MOTT MACDONALD

FOOD FORTIFICATION PROGRAMME

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INDEPENDENT STUDY ON SENSORY EVALUATION FOR ACCEPTABILITY FOR FORTIFIED FLOUR PRODUCTS

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List of abbreviations

AACC	American Association of Cereal Chemists
ANOVA	Analysis of Variance
AOAC	Association of Official Analytical Chemists
BWP	Bahawalpur
DFID	Department for International Development
FFP	Food Fortification Programme
KHI	Karachi
LHR	Lahore
NaFeEDTA	Ferric sodium ethylenediaminetetraacetate
PFMA	Pakistan Flour Mills Association
PSW	Peshawar

1 Executive Summary

Food Fortification Programme is supporting the millers to fortify wheat flour (Atta), Maida and fine across the three provinces. Some concerns were raised by the millers on the difference of colour of fortified baked products compared to the products made from unfortified flour specifically by Maida and fine Atta. Some millers indicated that the presence of zinc would be causing colour change while others suggested iron. This independent study was planned to conduct baking trials of fortified flour followed by sensory analysis and the level of acceptability. The overall objective of the study is to inform the policymakers, flour millers, consumers and other stakeholders about the influence of premix on fortified flour baked products and on maintaining quality and acceptability.

This explorative study comprised of two phases. In the first phase, a comprehensive trial was conducted under controlled laboratory settings of the Institute of Food Science and Nutrition, Bahauddin Zakariya University. In the second phase, replication of the trial was done in the commercial bakery settings. A total of one hundred and sixty products trials (96 with “Naan” and 64 with “Leavened bread”) were conducted with fortified flour (Maida and fine Atta) following the experimental protocols to rule out individual and combined effect of premixes, wheat flour source and types of leavening agents on sensory attributes including colour, taste, odour, texture, chewability, mouthfeel and overall acceptability of the baked products. Flour samples were procured in bulk from four flour mills across Punjab, Khyber Pakhtunkhwa and Sindh. Similarly, four premixes with identical composition were procured from Attaullah Zia International, Morgan technologies (Pvt.) Ltd., Genera Pharmaceuticals and Vitablend Asia Pacific Pvt. Ltd., Singapore. Premix-flour blends were prepared for “Naan” and leavened bread. Two brands of leaving agents including baking soda (Arm and Hammer baking™ powder, ICI baking soda) and yeast (SAF Yeast and Mauri Yeast) were used and evaluated for their role in sensory quality of naan and bread.

The results of the study indicated that none of the premixes were observed to negatively influence any of the products sensory attributes. Compositional assessment of the raw material did however identify certain differences in the samples of flour in terms of grain particle size distribution, gluten and total protein contents. The findings also suggested that in some sample’s bicarbonate and pH levels of the baking soda significantly affected the colour, taste and texture properties of baked products. The effect of different premix with zinc and without zinc was also assessed and no negative effect was found in terms of colour change on the baked products. This trial was replicated at commercial-scale settings followed by an expert panel evaluation of the fortified flour baked products. The evaluation validated the laboratory findings that keeping the source of flour, premixes and leavening agent constant or at par with the laboratory settings, the product recipes used by the commercial bakers in a commercial setting did not show any significant change in the sensory quality of the baked products.

This study concludes that premix has no effect on the sensory acceptability of the baked products. On the other hand, it was noted that the type of flour/ particle size affects the overall sensory quality but at an accepted level. The results of this explorative study imply that the quality of the flour in terms of particle size i.e., below 120 µm yields maximum sensorial quality of the baked products. The study findings recommend that improving the quality of flour specifically for maida by optimizing raw material quality, flour extraction rates and particle size distribution at production level can further enhance the quality of baked products.

2 Introduction and Context

The Food Fortification Programme (FFP) designed and funded by the UK Government's Department for International Development (DFID) is being implemented for a period of five years (2016-2021). The programme is being implemented by Mott MacDonald and Nutrition International in collaboration with key government departments at National and Provincial level and with industry associations, namely the Pakistan Flour Mills Association (PFMA) and Pakistan Vanaspati Manufacturers Association (PVMA). FFP supports industry to adequately fortify wheat flour and edible oil/ghee in Pakistan provides support to the Government to improve the food fortification regulatory system, helps to raise public awareness and conducts operational research. The programme aims to fortify wheat flour produced at commercial roller mills with iron, folic acid, vitamin B12, and zinc, as well as edible oil/ghee with vitamins A and D. The objective of the programme is to support improvements in the improved nutritional status of the population and especially women of reproductive age and children.

Looking into the prevalent micronutrient deficiencies in Pakistani's population, mandatory wheat flour fortification is expected to curb micronutrients malnutrition in the country. Like other Asian countries of the region, unleavened flatbread "chapatti", leavened flatbread "Naan" and bread are preferably developed with whole wheat flour and white flour by the bakers of Pakistan. Global evidence indicates that food fortification is a cost-effective solution to the challenge of chronic micronutrient deficiencies. Wheat flour is part of the staple diets of individuals in Pakistan and, if fortified, can improve micro-nutrient uptake without needing any additional changes in eating habits of the general population. This independent study on sensory evaluation was conducted to assess the acceptability of fortified wheat flour (maida and fine) baked products.

3 Relevant Review of Literature

Reports on the influence of fortification on the sensory quality of wheat products are quite variable. It is probably because sensory changes are also variable and not always predictable. Therefore, having selected a potential iron premix, it is essential that its effects on the sensory properties of the food to which it is to be added are determined prior to use.

There is a reasonable amount of literature available on the influence of different fortification compounds on the quality characteristics of different wheat flour products. Findings of a multi-country study coordinated by the Food Fortification Initiative (FFI) were published in 2013 reporting on the impact of flour fortification on common Asian wheat flour-based foods. According to the report, the fortified wheat flour products are generally slightly darker in colour but are highly acceptable. Pooris made with fortified (white) flour were highly preferred over control (Wijingart 2013). Consumer's acceptance studies conducted with wheat flour fortified with three different iron premixes in comparison with un-fortified control flour indicated that iron-fortified wheat flour was indistinguishable from the control flour for the consumers (Mahmood 2007).

According to one study, fortification of whole wheat flour with different iron compounds including Ferric sodium ethylenediaminetetraacetate (NaFeEDTA) resulted in some changes in various quality parameters during storage, however, the colour was not influenced (Rebellato 2018). A local study conducted at the Agriculture University Faisalabad reported a slight effect on texture but no effect on the colour of chappati prepared from iron and zinc fortified whole wheat flour. The same authors also concluded that NaFeEDTA is better than elemental iron as an iron premix with respect to sensory characteristics of the chapattis of fortified flours (Akhter 2008).

Dietary inadequacies of micronutrients associated with improper growth and development and suboptimal physiological functions may be referred to as micronutrient malnutrition or "hidden hunger". Global estimates on micronutrient deficiencies refer around 2 billion world population are experiencing micronutrient malnutrition

(Nutrition International 2009). In the summary report of the Pakistan National Nutrition Survey 2018, 53.7% of children in the age category under 5 are anaemic and children from rural backgrounds are more likely to be anaemic than those from the urban areas. The prevalence rate of iron deficiency anaemia (IDA) has been reported ~28.6% in the same age group. A sizeable number of children under 5 are zinc deficient. Anaemia has been reported in 41.7% of the women of reproductive age (WRAs) while 18.2% are experiencing IDA. Around 22% of the WRAs are zinc deficient while mild to severe iodine deficiency was observed in 27.2 – 4.6% women of the same age group (NNS 2018).

Vitamins and minerals deficiencies are silent epidemics that may affect peoples of all ages and gender. In addition to some specific nutrient deficiency disorders, micronutrients deficiency may also relate to certain other chronic health ailments including osteoporosis, thyroid dysfunction, cardiovascular disorders and a certain type of cancers (Tulchinsky 2010). World Health Organization (WHO) mortality data suggest 0.8 million deaths and loss of ~25 million disability-adjusted life years (DALYs) are attributed to iron deficiency, while vitamin A and Iodine deficiencies account for 18 million and 2.5 million DALYs lost, respectively. Iron deficiency alone has the heaviest overall health impact in terms of premature death, ill-health and lost productivity/earnings. Around 2.5 – 3.4 million maternal and neonatal deaths are linked to anaemia while iron and folates are the most efficacious solutions that may reduce infant, young child, and maternal mortality linked to anaemia (WHO 2011).

Addressing micronutrient malnutrition has become the public health priority of governments from both the industrialized developed and developing nations of the world in the last three decades. Globally, several strategies are in place to address the iron deficiency and iron deficiency anaemia among masses including dietary diversification, dietary modification, intermittent iron supplementation, staple crops fortification, bio-fortification, and blood transfusion indicated only for severe anaemia (WHO /FAO 2006; FAO/CAB International 2011). Improving dietary iron intake by mass-scale fortification of staple grains and condiments with iron and other micronutrients of human health significance is suggested as a preferred fortification strategy. Wheat flour being the staple food throughout much of the world is by far the most suitable medium of large-scale iron fortification. Worldwide, over 79 countries legislatively fortify wheat flour with minerals and vitamins while mandatory fortification includes at least iron and folic acid (FFI 2014). It is pertinent to mention that the portion of fortified wheat flour increased from 90% to 97% in the United States of America, while the rate of this increment was from 26% to 31% in Africa, 16% to 21% in South-East Asia, 3% to 6% in European region and from 2% to 4% in Western Pacific Regions between the years 2004 to 2007, indicating remarkable success rates in fortification globally. Flour fortification with folic acid has been shown to significantly improve serum folate concentration of at-risk populations where the prevalence of folic acid deficiency is higher. In addition, explorative findings suggest that folic acid supplementation reduces neural tube defects associated morbidity and mortality index, and also modulates certain other pregnancy outcomes like preeclampsia, seizure disorders, foetal growth restriction, anaemia and autism (Atta et al. 2016; Moussa et al., 2016).

Fortified wheat flour is used to produce various kinds of wheat-based formulations including leavened, unleavened and extruded products. Chapati, parotta, batura, sourdough, flatbread “Naan” and conventional leavened bread are a few versions of unleavened and leavened flatbread of South East Asia. Premix type and extent of fortification depend on the extraction rate and the level of flour consumption. The extraction rate is the extent to which flour is sifted for separating endosperm. Higher extraction rate refers to higher rate of bran and germ retention with the endosperm. However, high extraction flour i.e., above 80% contains higher levels of the mineral binding factors like phytates that interferes with intestinal iron absorption (Kumar 2010). Sensorial incompatibility of the fortification and type of premix is much common in high extraction flour. It has been suggested to define compatibility among flour type and fortification level in terms of sensory acceptability prior to the selection of premix and the level of fortification (Mary 2010). Ferric sodium ethylenediaminetetraacetate (NaFeEDTA) is the only recommended premix as it is readily absorbable in the gut than the other forms of iron compounds used in flour fortification. Bioavailability of iron compounds is critical in high extraction flour-based foods (WHO)

A scientific report published by Bothwell and MacPhail (2004) proclaims NaFeEDTA to cause the least organoleptic changes in carriers like cereal flours during storage when compared with other soluble iron salts. However, the experts still suggest consolidated studies to validate stability properties of NaFeEDTA and other premixes under various processing operations and storage conditions coupled with consumer acceptability studies. As with other premixes, zinc fortification has also been reported to have no disadvantages with regards to the sensory attributes of the fortified products at recommended levels of fortification (Brown et al. 2010). Evidence-based findings suggest zinc oxide as the most suitable candidate for zinc fortification of flour and flour-based products on account of its cost and least impact on sensory attributes of the finished consumable goods (Mary 2010). Apart from the fortification and type of premix, quality of the raw material i.e., nature and type of the flour, baking ingredients, and processing conditions are other major determinants of the baked good quality. Hard wheat has a less satisfactory response in ensuring an optimum product processing quality of the baked goods. A study observed that hard wheat doughs with higher extraction rates were likely to make the bread crust too dark (Drews 1985). Similarly, another study found that dough stability and sedimentation volume linked to protein contents, gluten index and gluten strength have a negative impact on the quality of baked chapatti (Kundu et al. 2017). In another study by Sifelani (2016), an excess amount of premix and the use of cast iron cookware were found to contribute to an undesirable taste in fortified maize porridge.

Although a plethora of literature advocates micronutrients fortification as the technologically most viable and cost-effective solution to help reduce micronutrient deficiencies and associated ailments, there remain concerns of local processors and consumers over the palatability and acceptability of fortified flours and products derived thereof which need to be satisfied by conducting independent sensory or consumers' acceptability studies. This research is therefore aimed at exploring the possible role of premixes, type of flours and their origin, bakery additives and processing conditions on the degree of variability in palatability and acceptability of common leavened products i.e., flatbread (Naan) and bread.

4 Objectives of the research study

The overall objective of the study was to assess the acceptability of baking products prepared with fortified flours among the target consumers and the stakeholders across Pakistan.

The specific objectives are to.

1. Produce evidence to inform policymakers, flour millers, bakers, consumers and other stakeholders about the effect of the addition of the fortification premix on baked products made from fortified flour particularly relating to colour and taste.
2. Evaluate sensory qualities of final products (naan and bread) prepared from different fortified wheat flour types (fine and maida)
3. Study the effects of other components used in baking (apart from premix) including baking soda, salt, yeast etc. on the products made from fortified flours.
4. Undertake consumer's studies (using a designated panel) to determine if the colour changes (if any) would impact the overall acceptability of the baked foods

5 Methodology

5.1 Flour samples procurement

Four flour mills were selected for collecting the sample of maida and fine atta. These mills were based in Bahawalpur (Punjab), Lahore (Punjab), Karachi (Sindh) and Peshawar (Khyber Pakhtunkhwa). The management of the mills was taken on board for formal samples collection approval. Sample procurement was made by the project staff including the Co-Principle Investigator and the research associates. Sample collection staff was given hands-on training on flour sampling, compositing, preparing premix – flour blends packaging and transportation. The samples were fortified in the mills and both fortified and unfortified samples were collected.

5.2 Procurement of Premixes and Baking Ingredients

Premixes with uniform composition i.e., Iron as NaFeEDTA (15ppm), Zinc as ZnO (30ppm), Folic acid (1.0ppm), Vitamin B12 (0.008ppm) were procured from the following sources: -

1. Premix 1 – Attaullah Zia International
2. Premix 2 – Morgan Technologies (Pvt.) Ltd.
3. Premix 3 – Genera Pharmaceuticals
4. Premix 4 – Vita blend Asia Pacific (Pvt.) Ltd. Singapore

Another premix was designed from Vita blend Asia Pacific (Pvt.) Ltd. Singapore with similar composition as that of Premix 1 – 4 but without Zinc Oxide and was coded as Premix 5.

Leavening agents including Baking Soda (Sodium Bicarbonate) and Yeast were procured from two varied sources as listed below: -

1. Baking Soda A-Arm and Hammer, Church & Dwight, USA
2. Baking Soda B – ICI (Pvt.) Ltd. Pakistan
3. Instant dry Yeast A – SAF-Instant, Vietnam.
4. Instant dry Yeast B – Mauripan Instant Dry Yeast, MAURI Australia

5.3 Preparation of flour – premix blends

Blends (Table 1) were prepared with a required dose of premixes and flour from each mill. Fortification of Maida and – fine was performed with four types of premixes listed above, in the presence of mill staff. Briefly, 2 grams of accurately weighed premixes were homogenously mixed with 100 grams of flour. Homogenate was further mixed with 900 grams of flour. Flour-premix blend was further mixed with 9 kilograms of flour to ensure uniform distribution of micronutrients in the composite sample. In addition to the plain Maida flour blends, fine flour (10%) and Maida (90%) were also combined to develop flour – premix blends for Naan. Spot test was performed for confirmation of flour fortification homogeneity. Non-fortified plain Maida and fine flour samples were also procured from the same lot of each mill and designated as normal control.

Table 1: Composition of different blends (10kg)	
Blend 1	Maida + Premix 1
Blend 2	Maida + Premix 2
Blend 3	Maida + Premix 3
Blend 4	Maida + Premix 4
Blend 5	Fine flour (10%) + Maida (90%) + Premix 1
Blend 6	Fine flour (10%) + Maida (90%) + Premix 2
Blend 7	Fine flour (10%) + Maida (90%) + Premix 3
Blend 8	Fine flour (10%) + Maida (90%) + Premix 4
Blend 9	Maida + Premix 5 (without zinc)

5.4 Compositional analysis of fortified flour blends

Non-fortified Maida and fine flour samples collected from the designated flour mills of the country were analysed for moisture, crude protein, crude fat, ash and dry gluten contents in accordance with the methods as laid down

by American Association of Cereal Chemists (AACC). Iron and Zinc concentration was quantified by Atomic Absorption Spectrometry (iCE 3000 Thermo Fisher Scientific) in accordance with the methods laid down by the Association of Official Analytical Chemists (AOAC) (Latimar Jr. 2012). All the samples of flour (maida and fine) were tested using the above methods.

5.5 Particle size distribution analysis

Flour samples were evaluated for particle size distribution by sifting 200 grams of the sample for 5 minutes in a sieve shaker with sieves have mesh size 35µm, 60 µm, 80 µm, 120 µm and above 120 µm.

5.6 Selection of baked products

Widely accepted wheat flour-based baked products including “leavened bread (Naan)” and “plain bread” were selected on account of the higher consumer preference for these products. Preparation of Naan and bread

Different combinations were used to produce Naan and bread which included different flour samples differentiated by their source and type (Maida and fine), and different types of premixes from different suppliers, to assess the effect of these on sensory properties of naan and bread. Each blend used for *naan* and *bread* production was tested with two different brands of instant dry yeast and baking soda.

The experimental plan for baking naan is shared in Figure 1. This plan was followed for all flour samples procured from four mills.

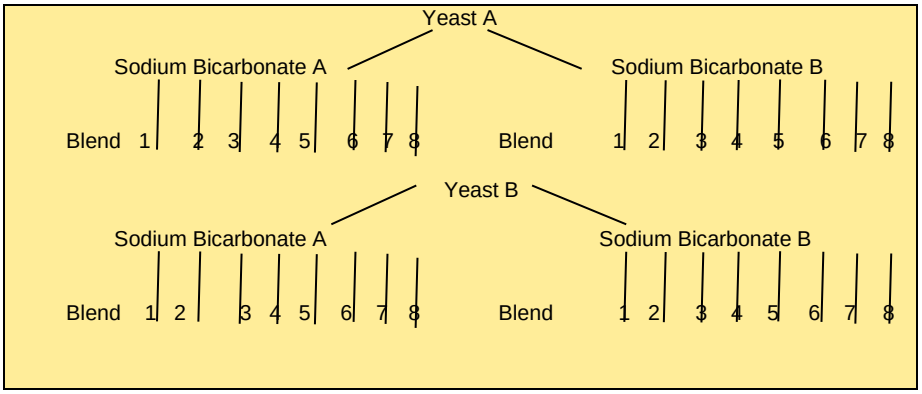


Figure 1: Experimental plan to produce *Naan (from all 4 sources)*

Recipe of the leavened flatbread (*Naan*)

1.	Fortified maida	900grams
2.	Fortified fine flour	100grams*
3.	Yeast	3.5grams
4.	Sodium Bicarbonate	1.5grams
5.	Edible oil	25grams
6.	Iodized table salt granulated	3.5grams
*Recipe of *naan* prepared with blend 1-4 (without fine flour) were optimized with maida @1000grams		

5.7 Experimental Plan to produce Plain Bread

The plan to produce bread is shared in Figure 2. The same plan was used for baking bread using flour procured from all four mills.

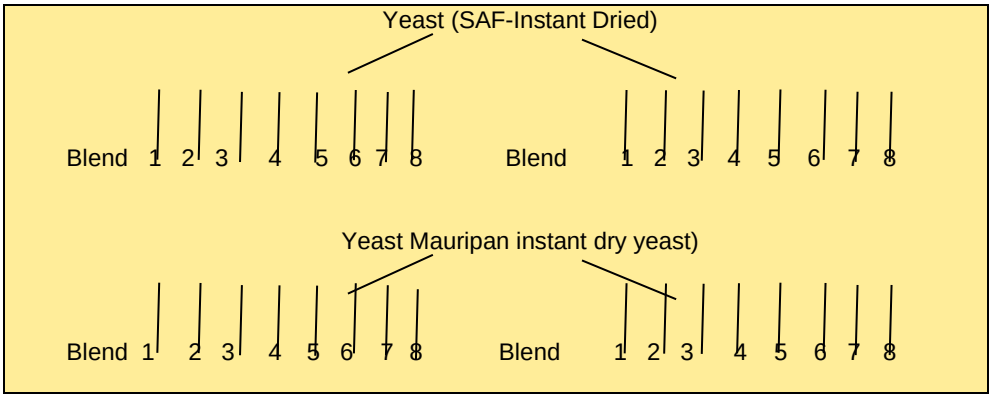


Figure 2: Experimental plan to produce *Bread (from all 4 sources)*

Commercial recipes were adopted for the development of *Naan* and bread.

5.8 Screening trials

Screening trials were performed in the baking unit of Institute of Food Science and Nutrition, while confirmative trials for both the leavened flat bread and bread were run in industrial settings.

5.9 Sensory profiling

Sensory profiling of the baked goods was conducted by adopting a preference test using nine-point hedonic scale (Table 2) in accordance with the method developed by Peryam and Girardot (1952). Panellist were screened based on their ability to discriminate between products for various sensory parameters. Each product was measured for acceptability for different parameters including Colour, Texture, Taste, Odour, Chewability and Mouth feel.

Table 2: 9-Point Hedonic Scale (measuring acceptability)

9.0	Like Extremely
8.0	Like Very Much
7.0	Like Moderately
6.0	Like Slightly
5.0	Neither Like nor Dislike
4.0	Dislike Slightly
3.0	Dislike Moderately
2.0	Dislike Very Much
1.0	Dislike Extremely

Following pre-requisites were met prior to the sensory profiling:

1. Using an odour and noise free, and adequately lightened environment for the sensory evaluation
2. Sensory panellists were provided with brief training to provide better sensory discrimination capability
3. Panellist were not allowed to smoke, have medication or eating within one-hour prior to participating in the sensory evaluation profiling exercise
4. Panellists were also asked to identify any observation on any sensory parameter irrespective of sensory scoring.
5. Samples were assigned random coding and presented for analysis
6. Plain drinking water was provided to the panellists after each sample testing to neutralize the taste effect for the next testing.

5.10 Colour indexing

Crust of leavened flatbread “Naan” and crumb of the bread loaves was instrumentally analysed using digital colorimeter for colour indexing and L-value or degree of lightness was recorded for each sample. The results were also compared with the products developed from non-fortified flour.

5.11 Minerals analysis of fortified products

All variants of the fortified *naan* and bread were evaluated for mineral composition i.e., Iron and Zinc in accordance with the methods laid down by AOAC (Latimar Jr. 2012).

5.12 Statistical Analysis

Quantitative and qualitative data generated from sensorial and biochemical analysis were statistically evaluated by using analysis of variance (ANOVA) and effect of experimental variables i.e. blends and sample sources were identified by Least significance difference test at p-value of <0.05.

6 Findings

6.1 Nutritional composition of the flour

Baking quality of the leavened and unleavened baked products is a complex feature determined by a variety of compositional features including the total protein contents and gluten protein that play a significant role in achieving dough making properties like dough viscosity, elasticity and dough strength (Xue et al., 2019). Data presented in Table (3) suggest proportionally higher amount of protein i.e., total protein and gluten protein in *maida* flour samples procured from the mills from the Bahawalpur region followed by Karachi, Peshawar and Lahore. Presence of lipids even in small amount can cause undesirable sensory properties, more specifically colour by oxidation. Maximum amount of lipids was recorded in *Maida* flour samples procured from Peshawar i.e., 0.92% while least level of crude fat i.e., 0.83% was observed in flour procured from the Bahawalpur region.

Table 3: Nutritional composition of *Maida*

Region	Type of Flour	Moisture Mean ± SD	Ash Mean ± SD	Fat Mean ± SD	Protein Mean ± SD	Gluten Mean ± SD
Bahawalpur	Maida	14.78±0.06a	0.89±0.03a	0.83±0.01c	11.73±0.10a	9.13±0.07a
Karachi	Maida	13.44±0.12c	0.66±0.04b	0.90±0.02ab	11.21±0.13b	8.84±0.14ab
Lahore	Maida	13.91±0.23bc	0.64±0.08b	0.88±0.01b	8.81±0.13c	7.18±0.20c
Peshawar	Maida	14.40±0.28ab	0.83±0.05a	0.92±0.02a	11.44±0.19ab	8.64±0.13b

6.2 Minerals Contents of the Flour

Maida and fine flour composites and the leavened bread were evaluated for iron profiling. Iron contents in non-fortified *Maida* samples were observed in range between 0.78 – 1.24ppm (Table 4). Maximum iron contents were recorded in *Maida* samples procured from Peshawar. Slightly non-uniform distribution of micronutrient i.e., iron was observed in *Maida*, *Maida* – fine composite samples procured from various flour mills. Variability in iron concentration may be associated with onsite manual fortification of the composite flour practiced during sample collection. Approximately 45-75% of the flour iron load was observed available in finished baked goods.

Table 4: Mean Iron contents of the fortified and non-fortified flour and leavened bread

Region	Non-fortified *Maida* (ppm)	Fortified *Maida* (ppm)	Fortified Fine + *Maida* flour (ppm)	Fortified *Naan* (ppm)	Fortified Bread (ppm)
Bahawalpur	0.82	15.73	25.34	13.13	10.88
Karachi	0.78	20.6	17.08	15.51	13.45
Lahore	1.02	26.34	19.23	22.07	14.56

Peshawar	1.24	22.85	23.62	13.72	14.22

6.3 Particle Size Distribution

Particle size distribution analysis of flour procured from various regions of the country indicated finer profile of Maida procured from Bahawalpur and Karachi region wherein around 70% of the flour was with particle size in range between 60 - 80 µm (Table 5). Contrarily, more than 70% of the flour fraction of the samples collected from Lahore and Peshawar region were with particle size ≥120 µm that may anticipate reduction in sensory quality of the fermented baked goods. Particle size affects dough development time, mixing stability and network (Wang et al., 2017). Finer fractions of wheat flour with particle size lesser than 75µm and in range between 75 – 118 µm have been reported to attribute good sensory features like colour, texture, layering and overall acceptability to Indian flatbread including Paratha (Sakhare et al. 2014). The results of this explorative study imply a need of improving milling quality of the grains in terms of reducing grain particle size i.e., below 120 µm to yield maximum sensorial quality of the baked goods.

Table 5: Particle size distribution of Maida flour

Region	Type of Flour	35 µm	60 µm	80 µm	120 µm	>120 µm
Bahawalpur	*Maida*	1.23	35.96	44.3	17.07	1.44
Karachi	*Maida*	1.8	7.4	67.51	19.04	4.25
Lahore	*Maida*	0.77	10.6	14.9	12.29	61.44
Peshawar	*Maida*	3.55	13.1	15.39	18.86	49.1

As per with the findings on the particle size distribution of *maida*, a better quality of fine flour compatible to the *maida* flour was observed for flour procured from Bahawalpur wherein ~75% of the particle's retention was noticed in sieves with a mesh size between 60 – 80 µm (Table 6). Flour particles retention for the flour procured from Karachi was ~90% in sieves with mesh size ranging between 80 – 120 µm. Fine flour particle size from the Peshawar flour mill was in a range between 80 to more than 120 µm where particle retention rate was ~90%.

Table 6: Particle size distribution of fine flour

Region	Type of Flour	35 µm	60 µm	80 µm	120 µm	>120 µm
Bahawalpur	Fine	0.29	36.51	41.66	18.51	3.03
Karachi	Fine	0.05	1.89	30.04	61.61	6.41
Lahore	Fine	1.73	78.56	15.7	3.6	0.42
Peshawar	Fine	0.56	9.49	40.61	28.28	21.06

6.4 Sensory profiling of fortified baked products

Sensory evaluation of the commonly consumed baked goods derived from fortified wheat flour i.e., *Maida* and fine was performed to elucidate consumer response for acceptability of fortified product and to identify role of varying sources and type of flour, source and type of premixes and source of baking soda on sensory properties of flatbread "*naan"* and bread.

Sensory study of the fortified products was completed in two phases a) laboratory-scale baking trials b) commercial baking trials deploying industrial conditions and recipes while keeping the source of ingredients unchanged.

6.5 Laboratory Scale Product Development & Sensory Profiling

6.5.1 Leavened flatbread "Naan"

Naan or the leavened flatbread is an earthen oven-baked fermented flatbread and commonly consumed in various part of the country as a staple food. A series of the trials were conducted at the pilot-scale baking unit and sensory evaluation was performed on 9-point hedonic scale Annex 1. The 9-point hedonic scale provides

an opportunity for the sensory panellist for his/her degree of liking or disliking toward certain sensory parameters. the higher the number in the 9-point scale the greater the preference by the taste panel.

A mean score of 5.0 out of 9.0 indicates that the panellist neither like nor dislike the product. Among the tested parameters i.e., colour, texture, taste, odour, Chewability, mouthfeel and overall acceptability, only colour and taste of the naan developed were found varying in different combination. Statistical analysis of the data generated from the sensory score charts of the panellist suggests a source of flour i.e., flour mill and baking soda to anticipate significant changes in the colour and taste of the naan.

Table 7: Mean scores for the sensory parameters of the colour of the Naan

Regions	Colour Index (Mean ± SD)
Bahawalpur	7.27 ± 0.99[a]
Karachi	7.00 ± 0.99[b]
Lahore	6.95 ± 0.99[b]
Peshawar	6.91 ± 0.99[b]

Furthermore, data analysis revealed none of the tested premixes imparted undesirable sensory changes to the baked goods. Highest mean colour score from the panel was assigned to *naan* made with flour procured from Bahawalpur i.e., 7.27 out of 9.0 followed product made with flour from Karachi (7.00), Lahore (6.95) and Peshawar (6.91) (Table 7 & Figure 3). It is pertinent to mention that none of the panellists scored product 5.0 that reads as “neither like nor dislike”. The difference was significant for Bahawalpur (a) compared to other three areas with a p-value<0.05 and were insignificant for Karachi, Lahore and Peshawar (b).

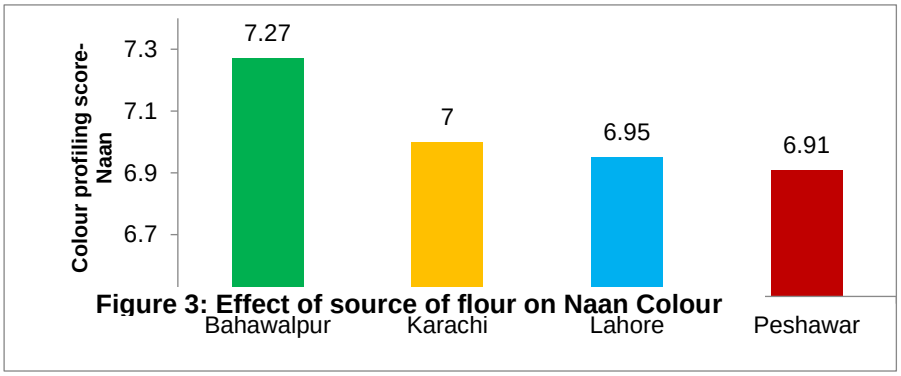
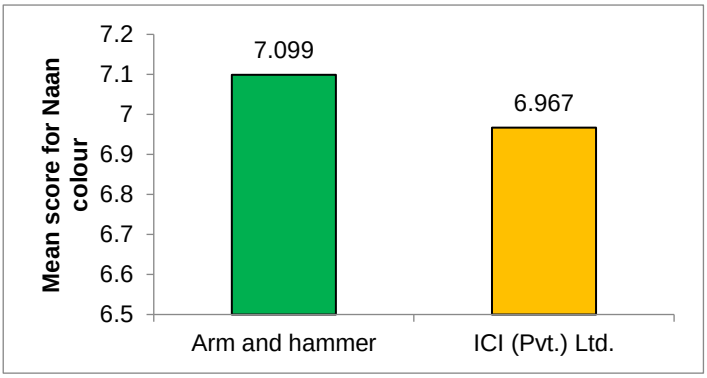


Figure 3: Effect of source of flour on Naan Colour

In addition to the effect of source of flour, a significant effect of the source of baking soda was also observed on colour acceptability of the Naan. Best scoring was assigned to the product made with Arm and Hammer™ baking soda (Figure 4). The combined effect of different variables i.e., source of flour and baking soda revealed highest colour scoring i.e., ~7.5 to the product developed with Arm and Hammer™ baking soda leavened Maida procured from Bahawalpur while least value was recorded for the product made with ICI (Pvt.) Ltd. baking soda leavened maida from Peshawar. The difference was significant with a p-value <0.05.



6.5.2 Degree of lightness (L-values) of the Naan

Degree of lightness of baked *naan* was measured instrumentally to rule out human error in sensory scoring. Again, the results suggested source of flour as the primary variable to influence product colour. Instrumental colour values i.e., L-values were observed highest for naan developed with the sample of flour taken from Karachi (L-value = 50.5) when leavened with SAF instant dried yeast (Table 8). Despite comparatively weaker flour quality properties, the flour sample from Lahore when leavened with Mauri yeast yielded a product with L-

value i.e., 48.8, comparable to the degree of lightness of *naan* developed with flour sample from Karachi. Lowest L-value was observed for the flour sample from Peshawar (47.62) (Table 8).

Best suitable variables combinations were identified by studying the combined effect of source of flour, premixes and baking soda for developing the product with highest L-value (degree of lightness). Best L-values were observed for naan prepared with flour sample from Karachi, fortified with premix supplied by Morgan Technologies and leavened with SAF yeast (Table 8 and 9)

Table 8: Impact of flour mill and yeast interaction on Naan L-values

Flour Mill	Yeast A	Yeast B
Bahawalpur	46.65^{b}	48.56^{ab}
Lahore	46.83^{b}	48.80^{ab}
Karachi	50.51^{a}	48.17^{b}
Peshawar	47.93^{b}	47.62^{c}

Yeast A = SAF instant dry yeast; Yeast B = Mauri instant dry yeast
Values having the same letters (a, b, c) do not differ significantly at $p \leq 0.05$.

A similar response was also observed for Arm and Hammer™ baking soda when used as a leavening agent for naan developed with flour sample from Karachi fortified with Morgan Technologies premix (Table 9).

The data on the degree of lightness validate a non-significant response of premixes alone in attributing poor colour profile to *naan*. Rather the flour quality and quality of baking ingredients including baking soda and yeast anticipated combined response in reducing the sensory quality of the finished good.

Table 9: Impact of premix and baking soda interaction on Naan L-values

Premixes	Arm & Hammer™ Baking soda	ICI Baking Soda
Attaullah Zia Int.	47.96^{ab}	49.50^{a}
Morgan Technologies	49.07^{a}	46.95^{b}
Genera Pharmaceuticals	46.97^{b}	48.35^{ab}

A = Attaullah Zia International, B = Morgan Technologies (Pvt.) Ltd., C = Genera Pharmaceuticals
Values having same letters (a, b) do not differ significantly at $p \leq 0.05$.

6.5.3 Taste

Changes in the taste of naan developed in the processing facility of the institute was observed by the sensory panellists at 9 – point hedonic scale. Data analysis revealed that the source of the flour as the only variable which imparted a decline in taste scoring of the product while all other variables did not attribute any significant change in product taste. This difference was found to be significant for Naan baked by using flour from Peshawar compared with other districts at a p-value <0.05. The highest mean score for the taste i.e., 7.00 was noticed for the product made with flour sourced from Karachi while the lowest taste score was assigned by the panellists to the product made with *Maida* sample procured from Peshawar (Table 10). Means comparison study indicate identical taste response by the panellists for the product made with fortified flour from Karachi, Bahawalpur and Lahore.

Table 10: Mean sensory scores for taste of the Naan*

Region	Taste Means ± SD
Bahawalpur	6.92 ± 1.02^{a}
Karachi	7.00 ± 1.02^{a}
Lahore	6.92 ± 1.03^{a}
Peshawar	6.82 ± 1.02^{b}

*Values having same letters (a, b) do not differ significantly at $p \leq 0.05$.

6.5.4 Sensory profiling of Bread

Bread is globally a product of industrial significance and has an appreciable acceptability i.e., 9.0 for like extremely to 1.0 for dislike extremely to be used as a breakfast staple in Pakistan. Similar to the sensory profiling of *naan*, organoleptic evaluation of bread was also conducted to determine the individual and combined effect

of variables including the source of flour, yeast and premixes on sensory attributes. The bread was developed from flour fortified with premixes sourced from Zia Ullah International, Morgan Technologies, Genera Pharmaceuticals and Vitablend Asia Pacific Pvt. Ltd., Singapore. Sensory profiling data revealed a significant change in colour and texture properties of the bread while all other parameters including taste, odour, chewability, mouthfeel and overall acceptability were observed unchanged. Only significant findings of the sensory evaluation of bread have been discussed in this section.

6.5.5 Colour

The study findings indicated effect of source of flour on bread colour scoring. Highest mean colour score was assigned by the panellists to bread made with Maida sourced from Bahawalpur i.e., 7.04 followed by Karachi, Lahore, and Peshawar, wherein mean colour score was 6.95, 6.9 and 6.8, respectively (Table 11 and Figure 5).

Table 11: Mean colour scores for the leavened bread

Region	Colour Means ± SD
Bahawalpur	7.04 ± 0.998[a]
Karachi	6.95 ± 0.997[ab]
Lahore	6.90 ± 0.998[ab]
Peshawar	6.83 ± 0.997[b]

*Values having same letters (a, b) do not differ significantly at $p \leq 0.05$.

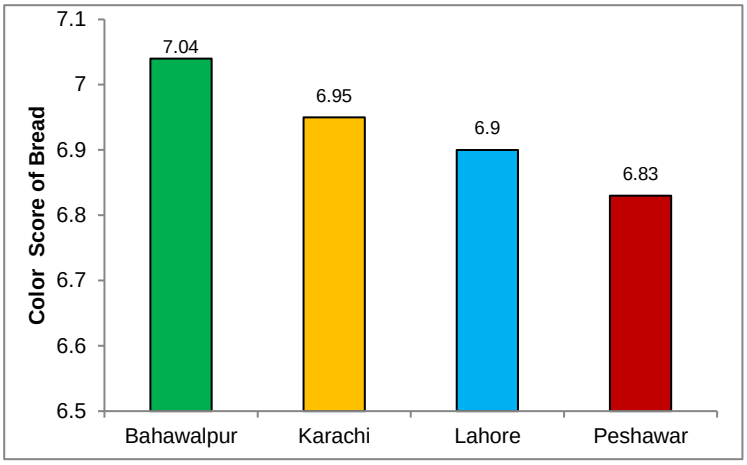


Figure 5: Effect of source of flour in Bread colour

As mentioned above, the study also indicated significant effect (p-value <0.05) of biological leavening i.e., yeast and source of flour on product colour acceptability score.

The higher colour score was assigned to fortified bread developed with SAF instant dried yeast (Figure 6).

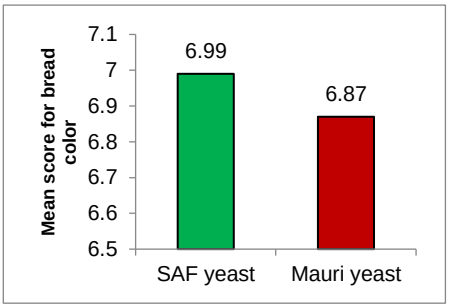


Figure 6: Effect of source of yeast on bread colour

6.5.6 Degree of lightness (L-values) of breads

Degree of lightness of the bread crumb was measured and L-value was assigned to each testing variable. Comparative analysis of bread crumb L-values for various variables identified non-significant effect of premixes alone, rather source of flour and combined effect of source of flour vs source of yeast (Table 12), source of flour vs source of premix, source of yeast vs source of premix (Table 12), and combined effect of source of flour, premix and yeast yielded measurable changes in bread crumb L-value. Highest L-value i.e., 69.3 indicating a higher degree of product acceptability in terms of colour was observed for the product developed with flour from Karachi and when leavened with SAF instant dried yeast (Table 12).

Table 12: Impact of flour mill and yeast interaction on L-values of leavened bread*		
Flour Mill	SAF-instant dry yeast	Mauri pan instant dry yeast
Bahawalpur	66.31[a]	67.09[b]
Lahore	65.5[b]	65.96[b]
Karachi	69.33[a]	66.28[b]
Peshawar	60.67[c]	60.80[c]
*Values having same letters (a, b) do not differ significantly at p ≤0.05.		

The highest L-value (67.05) was observed for the bread developed with premix from Genera Pharmaceuticals and SAF-Instant dry yeast (Table 13).

Table 13: Impact of premix and yeast interaction on L-values of leavened bread		
Premixes	SAF-Instant dry yeast	Mauri pan Instant dry yeast
Attaullah Zia International	65.07[b]	65.23[ab]
Morgan technologies (Pvt.) Ltd	64.01[b]	65.19[ab]
Genera Pharmaceuticals	67.05[a]	63.94[b]
Vitablend (Pvt.) Ltd,	65.66[ab]	65.78[ab]
*Values having same letters (a, b) do not differ significantly at p ≤0.05.		

6.5.7 Texture

The texture might collectively be referred to as a mechanical property of the bread including hardness, cohesiveness, springiness and chewiness. Textural properties of the bread are anticipated on account of carbon dioxide entrapment in solid matrix yielded either by microbiological fermentation or from a leavening agent. The textural trait of the bread developed from fortified flour was analysed on a 9-point hedonic scale. Statistical analysis of the texture score indicated significant effect of source of yeast and yeast vs premix interaction (p-value<0.05). All loaves of bread made with SAF yeast were scored higher for texture when compared with those developed with Mauri yeast (Figure 8).

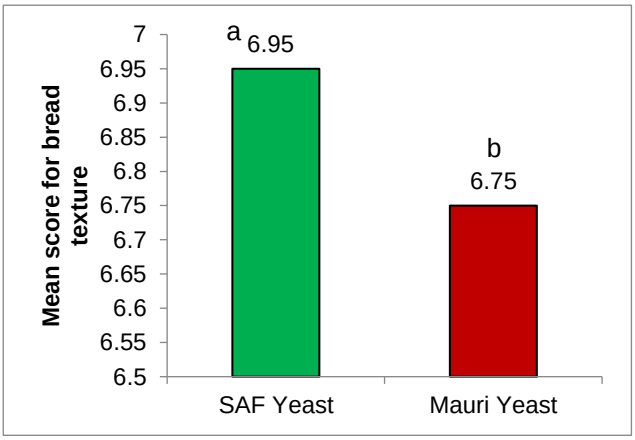


Figure 7: Effect of source of yeast on texture score of fortified breads

6.6 Findings of the screening study

The institute conducted around 160 screening trials to identify the best possible combinations in terms of defining variables that anticipated a higher degree of product sensory acceptability. The results are summarized as below: -

1. Varying source of premixes did not directly influence sensory attributes of the leavened flatbread "*Naan*" on a 9-point hedonic scale.
2. Source and type of the flour i.e., *maida* and fine contributed marked changes in sensory attributes particularly product Colour and Texture

3. As evident from the flour analysis, quality of flour in terms of particle size and gluten protein markedly influenced product sensory attributes

4. Bread colour was influenced with the source of yeast and source of flour while L-values suggested combined effect of source of flour, yeast and premix on bread colour

5. Highest colour scoring was assigned by the panellists to products made with *Maida* flour blends of – mills from Karachi and Bahawalpur followed by Lahore and Peshawar. At present, flour quality of samples from both these mills (Karachi and Bahawalpur) appears to be of better quality in comparison to the other samples.

A commercial-scale replication of the study trial keeping in consideration the findings of the screening study was conducted in a commercial bakery of Multan namely Food Festival Bakers. This trial was aimed to

1. Replicate the laboratory scale trial at commercial settings, and to authenticate screening study findings in a set of conditions followed by bread and *Naan* manufacturers.

2. Validate the findings of the screening study i.e., flour quality is the primary factor influencing sensory properties of the baked goods

3. Identify if premixes (with and without zinc) led to any significant effect on baking properties of selected flour type and sources.

4. Study the combined effect of flour, additives and premixes for developing good quality baked goods from lower-quality flour

6.7 Findings of the commercial trial

An expert panel comprising of 10 learned and highly qualified food technologists (Annex 2) with vast experience in sensory profiling was engaged for sensory evaluation of the commercial scale fortified *Naan* and bread. The data from the sensory analysis findings of the experts' panel identified: -

1. A Non-significant response of the premix's sources appeared on colour, taste, and other sensory parameters of *naan* and bread prepared with *Maida* procured from the designated flour mills of Bahawalpur and Karachi. Highest mean colour score i.e., 7.6 – 7.66 was assigned to *naan* fortified with premixes procured from Morgan Technologies and Attaullah Zia International.

2. The mean colour score for all premixes was statistically non-significant. Instrumental colour indexing of naan ranked premixes from Morgan Technologies and Atta Ullah Zia International as superior in terms of attributing higher degree of lightness to naan crust.

3. Zinc free premix did not attribute any significant change in sensory attributes of *naan* and was ranked at par with premixes containing zinc.

4. Flour samples sourced from Lahore and Peshawar attributed comparatively lesser but organoleptically acceptable sensory score (like moderately) for *naan* and bread colour i.e., 7.03 – 7.48 and 6.9 – 7.45, respectively and other sensory parameters to that of fortified flour procured from Bahawalpur and Karachi. Colour profile of the product was observed to be better when leavened with baking soda sourced from ICI (Pvt.) Ltd.

7 Conclusion and Recommendations

Sensory quality of the bread leavened, and unleavened flatbread is determined by the type and quality of principle ingredients including flour, chemical and biological leavening agents, sugar and other minor components like salts. This study concludes that fortification is not expected to result in an undesirable or unlikeness sensory response to the baked products. Across the country, the high degree of variability in the baking quality of flour meant for naan and bread production was observed as the major confounding factor linked to significant sensory scoring differences (reduction). The explorative study further concludes that baking soda, as well as other important ingredients, may enhance crust and crumb colour acceptability of leavened baked goods by maintaining a composition that favours optimum bicarbonate – acid balance. At present, most conventional baking soda recipes followed by small and medium bakers are not very suitable for the fortified flours as has been identified in this sensory acceptability research study. Based on the sensory study findings of the products developed we would recommend the ideal composition of baking soda to be carrying not less than 99.0% $NaHCO_3$ (w/w) and 8.2 pH in 1% solution (w/v) is likely to provide the best sensory attributes for similar fortified baked products. It is pertinent to mention that none of the fortified products in all cases was disliked by the consumer and expert sensory panellists.

Following are the key recommendations derived from this study

- Uniform standards of milling quality of the grains meant for fortification and leavened baked goods production need to be adopted to enhance the quality and acceptability of fortified baked products across the board.

- Grain quality standards and in practice quality monitoring mechanism currently followed by the millers should be reviewed to ensure uniformity in good manufacturing practices. Wheat procurement quality criteria (Annex 3) established by the Food departments under the Pure Food Rules 2007 may be uniformly adopted by the millers and strict in-house quality monitoring of the fresh procurement and stored wheat may be practised before processing flour.

- Flour extraction rates and grain particle size below 80µm must be considered as a benchmark to yield maximum sensorial quality of the fortified leavened baked goods.

- Quality evaluation of the chemical and biological leavening agents may also be referred to as a gold standard for the commercial bakers. Quality specifications of baking soda for the professional bakers are available in Annex 4.

- The bakers may be encouraged to implement in-house quality assessment procedures for flour and leavening agents to develop premium quality fortified baked goods with higher consumer acceptability. In-house quality testing facilities for the wheat flour and other baking ingredients may be established by the bakers. At present, a sizeable number of commercial baking organisations have established raw material quality monitoring mechanisms with functional laboratories but a significant proportion of national baked goods production lies with the small and medium baking industry, where feasible such processors should be encouraged to establish minimum quality testing infrastructure or otherwise arrange to have their fresh raw material supplies randomly analysed from the quality testing facilities at the regional food research stations or laboratories.

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Annex 1: Sensory Evaluation Form

Product:_____Date: ----------

Name of Judge:

Sample Code	Colour (1-9)	Texture (1-9)	Taste (1-9)	Odour (1-9)	Chewability (1-9)	Mouth feel (1-9)	Overall. Acceptability (1-9)
1.							
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							
11.							
12.							
13.							
14.							
15.							
16.							
17.							
18.							
19.							
20.							

1. *Please rate (1 to 9) the product for colour, texture, taste and odour*
2. *1=Extremely disliked, 9=Extremely liked.*
3. *Do not assign score to "Overall Acceptability". This will be calculated as the average of the other 6 parameters.*

***** Please comment if you have any observation on any sensory parameter irrespective of the score assigned above***

Signature of Judge

Annex 2: Sensory Expert Panel

List of the expert panel for commercial-scale product sensory testing	
Dr Saeed Akhtar	Director
Dr Muhammad Tauseef Sultan	Assistant Professor
Dr Tariq Ismail	Assistant Professor
Dr Majid Hussain	Assistant Professor
Dr Amir Ismail	Assistant Professor
Dr Adnan Amjad	Assistant Professor
Dr Sameem Javed	Assistant Professor
Dr Inamullah	Assistant Professor
Dr Khurram Afzal	Assistant Professor
Mr Muhammad Waseem	Research Associate

Annex 3: Quality Standards for Wheat and Maida

Quality standards for bread wheat		
Moisture	Note more than 10.0%	
Total protein	Not less than 11.0%	
Dust, Dirt and other non-edible matter	Tolerance Limit: 0.50%	Rejection Limit: 1.00%
Other Food Grains	Tolerance Limit: 3.00%	Rejection Limit: 5.00%
Shrivelled / Damage Grains	Tolerance Limit: 3.00%	Rejection Limit: 5.00%
Weeviled / Insect Damaged Grain		
New crop up to end of August	Tolerance Limit: Nil	Rejection Limit: Nil
September and October	Tolerance Limit: 0.50%	Rejection Limit: 1.00%
November and December	Tolerance Limit: 1.00%	Rejection Limit: 2.00%
January to onward	Tolerance Limit: 1.50%	Rejection Limit: 3.0

Quality standards for *maida*	
Moisture	Not more than 13.0%
Ash	Not more than 0.5%
Wet gluten	Not less than 25%
Dry gluten	Not less than 8.0%
Titratable acidity	Not more than 0.115%
Extraction rate	70-80%
Particle size (µm)	80 – 120 (retention rate up to 80%)

Annex 4: Quality Specifications of Baking Powder

Quality specifications of baking powder	
Chemical ingredient (% by weight)	100% Sodium bicarbonate (Contain not less than 99.0% $NaHCO_3$ on dry weight basis)
Appearance	White crystalline
Odour	None
pH (1% solution w/v)	8.2
Solubility in water	8.6g/100ml @ 20C (Dissolve 1g in 20ml water: The resulting solution is complete and clear)

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