shelf life was evaluated at an interval of 7 day for 3 months.The moisture, fat, protein, crude fiber, mineral (iron & Calcium) content of best rated composite flour was estimated by standard methods using reference book published by NIN. All the different samples of flour were kneaded into smooth dough which then was pressed and rested in the Kieffer Dough and Extensibility Rig's Dough Press attachment for 40 min. The dough so obtained was ten cut into thin strips using the same rig's Cutting Attachment. The strips so obtained were loaded onto the test platform for extensibility test. The Kieffer rig was affixed on the machine base. It was ensured that the hook probe was covered with the plastic sleeve to prevent it from shearing through the sample. The hook probe was lowered to just above the upper surface of the spring loaded clamp and the strip of dough/ gluten was placed onto the grooved region of the sample plate and, holding down the spring clamp lever was loaded. The plate was then inserted into the rig and handle was released slowly. Completely Randomized Design (CRD) was used for data analysis.

**RESULTS AND DISCUSSION**

The study was conducted in 2015 to 2019 at ASPEE College of Home Science and Nutrition, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. There are very few data available on the standardization of multigrain flour. Keeping this in view, Multigrain Flours were prepared by mixing locally available ingredients namely wheat, bajara, amaranth, oat, soybean, ragi and black gram dhal in different proportion.

**Preparation of Multigrain Flour**: The proportion of each ingredient was different in all the 14 developed flours as stated in Table 1.

**Quality parameters of flour**: Percent absorption and Quality of dough made up from multigrain flour was also evaluated and presented in Table 2. The results obtained revealed that $T_{1,}$ i.e. wheat flour absorbed slightly higher water, pale yellow in colour and it was non sticky on touch where as other treatments contained different grains in different proportion, i.e multigrain flour absorbed 65 to 84% of water, dull white to dark brownish in colour and slight sticky to very sticky on touch. This was may be due to the color pigments of the different grains and different binding capacity.

**Shelf-life / Storage study of Multigrain Flour**: The shelf life of a product can be defined as the time phase in which the product is safe and has acceptable qualities to be purchased and consumed. The shelf life study was done for period of 3 months. The results indicated that $T_{12}$ where ragi and wheat were main ingredients smells rancid from the 35$^{th}$ day of storage. There was no significant change found in all other 13 treatments. Therefore, it can be concluded that the flour is safe for consumption for up to 3 months under standard storage conditions. (Table 3)

**Preparation of recipes**: Three Indian recipes, i.e. chapati, puri and paratha were prepared from this Multigrain flour (Figure 1) and comparison was made between each type of treatments to evaluate which level of proportion is highly acceptable and sensory evaluation was carried out.

**Sensory Evaluation**: Sensory evaluation of three standardized *recipes viz.* chapati, puri and paratha was carried out using Composite Rating Scale. The same dough was used to prepare chapati, puri and paratha. These were coded as $T_1$ to $T_{14}$.Semi trained panel members were enrolled to rate various attributes of each food preparations. Seven attributes were included for composite rating scale. All three recipes prepared from Multigrain flour were found to be orgenoleptically acceptable. However, the acceptable level of flour varied in different food preparation and different treatments of one food recipe. The mean scores for various sensory traits for the recipe chapati are mentioned in Table 4.

As per the Chakrabarti-Bell et al. 2013 *Chapatis* are unleavened flat breads and a staple food made in every Indian homes. *Atta* flour is widely used to make *chapatis* and is obtained by grinding wheat in stone *chakkis*. Supplementing *atta* with various other grain and legumes flours increases protein and mineral content and therefore increases the nutritional content of *chapatis*. Grains differ in their nutritional composition; some are richer in one nutrient and others in different nutrients. Therefore different grains and legumes can be selected based on their nutrient composition and combined to produce more nutritious flours to get more wholesome and balanced food. Since *wheat* is the staple food, *chapatis* with multigrain flour can be a healthier option without changing the food habits and are also being eaten at least twice a day by a majority of the population in India. Multigrain flour brings significant differences in the various sensory attributes of chapati. A typical wheaty aroma and creamish white in color was desirable for any homemade chapati which was found in control chapati, but in multigrain flour chapati, it became bland in taste and dark in color. As expected, overall acceptability of the chapatis was found to be highest for T1 i.e. control chapati. However, the T2 and T3 chapati were nearer to the overall acceptability scores of chapati form control.

Table 5 depict the mean scores of the attributes of the recipes puri. Here, $T_{14}$ gained maximum score followed by $T_{13}$ and $T_{11}$.

In the recipe paratha (Table 6), $T_{13}$ scored highest followed by $T_1$ and $T_2$. No significant differences were found between treatments of both the recipe puri and paratha. This may be due to the use of different cooking process like roasting, deep fat fraying and shallow fat fraying in chapati, puri and paratha respectively. As fat improves the textural quality of same mouth feels which hinder to differentiate the sensory attribute of treatments. Similar course grain products were prepared by Baljeet et al. (2010), Desai et al. (2009) and Kumar et al. (2013).

**Consumer acceptance test**: Consumers scored the acceptability of multigrain flour sample using 9 point hedonic rating scale that varied from 'like extremely' to 'dislike extremely'. The targeted three multigrain products were chapatti, puri and paratha. The results indicated that the highest scored treatment was $T_{13}$ among all of the 14 multigrain flour treatments. Multigrain flour paratha received the highest mean score i.e. 7.76 followed by multigrain

puri (7.41) and multigrain chapati (6.94). (Table 7 , Figure 2) Based on consumer acceptance analysis, it was found that all the multigrain products scored like moderately to like slightly; however there is a need for larger consumer acceptance to increase the consumption of multigrain products at household levels.

In the present study, T13 was found to be the highest rated which contained higher percent of black gram dhal. Incorporation of black gram dhal at 10% level in the blend gives the appropriate taste and other attributes of the recipes and thus it is recommended.

**Nutritional Profile**: Nutrient contents of all fourteen treatments was assessed and presented in Table 8. Results of nutritional profile showed that moisture content of $T_1$ was 12.20% whereas, in $T_{13}$ it was found 11.74%. Protein content was highest in multigrain flour i.e. $T_{13}$ (14.59%) as compared to $T_1$ (11.8%). Data also depicts that 1.20% and 1.95% fat present in $T_1$ and $T_{13}$ respectively. Fiber content of $T_{13}$ was found to be higher (1.95%) whereas $T_1$ has 1.2% fiber. In $T_1$, iron and calcium content was 4.90 mg and 48.0 mg respectively, where as in $T_{13,}$ iron content was 5.42 mg and calcium content was 105.9 mg.(Table 8)

**Rheological properties of the dough/flour**: The dough was prepared and the extensibility and resistance of the dough was measured. Once the test commences, the hook then proceeds to centrally extend the dough sample until its elastic limit (at the maximum force) is exceeded and the dough separates. At this point the distance was noted and used as an indication of dough extensibility. The results showed that $T_9$, $T_{10}$ and $T_{12}$ showed the resistance to extension in similar range, which is drastically different from that of other treatments. Thus, It can be concluded that these 3 flour samples will not extend much and thus the use of these flour samples may be different as compared to the rest of the lot.(Table 9)

**Conclusion**:

The developed multigrain flour consisted of wheat flour (65%) and bajara, amaranth, oats, soyabean and ragi (each grain 5%) along with blackgram dhal flour (10%) was highly acceptable, also improved the taste and nutritional quality of the traditional Indian recipes especially puri and paratha. Rheologically, the dough also showed good extensibility which is desired quality for all these recipes. It was also accepted for making roti/chapati. Further, nutritional profile showed that It was rich it the nutrient such as protein, calcium and iron and fiber than normal wheat flour. It has a long shelf life and safe for consumption till 3 months period under standard storage conditions. Thus, it is recommended that the developed multigrain flour can be used for Indian recipes for enhancing the nutrients.

**REFERENCES**


- A, Y., Park, S., Kwack, H., 2013. Rice-eating pattern and the risk of metabolic syndrome especially waist; circumference in Korean Genome and Epidemiology Study (KoGES) *BMC Public Health*, 13 (1): 61.
- Anderson, J, W., 2010. Whole grains protect against atherosclerotic cardiovascular disease. *Proceedings of the Nutrition Society*, 62 (1): 135-142.
- Baljeet, S.Y., Ritika, B.Y., and Roshan, L.Y., 2010. Studies on functional properties and incorporation of buckwheat flour for biscuit making, *International Food Research Journal*, 17:1067-1076.
- Chakrabarti, Bell, S., Wang, S., Patel, MJ., Weiss, RM., Austin, PJ., 2013. Bubbles in chapatti doughs. *J Cereal Sci*. ; 57: 504–513.
- Anuradha, D,Desai., Sharduli, S, Kulkarni., A, K, Sahoo., R, C., Ranveer and P, B,Dandge., 2010. Effect of Supplementation of Malted Ragi Flour on the Nutritional and Sensorial Quality Characteristics of Cake, *Advance Journal of Food Science and Technology*. 2 (1): 67-71. Gopalan, C., Ramasastry, BV., Balasubramanian, SC., 1989. Nutritivevalues of Indian foods (NVIF).

National Institute of Nutrition,Hyderabad.

- Kumar, Vijaya., M,Chappalwar., Dayanand, Peter., H,Bobde., Steffi, M, John., 2013. Quality characteristics of cookies prepared from oats and finger millet based composite flour, *An International Journal of Engineering Science and Technology.* 3: 432-455.
- Zhang, N., Xiu, L., Min, W. H., 2014. The nutrition compound and valuation of the whole nutrition of maize. *Food Industry.* 35 (6) : 98-101.
- iu, M., Hou, G,G., Kindelspire, J., 2017. Microstructural, textural, and sensory properties of whole-wheat noodles modified by enzymes and emulsifiers. *Food Chemistry*. 223: 16-24.
- Pande, S., Sakhare, S. D., Bhosale, M. G., Haware, D. J., & Inamdar, A. A. 2017. Atta (whole wheat flour) with multi-wholegrains: flour characterization, nutritional profiling and evaluation of chapati making quality. *Journal of food science and technology.* 54(11): 3451–3458.

## DATA TABLES AND FIGURES

**Table 1: Proportion of different ingredients used to develop multigrain flour.**

| Treatment No. | Wheat | Bajara | Ama-ranth | Oat | Soy-bean | Ragi | Black gram dhal | Total |
|---|---|---|---|---|---|---|---|---|
| | (g) | (g) | (g) | (g) | (g) | (g) | (g) | (g) |
| $T_1$ | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 100 |
| $T_2$ | 70 | **5** | 5 | 5 | 5 | 5 | 5 | 100 |
| $T_3$ | 65 | **10** | 5 | 5 | 5 | 5 | 5 | 100 |
| $T_4$ | 60 | **15** | **5** | 5 | 5 | 5 | 5 | 100 |
| $T_5$ | 65 | 5 | **10** | 5 | 5 | 5 | 5 | 100 |
| $T_6$ | 60 | 5 | **15** | **5** | 5 | 5 | 5 | 100 |
| $T_7$ | 65 | 5 | 5 | **10** | 5 | 5 | 5 | 100 |
| $T_8$ | 60 | 5 | 5 | **15** | **5** | 5 | 5 | 100 |
| $T_9$ | 65 | 5 | 5 | 5 | **10** | 5 | 5 | 100 |
| $T_{10}$ | 60 | 5 | 5 | 5 | **15** | **5** | 5 | 100 |
| $T_{11}$ | 65 | 5 | 5 | 5 | 5 | **10** | 5 | 100 |
| $T_{12}$ | 60 | 5 | 5 | 5 | 5 | **15** | **5** | 100 |
| $T_{13}$ | 65 | 5 | 5 | 5 | 5 | 5 | **10** | 100 |
| $T_{14}$ | 60 | 5 | 5 | 5 | 5 | 5 | **15** | 100 |

**Figure.1: Method of preparation of multigrain flours**

Step 1: Cleaning and sun drying of grains
Step 2: Milling the grain separately
Step 3: Mixing different flours to develop Multigrain flour
Step 4: Mixing thoroughly (Avoid sieving to retain the fibre content)
Step 5: Packaging of Multigrain flours

**Table 2: Quality of dough made up from multigrain flour**

| Treatment | % $H_2O$ absorption (ml) | Colour of dough | Nature of dough |
|---|---|---|---|
| $T_1$ | 86 | Yellowish | Non sticky |
| $T_2$ | 84 | Creamish white | Slight sticky |
| $T_3$ | 78 | Light creamish white | Sticky |
| $T_4$ | 77 | Light brownish white | Very sticky |
| $T_5$ | 75 | Dull white | Sticky |
| $T_6$ | 76 | Dull white | Non sticky |
| $T_7$ | 74 | Dull white | Slight sticky |
| $T_8$ | 72 | Dull white | Very sticky |
| $T_9$ | 70 | Brownish white | Sticky |
| $T_{10}$ | 70 | Brownish white | Sticky |
| $T_{11}$ | 73 | Brownish white | Sticky |
| $T_{12}$ | 74 | Dark Brownish white | Slight sticky |
| $T_{13}$ | 71 | Brownish white | Very sticky |
| $T_{14}$ | 65 | Brownish white | Very sticky |

**Table 3: Shelf life study of multigrain flour**

| Storage Period | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | T9 | T10 | T11 | T12 | T13 | T14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day 0 | 8.90 | 8.90 | 8.90 | 8.80 | 9.00 | $9.00^{a}$ | $9.00^{a}$ | $9.00^{a}$ | $9.00^{a}$ | 9.00 | $9.00^{a}$ | $8.90^{a}$ | 9.00 | $9.00^{a}$ |
| Day 7 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 | $9.00^{a}$ | $9.00^{a}$ | $9.00^{a}$ | $9.00^{a}$ | 9.00 | $9.00^{a}$ | $9.00^{a}$ | 9.00 | $9.00^{a}$ |
| Day 14 | 8.90 | 8.80 | 9.00 | 8.90 | 8.80 | $8.90^{a}$ | $8.90^{a}$ | $8.90^{ab}$ | $9.00^{a}$ | 8.90 | $8.80^{b}$ | $9.00^{a}$ | 8.90 | $9.00^{a}$ |
| Day 21 | 8.70 | 8.80 | 8.80 | 8.80 | 9.00 | $8.60^{ab}$ | $8.60^{b}$ | $8.70^{abc}$ | $9.00^{a}$ | 9.00 | $9.00^{a}$ | $8.60^{a}$ | 9.00 | $9.00^{a}$ |
| Day 28 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 | $9.00^{a}$ | $9.00^{a}$ | $9.00^{a}$ | $9.00^{a}$ | 9.00 | $9.00^{a}$ | $9.00^{a}$ | 9.00 | $9.00^{a}$ |
| Day 35 | 8.80 | 8.80 | 9.00 | 9.00 | 9.00 | $9.00^{a}$ | $9.00^{a}$ | $9.00^{a}$ | $9.00^{a}$ | 9.00 | $9.00^{a}$ | $8.70^{a}$ | 9.00 | $9.00^{a}$ |
| Day 42 | 9.00 | 9.00 | 9.00 | 9.00 | 9.00 | $9.00^{a}$ | $9.00^{a}$ | $9.00^{a}$ | $9.00^{a}$ | 9.00 | $9.00^{a}$ | $2.90^{b}$ | 9.00 | $9.00^{a}$ |
| Day 49 | 8.50 | 8.80 | 8.90 | 8.60 | 8.70 | $8.80^{ab}$ | $8.90^{a}$ | $8.90^{ab}$ | $9.00^{a}$ | 9.00 | $9.00^{a}$ | $1.80^{c}$ | 9.00 | $9.00^{a}$ |
| Day 56 | 8.80 | 9.00 | 9.00 | 9.00 | 9.00 | $8.30^{b}$ | $9.00^{a}$ | $9.00^{a}$ | $9.00^{a}$ | 9.00 | $9.00^{a}$ | $1.40^{cd}$ | 9.00 | $9.00^{a}$ |
| Day 63 | 8.70 | 8.90 | 8.90 | 8.80 | 9.00 | $5.40^{c}$ | $9.00^{a}$ | $9.00^{a}$ | $9.00^{a}$ | 9.00 | $9.00^{a}$ | $1.00^{d}$ | 9.00 | $9.00^{a}$ |
| Day 70 | 8.80 | 8.50 | 9.00 | 8.90 | 8.80 | $4.80^{d}$ | $8.80^{ab}$ | $8.50^{c}$ | $9.00^{a}$ | 8.90 | $8.80^{b}$ | $1.20^{d}$ | 8.90 | $8.80^{b}$ |
| Day 77 | 8.90 | 8.90 | 8.80 | 8.90 | 9.00 | $4.60^{d}$ | $8.90^{a}$ | $8.90^{ab}$ | $8.80^{b}$ | 8.90 | $9.00^{a}$ | $1.20^{d}$ | 8.90 | $9.00^{a}$ |
| Day 84 | 8.80 | 8.60 | 9.00 | 8.70 | 8.80 | $4.90^{cd}$ | $8.80^{ab}$ | $8.60^{bc}$ | $9.00^{a}$ | 8.70 | $8.80^{b}$ | $1.00^{d}$ | 8.70 | $8.80^{b}$ |
| Day 90 | 9.00 | 8.90 | 8.80 | 9.00 | 9.00 | $5.00^{cd}$ | $9.00^{a}$ | $8.90^{ab}$ | $8.80^{b}$ | 9.00 | $9.00^{a}$ | $1.00^{d}$ | 9.00 | $9.00^{a}$ |
| SE(d) | 0.16 | 0.17 | 0.10 | 0.15 | 0.12 | 0.26 | 0.12 | 0.15 | 0.07 | 0.10 | 0.08 | 0.27 | 0.10 | 0.07 |
| LSD at 5% | NS | NS | NS | NS | NS | 0.513 | 0.23 | 0.30 | 0.14 | NS | 0.17 | 0.54 | NS | 0.14 |
| CV(%) | 4.25 | 4.38 | 2.73 | 4.01 | 2.97 | 7.78 | 2.88 | 3.83 | 1.78 | 2.59 | 2.18 | 13.29 | 2.59 | 1.78 |

**Table 4: Mean scores for the sensory attributes of the recipe chapati (Mean ± SEM) n=16)**

| Treatment | Sensory attributes | | | | | | | Aver-age total score |
|---|---|---|---|---|---|---|---|---|
| | Colour and Appearance (10) | Aroma (10) | Texture (10) | Taste (20) | After taste (10) | Mouth-feel (20) | Overall acceptability (20) | |
| $T_1$ | 8.63 ± 0.13$^{a}$ | 8.38 ± 0.16$^{a}$ | 8.59 ± 0.12$^{a}$ | 17.84 ± 0.17$^{a}$ | 8.31 ± 0.20$^{a}$ | 17.72 ± 0.22$^{a}$ | 18.13 ± 0.16$^{a}$ | 87.60 |
| $T_2$ | 7.84 ± 0.13$^{bcd}$ | 7.84 ± 0.19$^{ab}$ | 7.84 ± 0.19$^{bc}$ | 17.06 ± .27$^{ab}$ | 8.00 ± 0.18$^{ab}$ | 17.19 ± 0.19$^{ab}$ | 17.31 ± 0.15$^{ab}$ | 83.08 |
| $T_3$ | 7.50 ± 0.22$^{bcde}$ | 7.56 ± 0.18$^{bcd}$ | 7.81 ± 0.20$^{bc}$ | 16.81 ±0.29$^{abc}$ | 7.81 ± 0.13$^{abc}$ | 16.84 ± 0.30$^{abc}$ | 16.78 ± 0.31$^{bc}$ | 81.51 |
| $T_4$ | 7.31 ± 0.24$^{cde}$ | 7.38 ± 0.22$^{bcdef}$ | 7.31 ± 0.22$^{cde}$ | 16.88 ± 0.26$^{abc}$ | 7.66 ± 0.19$^{abcde}$ | 16.13 ± 0.27$^{abc}$ | 16.75 ± 0.34$^{bc}$ | 79.42 |
| $T_5$ | 7.19 ± 0.23$^{ef}$ | 7.03 ± 0.32$^{defg}$ | 7.25 ± 0.28$^{cdef}$ | 16.44 ± 0.61$^{bcd}$ | 7.44 ± 0.29$^{bcdef}$ | 16.25 ± 0.54$^{bcde}$ | 16.19 ± 0.49$^{cd}$ | 77.79 |
| $T_6$ | 5.13 ± 0.26$^{b}$ | 5.75 ± 0.30$^{h}$ | 5.31 ± 0.30$^{g}$ | 13.59 ± 0.89$^{f}$ | 6.00 ± 0.30$^{a}$ | 13.88 ± 0.91$^{f}$ | 13.06 ± 0.84$^{e}$ | 62.72 |
| $T_7$ | 7.59 ± 0.2$^{bcde}$ | 7.31 ± 0.25$^{bcdef}$ | 7.38 ± 0.20$^{bcde}$ | 15.84 ± 0.42$^{bcde}$ | 7.31 ± 0.20$^{cdef}$ | 16.25 ± 0.35$^{bcde}$ | 16.56 ± 0.34$^{bc}$ | 78.27 |
| $T_8$ | 6.31 ± 0.25$^{g}$ | 6.63 ± 0.22$^{g}$ | 6.78 ± 0.29$^{ef}$ | 14.69 ± 0.57ef | 6.81 ± 0.28$^{f}$ | 15.00 ± 0.60$^{ef}$ | 15.25 ± 0.48$^{d}$ | 71.47 |
| $T_9$ | 7.22 ± 0.19$^{def}$ | 7.13 ± 0.18$^{cdefg}$ | 7.41 ± 0.17$^{bcde}$ | 15.59 ± 0.51$^{cde}$ | 7.00 ± 0.22$^{ef}$ | 15.91 ± 0.51$^{cde}$ | 16.00 ± 0.43$^{cd}$ | 76.26 |
| $T_{10}$ | 7.94 ± 0.28$^{bc}$ | 7.50 ± 0.20$^{bcde}$ | 8.00 ± 0.24$^{ab}$ | 16.16 ± 0.41$^{bcd}$ | 7.69 ± 0.25$^{abcd}$ | 16.75 ± 0.41$^{abc}$ | 16.68 ± 0.40$^{bc}$ | 80.72 |
| $T_{11}$ | 6.59 ± 0.26$^{fg}$ | 6.75 ± 0.23$^{fg}$ | 6.63 ± 0.32$^{f}$ | 15.25 ± 0.51$^{de}$ | 7.16 ± 0.22$^{cdef}$ | 15.31 ± 0.48$^{de}$ | 15.69 ± 0.51$^{cd}$ | 73.38 |
| $T_{12}$ | 6.59 ± 0.26$^{fg}$ | 6.88 ± 0.85$^{efg}$ | 7.13 ± 0.15$^{def}$ | 16.19 ± 0.36$^{bcd}$ | 7.13 ± 0.27$^{def}$ | 15.88 ± 0.38$^{cde}$ | 15.94 ± 0.30$^{cd}$ | 75.74 |
| $T_{13}$ | 8.00 ± 0.20$^{ab}$ | 7.44 ± 0.29$^{bcde}$ | 7.84 ± 0.23$^{bc}$ | 16.25 ± 0.49$^{bcd}$ | 7.50 ± 0.31$^{bcde}$ | 16.38 ± 0.36$^{bcd}$ | 16.84 ± 0.42$^{bc}$ | 80.25 |
| $T_{14}$ | 7.94 ± 0.21$^{bc}$ | 7.69 ± 0.25$^{bc}$ | 7.72 ± 0.25$^{bcd}$ | 16.53 ± 0.44$^{abcd}$ | 7.50 ± 0.30$^{bcde}$ | 16.31 ± 0.38bed | 16.72 ± 0.56$^{bc}$ | 79.86 |
| **SE(d)** | 0.319$^{*}$ | 0.323$^{*}$ | 0.325$^{*}$ | 0.673$^{*}$ | 0.348$^{*}$ | 0.648* | 0.627$^{*}$ | - |
| **LSD at 5%** | 0.628 | 0.637 | 0.639 | 1.326 | 0.685 | 1.278 | 1.236 | - |
| **CV (%)** | 12.41 | 12.64 | 12.48 | 11.83 | 13.33 | 11.32 | 10.89 | - |

**Table 5: Mean scores for the sensory attributes of the recipe puri (Mean ± SEM) (n=10)**

| Treatment | Sensory attributes | | | | | | | Aver-age total score |
|---|---|---|---|---|---|---|---|---|
| | Colour and Appearance (10) | Aroma (10) | Texture (10) | Taste (20) | After taste (10) | Mouth-feel (20) | Overall acceptabi-lity (20) | |
| $T_1$ | 7.40 ± 0.64 | 7.10 ± 0.61 | 7.20 ± 0.61 | 14.10 ± 0.96 | 6.70 ± 0.65 | 14.00 ± 1.21 | 14.30 ± 1.09 | 70.8 |
| $T_2$ | 7.40 ± 0.56 | 7.10 ± 0.43 | 7.30 ± 0.56 | 15.10 ± 1.07 | 7.10 ± .48 | 14.20 ± 1.20 | 14.90 ± 1.03 | 73.1 |
| $T_3$ | 7.10 ± 0.52 | 7.10 ± 0.38 | 7.00 ± 0.62 | 14.40 ± 1.39 | 7.00 ± 0.52 | 14.20 ± 1.02 | 15.50 ± 0.82 | 72.3 |
| $T_4$ | 7.50 ± 0.56 | 7.20 ± 0.44 | 7.30 ± 0.56 | 15.00 ± 1.31 | 7.20 ± 0.42 | 14.90 ± 1.07 | 14.90 ± 1.01 | 74 |
| $T_5$ | 7.40 ± 0.43 | 6.70 ± 0.51 | 7.20 ± 0.50 | 14.90 ± 1.31 | 6.60 ± 0.52 | 14.10 ± 0.99 | 14.40 ± 0.96 | 71.3 |

| Treatment | Sensory attributes | | | | | | | Average total score |
|---|---|---|---|---|---|---|---|---|
| | Colour and Appearance (10) | Aroma (10) | Texture (10) | Taste (20) | After taste (10) | Mouth-feel (20) | Overall acceptability (20) | |
| $T_6$ | 7.20 ± 0.39 | 7.10 ± 0.38 | 8.00 ± 0.42 | 14.30 ± 1.20 | 7.30 ± 0.42 | 13.70 ± 1.10 | 15.50 ± 0.86 | 73.1 |
| $T_7$ | 7.80 ± 0.35 | 7.40 ± 0.37 | 8.00 ± 0.27 | 14.90 ± 1.13 | 7.40 ± 0.34 | 13.80 ± 0.84 | 15.70 ± 0.80 | 75 |
| $T_8$ | 7.60 ± 0.48 | 7.10 ± 0.53 | 7.90 ± 0.38 | 14.50 ± 1.23 | 6.80 ± 0.55 | 14.80 ± 0.81 | 15.40 ± 0.82 | 74.1 |
| $T_9$ | 7.80 ± 0.42 | 7.50 ± 0.28 | 7.80 ± 0.39 | 15.10 ± 0.99 | 7.60 ± 0.40 | 15.00 ± 0.88 | 16.10 ± 0.75 | 76.9 |
| $T_{10}$ | 7.80 ± 0.36 | 7.40 ± 0.37 | 7.80 ± 0.42 | 15.40 ± 0.88 | 7.80 ± 0.42 | 15.20 ± 0.68 | 16.20 ± 0.59 | 77.6 |
| $T_{11}$ | 7.80 ± 0.44 | 7.50 ± 0.26 | 8.00 ± 0.40 | 15.90 ± 0.88 | 7.90 ± 0.28 | 15.50 ± 0.68 | 16.70 ± 0.58 | 79.3 |
| $T_{12}$ | 6.80 ± 0.47 | 7.00 ± 0.41 | 7.50 ± 0.46 | 15.00 ± 0.88 | 7.50 ± 0.45 | 14.60 ± 0.67 | 15.70 ± 0.60 | 74.1 |
| $T_{13}$ | 8.00 ± 0.50 | 7.60 ± 0.48 | 8.20 ±0.50 | 16.20 ± 0.68 | 8.00 ± 0.39 | 15.60 ± 0.60 | 16.80 ± 0.53 | 80.4 |
| $T_{14}$ | 8.40 ± 0.45 | 7.80 ± 0.40 | 8.50 ± 0.30 | 16.60 ± 0.77 | 8.00 ± 0.38 | 15.80 ± 0.66 | 16.90 ± 0.54 | 82 |
| SE(d) | 0.672 | 0.599 | 0.658 | 1.484 | 0.642 | 1.287 | 1.138 | - |
| LSD at 5% | NS | NS | NS | NS | NS | NS | NS | - |
| CV (%) | 19.82 | 18.48 | 19.13 | 22.08 | 19.54 | 19.69 | 16.30 | - |

**Table 6: Mean scores for the sensory attributes of the recipe paratha (Mean ± SEM) (n=9)**

| Treatment | Sensory attributes | | | | | | | Average total score |
|---|---|---|---|---|---|---|---|---|
| | Colour and Appearance (10) | Aroma (10) | Texture (10) | Taste (20) | After taste (10) | Mouth-feel (20) | Overall acceptability (20) | |
| $T_1$ | 8.14 ± 0.34 | 7.56 ± 0.38 | 7.78 ± 0.32 | 16.11 ± 0.86 | 7.00 ± 0.60 | 15.44 ± 0.10 | 16.33 ± 0.76 | 78.36 |
| $T_2$ | 7.89 ± 0.42 | 7.62 ± 0.32 | 7.63 ± 0.33 | 16.22 ± 0.70 | 7.51 ± 0.26 | 15.44 ± 0.82 | 16.22 ± 0.60 | 78.13 |
| $T_3$ | 7.78 ± 0.28 | 7.56 ± 0.24 | 7.56 ± 0.29 | 15.44 ± 0.69 | 7.22 ± 0.40 | 14.89 ± 0.68 | 15.89 ± 0.51 | 76.34 |
| $T_4$ | 7.89 ± 0.26 | 7.22 ± 0.40 | 7.33 ± 0.29 | 15.78 ± 0.64 | 7.22 ± 0.36 | 15.11 ± 0.66 | 15.89 ± 0.46 | 76.44 |
| $T_5$ | 7.67 ± 0.37 | 7.11 ± 0.46 | 6.89 ± 0.39 | 15.44 ± 0.53 | 7.00 ± 0.37 | 15.00 ± 0.58 | 16.00 ± 0.41 | 75.11 |
| $T_6$ | 7.67 ± 0.41 | 7.11 ± 0.48 | 7.11 ± 0.46 | 15.11 ± 0.63 | 7.00 ± 0.24 | 14.78 ± 0.59 | 15.67 ± 0.65 | 74.45 |
| $T_7$ | 7.78 ± 0.36 | 7.56 ± 0.34 | 7.33 ± 0.37 | 15.33 ± 0.41 | 7.33 ± 0.29 | 14.56 ± 0.63 | 15.78 ± 0.36 | 75.67 |
| $T_8$ | 7.78 ± 0.40 | 7.56 ± 0.34 | 7.33 ± 0.33 | 15.44 ± 0.44 | 7.22 ± 0.32 | 15.00 ± 0.60 | 15.67 ± 0.53 | 76 |
| $T_9$ | 7.78 ± 0.28 | 7.56 ± 0.29 | 7.44 ± 0.38 | 15.56 ± 0.65 | 7.33 ± 0.37 | 15.00 ± 0.69 | 15.67 ± 0.44 | 76.34 |
| $T_{10}$ | 7.78 ± 0.27 | 7.44 ± 0.34 | 7.44 ± 0.41 | 15.67 ± 0.60 | 7.44 ± 0.38 | 14.67 ± 0.76 | 16.00 ± 0.58 | 76.44 |
| $T_{11}$ | 7.22 ± 0.47 | 7.33 ± 0.29 | 7.11 ± 0.48 | 15.22 ± 0.70 | 7.44 ± 0.41 | 15.22 ± 0.68 | 16.00 ± 0.58 | 75.54 |

| Treat-ment | Sensory attributes | | | | | | | Aver-age total score |
|---|---|---|---|---|---|---|---|---|
| | Colour and Appearance (10) | Aroma (10) | Texture (10) | Taste (20) | After taste (10) | Mouth-feel (20) | Overall acceptabi-lity (20) | |
| $T_{12}$ | 6.78 ± 0.36 | 7.00 ± 0.33 | 7.11 ± 0.31 | 14.56 ± 0.58 | 7.00 ±0.33 | 14.33 ± 0.58 | 15.67 ± 0.58 | 72.45 |
| $T_{13}$ | 8.22 ± 0.28 | 7.57 ± 0.38 | 7.89 ± 0.37 | 16.00 ± 0.55 | 7.56 ± 0.24 | 15.51 ± 0.72 | 16.41 ± 0.51 | 79.11 |
| $T_{14}$ | 7.89 ± 0.35 | 7.22 ± 0.40 | 7.89 ± 0.26 | 14.89 ± 0.66 | 7.44 ± 0.29 | 14.78 ± 0.70 | 16.33 ± 0.50 | 76.44 |
| SE(d) | 0.499 | 0.512 | 0.513 | 0.887 | 0.509 | 0.990 | 0.766 | - |
| LSD at 5% | NS | NS | NS | NS | NS | NS | NS | - |
| CV (%) | 13.64 | 14.77 | 14.75 | 12.21 | 14.91 | 14.05 | 10.19 | - |

**Table 7: Mean scores of products of recommended Multigrain flour treatment (T13) for consumer acceptability test through hedonic rating scale (n=17)**

| Treatment Name | Treatment of 'Quality' | Rank of Treatment |
|---|---|---|
| **Chapati** | 6.94 | 3 |
| **Paratha** | 7.76 | 1 |
| **Puri** | 7.41 | 2 |
| **General Mean** | 7.37 | . |
| **CV(%)** | 14.67 | . |
| **SE(d)** | 0.371 | . |
| **LSD at 5%** | NS | . |

**Figure 2: Quality graph for products for consumer acceptabilityw**

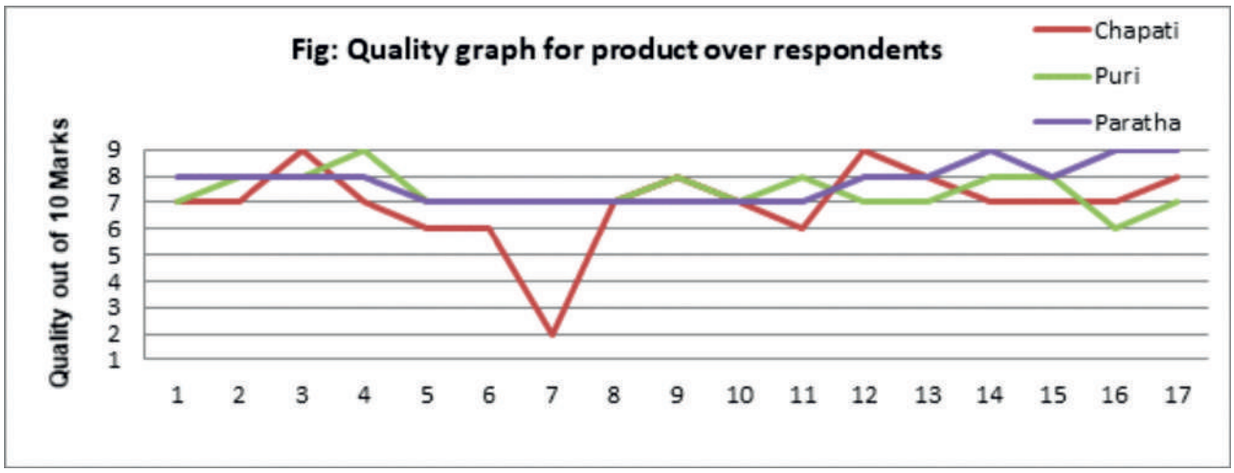



**Table 8: Nutrient contents of Multigrain flour**

| Treatment | Moisture (%) | Fat ( %) | Protein (%) | Crude Fiber (%) | Iron (mg/100g) | Calcium (mg/100g) | Ash (%) |
|---|---|---|---|---|---|---|---|
| T1 | $12.20^{a}$ | $1.70^{g}$ | $11.80^{f}$ | $1.20^{f}$ | $4.90^{e}$ | $48.00^{i}$ | $1.50^{g}$ |
| T2 | $11.80^{bcd}$ | $3.03^{f}$ | $13.98^{d}$ | $1.97^{de}$ | $5.48^{cd}$ | $100.60^{h}$ | $1.94^{f}$ |
| T3 | $11.81^{bcd}$ | $3.19^{e}$ | $13.97^{de}$ | $1.97^{de}$ | $5.63^{bc}$ | $100.33^{h}$ | $1.98^{ef}$ |
| T4 | $11.82^{bc}$ | $3.36^{d}$ | $13.96^{de}$ | $2.39^{b}$ | $5.79^{b}$ | $100.00^{h}$ | $2.02^{def}$ |

| Treatment | Moisture (%) | Fat ( %) | Protein (%) | Crude Fiber (%) | Iron (mg/100g) | Calcium (mg/100g) | Ash (%) |
|---|---|---|---|---|---|---|---|
| T5 | 11.69$^{def}$ | 3.04$^{f}$ | 14.13$^{d}$ | 2.39$^{b}$ | 5.78$^{b}$ | 123.00$^{c}$ | 2.02$^{def}$ |
| T6 | 11.58$^{f}$ | 3.05$^{f}$ | 14.27$^{cd}$ | 2.81$^{a}$ | 6.09$^{a}$ | 146.80$^{a}$ | 2.10$^{bc}$ |
| T7 | 11.58$^{f}$ | 3.32$^{d}$ | 14.07$^{d}$ | 2.08$^{cde}$ | 5.42$^{d}$ | 101.70$^{h}$ | 1.95$^{ef}$ |
| T8 | 11.73$^{cde}$ | 3.62$^{c}$ | 14.16$^{cd}$ | 2.20$^{bcd}$ | 5.37$^{d}$ | 100.83$^{h}$ | 1.97$^{ef}$ |
| T9 | 11.65$^{ef}$ | 3.92$^{b}$ | 15.58$^{b}$ | 2.09$^{cde}$ | 5.75$^{b}$ | 110.20$^{f}$ | 2.09$^{bcd}$ |
| T10 | 11.39$^{g}$ | 4.81$^{a}$ | 17.12$^{a}$ | 2.22$^{bc}$ | 6.03$^{a}$ | 119.83$^{d}$ | 2.25$^{a}$ |
| T11 | 11.85$^{bc}$ | 3.01$^{f}$ | 17.12$^{a}$ | 2.09$^{cde}$ | 5.43$^{d}$ | 115.42$^{e}$ | 2.02$^{def}$ |
| T12 | 11.89$^{b}$ | 2.99$^{f}$ | 13.53$^{e}$ | 2.21$^{bc}$ | 5.38$^{d}$ | 130.20$^{b}$ | 2.06$^{bcd}$ |
| T13 | 11.74$^{cde}$ | 3.01$^{f}$ | 14.59$^{c}$ | 1.95$^{e}$ | 5.42$^{d}$ | 105.91$^{g}$ | 2.02$^{cde}$ |
| T14 | 11.67$^{ef}$ | 3.00$^{f}$ | 15.20$^{b}$ | 1.94$^{e}$ | 5.37$^{d}$ | 111.22$^{f}$ | 2.11$^{b}$ |
| SE(d) | 0.061 | 0.037 | 0.221 | 0.114 | 0.084 | 1.453 | 0.038 |
| LSD at 5% | 0.1252 | 0.0759 | 0.4517 | 0.233 | 0.1727 | 2.9757 | 0.0781 |
| CV(%) | 0.64 | 1.41 | 1.86 | 6.61 | 1.86 | 1.65 | 2.33 |

**Table 9: Rheological Properties of Multigrain Flour (Multigrain Flour Extensibility Test using the Kieffer Dough and Gluten Extensibility Rig)**

| Treat-ments | Resistance to Extension (g) | Extensibility (mm) |
|---|---|---|
| | Force 1 | Distance 1 |
| T1 | 404.97 | -3.64 |
| T2 | 537.67 | -5.14 |
| T3 | 282.74 | -6.3 |
| T4 | 520.12 | -8.04 |
| T5 | 520.56 | -8.7 |
| T6 | 532.92 | -7.44 |
| T7 | 699.93 | -8.82 |
| T8 | 564.3 | -6.96 |
| T9 | 282.3 | -9.27 |
| T10 | 306.29 | -8.76 |
| T11 | 528.31 | -8.18 |
| T12 | 264.96 | -7.78 |
| T13 | 526.99 | -6.98 |
| T14 | 527.14 | -4.35 |