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Effect of Wheat Flour Extraction Rates on Flour Composition, Farinographic Characteristics and Sensory Perception of Sourdough Naans

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Abstract**—**The effect of wheat flour extraction rates on flour composition, farinographic characteristics and the quality of sourdough naans was investigated. The results indicated that by increasing the extraction rate, the amount of protein, fiber, fat and ash increased, whereas moisture content decreased. Farinographic characteristic like water absorption and dough development time increased with an increase in flour extraction rate but the dough stabilities and tolerance indices were reduced with an increase in flour extraction rates. Titratable acidity for both sourdough and sourdough naans also increased along with flour extraction rate. The study showed that overall quality of sourdough naans were affected by both flour extraction rate and starter culture used. Sensory analysis of sourdough naans revealed that desirable extraction rate for sourdough naan was 76%.

Keywords**—**Extraction rates, Farinographic characteristics, Flour composition, Sourdough naans, Wheat flour.

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I. Introduction

WHEAT (*Triticum aestivum*) is the most important crop for making bread, due to its absolute baking performance in comparison to all other cereals [1]. In Pakistan, 80% of the total wheat produced is used for making chapattis, rotis, and naan. These are primary and the cheapest source of protein and calories for the population [2]. Flat breads are oldest, most diverse, and most popular product in the world. It is estimated that over 1.8 billion people consume various kinds of flat breads all over the world. The popularity of these traditional breads is growing due to ethnic population, higher demand for exotic, healthy and natural breads [3]. Flat bread (naan) is the usual commercial flat bread of Pakistan. It is mostly prepared from lower extraction rate wheat flour and dough is leavened either with yeast or sourdough or both. It is baked mostly in the country restaurants and small bake shops known as tanoor shops and comparatively more nutritious than chapatti/roti, as it is prepared from fermented dough.

Sourdough process may be used to prepare various types of good quality breads. The sourdough fermentation have a number of beneficial effects that include, a prolong shelf, accelerated volume, delayed staling, improved bread flavor and nutritional value [4], [5]. However, quality of sourdough bread depends upon several factors such as source of acidification, the form of starter addition and flour extraction rates [6], [7]. The sourdough bread is preferred over yeast leavened bread due to production of organic acids during fermentation which may exert beneficial effects on sensory properties and keeping quality of the breads. Moreover, sourdough fermentation may contribute towards production of flavoring compounds in the baked goods, thus enhancing their popularity among consumers.

Flat bread quality depends upon a number of variables such as wheat quality, flour types, extraction rate, ingredients and processing methods. Moreover, Inherit characteristics of wheat, tempering conditions, and milling practices cause a significant difference in flour quality [3]. Flour extraction rate has marked effect on its nutritional content [8]. Studies indicated that flour extraction rate affects the protein content, farinographic water absorption and gluten strength [9]. With an increase in exaction rate, the protein content, fiber, sugar, lipids and mineral matter increase, whereas the starch decreases [10]. Studies have shown that incidence of cardiovascular and gastrointestinal diseases have increased among people living in big cities. The main reason for these diseases could be due to the lack of fiber in their diet [11]. Flat breads prepared from higher extraction rate flours are the best potential source of fiber to prevent these kinds of diseases. However wheat bran has adverse effect of bread volume, but, use of bran up to seven percent in bread making could result in acceptable quality bread comparable with the bread produced from white flour [12].

Different researches like [13], [14], [15] have investigated the effect of flour extraction rate on flour composition and quality of bread. However, there is no information on the effect of flour extraction rate on the quality of sourdough naan. Therefore, this study was planned to investigate the effect of different extraction rates and mixed cultures of LAB and yeast on the quality characteristics of sourdough naan.

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II. MATERIALS AND METHODS

A. Materials

Pakistani grown winter wheat variety AS-2002 was procured from Wheat Research Institute, Ayub Agriculture Research Institute, Faisalabad-Pakistan. Freeze dried cultures were procured from Lallemand Baking Solutions, Montreal, Canada. Freeze dried cultures namely, LA-1 containing homo-fermentative strain *Pediococcus acidilacti* along with yeast *Saccharomyces cerevisiae* and LA-5, mixed culture containing hetero-fermentative strain *L. brevis* and homo-fermentative strain *L. casei*, along with yeast *Saccharomyces cerevisiae*, was used.

B. Different extraction rate flours

Wheat tempered to 15% moisture was milled by using Quadrumate Senior Mill (C. W. Brabender, Duisburg, Germany). Four milling fractions namely break flour, reduction flour, bran and shorts were obtained. Break and reduction flours were mixed to get straight grade flour. The by-products obtained during milling such as bran and shorts were milled in a hammer mill and blended with 64% extraction rate flour by passing through a 40-mesh sieve (610 µ). The 64%, 76%, 88% and 100% extraction rates flours were obtained by proportional mixing of the by-product of wheat with 64% extraction rate flour.

C. Proximate analysis of wheat flours

Wheat flours with different extraction rates were analyzed for moisture, crude protein, crude fat, crude fiber, total ash and NFE contents according to their respective standard methods [16].

D. Farinographic studies

Rheological behavior of different flour samples was evaluated by running flour samples through Brabender Farinograph (C. W. Brabender, Duisburg, Germany) [16]. Dough characteristics such as water absorption, dough stability, dough development time and tolerance index of dough were interpreted from farinogram.

E. Mother sponge

Mother Sponge was prepared from flour (200g), tap water (200ml at 30°C) and freeze dried starter culture was added to give colony-forming units (cfu) of 10^8 bacteria per gram and yeast count as 10^6 cfu per gram of sponge. This was mixed by hand with a spoon and incubated for 20 h at 30 °C [17].

F. Sourdough preparation

Sourdough was prepared from flour with 64, 76, 88 and 100% extraction rates. The flour (200 g), water (100 ml) and fermented sponge (70 g) were mixed together into dough and incubated for 20 h at 30°C.

G. Acid content analysis

pH and total titratable acidity (TTA) of dough samples were determined according to method given by [18], using the Inolab WTW Series 720 pH meter. A 10g sample was blended with 90 ml distill water and the suspension was then titrated with a 0.1 mol/L NaOH to a final pH of 8.5. The TTA was expressed as the amount (ml) of NaOH used.

H. Preparation of sourdough naan

The sourdough naans were prepared by using wheat flours of different extraction rates. Dough was prepared by mixing flour (250 g), fermented sponge (100 g), sugar (10g), salt (6 g), and water as determined by farinographic water absorption and incubated for 20 h at 30 °C. A dough ball of 100 g was taken and sheeted into a disk of 7-in. diameter with rolling pin. The disk was pressed with the fingertips in the center covering 5-in. diameter. Put it in proofing chamber at 37°C and 85% RH for 45 min. Finally it was baked in oven at 315ºC for 3 min. The sourdough breads were packed in a polyethylene bag and kept at -20°C for further analysis.

I. Measurement of pH and Titratable acidity

pH and total titratable acidity (TTA) of sourdough naans were determined using the Inolab WTW Series 720 pH meter. A 10g sample was blended with 90 ml distill water and the suspension was then titrated with a 0.1 mol/L NaOH to a final pH of 8.5. The TTA was expressed as the amount (ml) of NaOH used.

J. Sensory evaluation

Freshly prepared sourdough naans were evaluated for sensory characteristics like color, flavor, taste, texture, foldingability, chewability and overall acceptability at room temperature in sensory evaluation laboratory by a panel of 10 judges on 9-point Hedonic Scale [19].

K. Statistical analysis

Statistical analysis was carried out using Minitab (V.13.1, Minitab Inc., PA 16801-3008, USA). Duncan's Multiple Range Test was applied to calculate the level of significance [20].

III. RESULTS AND DISCUSSION

A. Proximate analysis of wheat flours

Results for proximate composition of different extraction rate flours is shown in Table I. All the parameters showed highly significant ($P<0.01$) differences from each other. The moisture contents of different extraction rate flours ranged from 9.8 to 11.78%. The highest moisture level (11.78%) was found in 64% extraction rate flour which decreased gradually with an increase in extraction rate and the lowest (9.80%) moisture was found in 100% extraction rate flour. The decrease in flour moisture contents might be due to the higher amount of bran in higher extraction rate flours. The protein contents increased with an increase in extraction rate. The 64% extraction rate flour showed the lowest crude protein (12.05%) whereas, 100% extraction rate flour showed the highest (13.36%) protein contents. low quantity of protein in straight grade flour might be due to the removal of bran and aleurone layer which contains appreciable amount of protein [21]. Both crude fat and fiber contents increased with an increase in flour extraction rate. The highest fat content (2.76%) was found in 100% extraction rate flour, whereas, the lowest (1.40%) was found in 64% extraction rate flour. The fat percentage was higher in 100% extraction rate than that of 64% extraction rate or white flour because germ is ground along with endosperm during milling [22]. The crude fiber

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contents ranged from 0.40 to 2.14%. The 64% extraction rate flour showed less fiber contents because wheat bran was removed during milling process which decreased the amount of fiber in flour. Similarly ash contents increased with an increase in flour extraction rate. This increase might be due to higher proportion of pericarp and aleuronic layer as reported by [21].

B. Farinographic studies

The effect of flour extraction rate on farinographic characteristics is shown in Table II. The farinographic parameters like Water absorption, dough development time, dough stability and tolerance index were found highly significant ($P<0.01$) among all the flours. The water absorption was found in the range of 55.83 to 64.72%. It increased with an increase in flour extraction rate and was observed the highest (64.72%) in flour with 100% extraction rate and gradually decreased to 55.83% in 64% extraction rate flour. The increase in WA might be due higher protein and complex carbohydrate contents contributed from bran [13]. Similar results were reported by [23], who reported WA of different extraction rate flours in the range of 56 to 66%.

Similarly Dough development time (DDT) also increased with an increase in flour extraction rate. The highest DDT (6.58 min) was given by 100% extraction rate flour. The flour with 64% extraction rate showed DDT 4.53 min. High DDT maybe due to the presence of increased amount of bran particles in high extraction rate flours, which may interfere in the quick development of gluten and hydration of endosperm [24]. Both Dough stabilities (DS) and tolerance indices (TIs) were reduced with an increase in flour extraction rates. The DSs were in the range of 1.80 to 6.27 min, whereas, TIs were found in the range of 45 to 64 BU. The variations in the farinographic characteristics might be due to difference in endosperm portion among the different extraction rate flours [24].

C. pH and acidity of sourdoughs

The results for pH and acidity are shown in Table III. Flour extraction rate showed highly significant effect ($P<0.01$) on TTA and with the increase in flour extraction rate TTA increased. Flour ash content might have influenced the acidification of sourdough [25]. The sourdough made from whole meal flour showed almost double TTA than sourdough made from straight grade flour. The increase in TTA might be due to the presence of more quantity of fermentable carbohydrates in whole meal flour. The starter culture also had an effect on TTA, but this effect was small in comparison to flour extraction rates [26].

D. pH and acidity of sourdough naan

The results of pH and acidity are shown in Table IV. Yeast leavened naan showed the highest pH (5.2) and the lowest acidity (3.5) values. The pH of sourdough naan changed little with an increase in flour extraction rate and was in the range of 4.6 to 4.8. The sourdough naans prepared from different extraction rate flours using LA-1 and LA-5 starter culture showed acidity in the range of 3.5 to 9.7 ml, which increased with an increase in flour extraction rate. The results showed that TTA value of 100% extraction rate flour sourdough naan was almost double than sourdough naan made from straight grade flour. Brümmer and Seibel [27] Suggested TTA values between 3.5 and 4.0 in order to get good taste in wheat bread. Similarly Martinez-Anaya [28] reported lower pH and higher TTA in breads fermented with LAB than yeast fermented breads.

E. Sensory evaluation

The Sensory characteristics of sourdough naans prepared from different extraction rates are shown in Fig.I. Sourdough naans were evaluated for sensory characteristics like color, flavor, taste, texture, foldingability, chewability and overall acceptability by a panel of 10 expert panelists. All treatments differed significantly ($P<0.01$) with regards to all sensory parameters. Comparison of control with sourdough naan prepared from LAB cultures resulted in significant effect ($P<0.05$) on color and taste, whereas flavor, texture, flexibility, chew ability and overall acceptability were effected highly significantly ($P<0.01$).

In the present study scores for color of sourdough naans were higher than color scores shown by control bread, might be due to the production of lactic acid which improved bread color. The color scores decreased with an increase in flour extraction rate due to the increase in bran portion, which masked the color of sourdough naan at higher extraction rat. There was considerable improvement in bread flavor due to sourdough addition. The sourdough naan flavor was improved up to 88% extraction rate flour. The higher ash content flour strongly increased the metabolic activities like formation of acids and volatile compounds but resulting stronger flavor of bread was not necessarily accepted and liked by the consumer [29]. The present study showed that sourdough naan made from both LA-1 and LA-5 starter culture got higher scores for taste as compared to control. The control bread produced sweet yeasty odor and sweet bread taste, whereas sourdough naans resulted in mild pickling and sour odor and had home made bread taste. The taste of sourdough naans were improved up to 88% extraction rate, higher extraction resulted in sourdough naan with extreme sour taste, disliked by the panel. This extreme sour taste might be due to higher TTA. Similarly, results for the texture of sourdough naan showed improvement in texture and palatability. Production of organic acids during sourdough fermentation helps in the swelling of gluten and increases gases retention which produces products with good texture and increased volume [30].

Flexibility of sourdough naans decreased with an increase in flour extraction rate due to the increase of bran particle. The difference in flexibility of all the flat breads may be due to the difference in the hardness of wheat grains and several other factors like flour types and milling characteristics [31]. The scores for chewability indicated that judges gave maximum scores to 76% extraction rate sourdough naan followed by 64% extraction rate sourdough naan which were little sticky due to the absence of bran particles (Fig. I). Freshly prepared naan had maximum chewability that gradually decreased with the passage of time due to the loss of moisture

The flour of high extraction rate imparts darker color which was not attractive and got les scores. Also with the increase in flour extraction rate, taste and other sensory attributes were also affected significantly. The results of present study suggest that the addition of sourdough improve the overall acceptability of sourdough naans. On the basis of sensory evaluation it was concluded that sourdough naan prepared from 76% extraction rate flour and starter culture ranked first for overall acceptability.

IV. Conclusion

After considering all parameters like physico-chemical, reheological characteristics of flour and sensory evaluation of sourdough naans, it is concluded that the quality of sourdough naans might be enhanced depending upon the types of flour and starter culture used. The overall quality of sourdough naans were affected by flour extraction rates. Keeping in view the nutritional benefits and results of sensory analysis it could be concluded that sourdough naan produced from 76% extraction was of superior quality. Hence 76% extraction rate flour declared as best for sourdough naan preparation.

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TABLE I
PROXIMATE COMPOSITION OF DIFFERENT EXTRACTION RATE FLOURS

Parameters	Wheat flour with different extraction rates			
	64%	76%	88%	100%
Moisture	11.78±0.70a	11.08±0.22ab	10.42±0.26bc	9.80±0.32c
Crude protein	12.05±0.74c	12.48±0.46bc	12.92±0.44ab	13.36±0.29a
Crude fat	1.40±0.06d	1.90±0.01c	2.34±0.07b	2.76±0.09a
Crude fiber	0.40±0.04d	1.06±0.08c	1.62±0.10b	2.14±0.01a
Total ash	0.56±0.03d	0.86±0.04c	1.21±0.07b	1.55±0.04a
NFE	73.81±0.16a	72.62±0.75b	71.49±0.41c	70.39±0.56d

*Means with different letters have significant ($p<0.05$) and with no letter have non-significant variation ($p>0.05$)

TABLE II
FARINOGRAPHIC CHARACTERISTICS OF DIFFERENT EXTRACTION RATE FLOURS

Parameters	Wheat flour with different extraction rates			
	64%	76%	88%	100%
WA (%)	55.83±0.14c	58.30±0.23bc	61.24±4.54ab	64.72±1.98a
DDT (min)	4.53±0.09c	5.47±0.10b	6.14±0.56a	6.58±0.17a
DS (min)	6.27±0.22a	3.70±0.46b	2.26±0.15c	1.80±0.08c
TI (BU)	64.00±2.33a	62.10±1.02a	56.24±3.59b	45.08±2.84c

*Means with different letters have significant ($p<0.05$) and with no letter have non-significant variation ($p>0.05$)

WA: Water absorption, DDT: Dough development time, DS: Dough stability, TI: Tolerance index

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TABLE III
PH AND ACIDITY OF SOURDOUGH PREPARED WITH DIFFERENT EXTRACTION RATE FLOURS AND CULTURES

Starter cultures	Extraction rates	pH	Acidity (ml 0.1N NaOH)
Control		4.8±0.046a	6.8±0.162f
LA-1	**64%**	3.6±0.023b	9.5±0.138e
	76%	3.5±0.115bc	16.5±0.537d
	88%	3.4±0.035bcd	17.5±0.162cd
	100%	3.3±0.052cd	20.8±0.439b
LA-5	**64%**	3.6±0.023b	10.1±0.335e
	76%	3.5±0.046bc	18.7±0.266c
	88%	3.3±0.109cd	21.4±0.843ab
	100%	3.2±0.023d	22.3±0.369a

*Means with different letters have significant ($p<0.05$) and with no letter have non-significant variation ($p>0.05$)

Control dough made from *Saccharomyces cerevisiae* alone

LA-1 Starter culture containing *Pediococcus acidilacti* + *Saccharomyces cerevisiae*.

LA-5 Starter culture *L .brevis* + *L .casei* + *Saccharomyces cerevisiae*

TABLE IV
PH AND ACIDITY OF SOURDOUGH NAAN PREPARED WITH DIFFERENT EXTRACTION RATE FLOURS AND CULTURES

Starter cultures	Extraction rates	pH	Acidity (ml 0.1N NaOH)
Control		5.2±0.144a	3.5±0.046f
LA-1	**64%**	4.8±0.063b	4.7±0.092e
	76%	4.8±0.104b	5.7±0.196d
	88%	4.7±0.052b	6.9±0.069c
	100%	4.6±0.052b	9.5±0.387a
LA-5	**64%**	4.8±0.052b	3.5±0.087f
	76%	4.8±0.081b	7.2±0.248c
	88%	4.7±0.156b	8.5±0.179b
	100%	4.7±0.017b	9.7±0.300a

*Means with different letters have significant ($p<0.05$) and with no letter have non-significant variation ($p>0.05$)

Control Naan bread made from *Saccharomyces cerevisiae* alone

LA-1 Starter culture containing *Pediococcus acidilacti* + *Saccharomyces cerevisiae*.

LA-5 Starter culture *L .brevis* + *L .casei* + *Saccharomyces cerevisiae*

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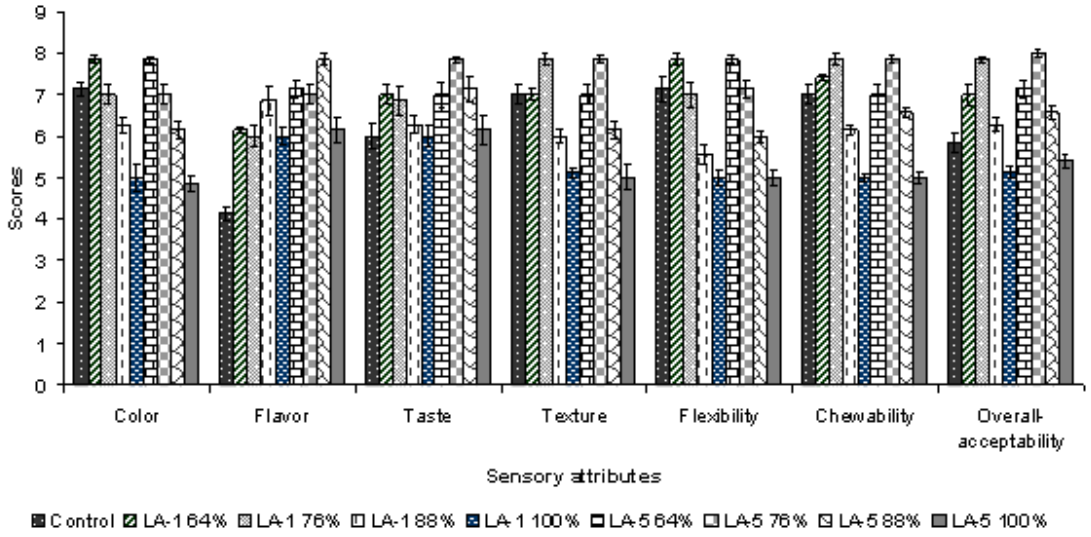


Fig. 1 Sensory characteristics of sourdough naan prepared with different extraction rate flours and cultures

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