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Rheological Characteristics and Chemical Compositions of Commerical Flours for Breadmaking in Saudi Arabia[1]

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Abstract. The flour milling industry is expanding rapidly in Saudi Arabia. There are ten large silos of total 2,380,000 tons grain storage capacity and five modern flour mills of 5,400 ton flour per 24 hr. The purpose of this study was to evaluate the rheological characteristics and chemical compositions of the three major locally milled extraction wheat flours, namely; *bodra, aidy* and *burr* flours of 75, 85 and 95% extraction rate, respectively.

For this study, 35, 25 and 35 *bodra, aidy* and *burr* flour samples, respectively were colleccted from commerical bakeries in Riyadh city. Results show an increase in farinograph water absorption, protein ash, fat, crude fiber and minerals content of the flour with the increase in extraction rate. Dough stability, carbohydrate, wet gluten and amino acids decreased when increasing extraction flour rate.

The results obtained could serve as over all quality criteria of these local flours. It should also help national bakeries to utilize the different flours according to their rheological properties and chemical compositions for making various types of bread and other bakery products in Saudi Arabia.

Introduction

The total world production of cereals in 1981 was estimated at 1652 million tons. This production was sufficient to provide approximately 370 kg of cereal grain per head per annum, or about 1 kg/head/day. The average human consumption of cereals is

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only about one third of this figure as a variable proportion is used for other purposes, mainly as animal feed, industrial processing, seeds, and there is a considerable waste [1].

In Saudi Arabia, the per capita consumption of cereals increased from 94.4 to 131.9 kg/year during the period 1975–1984. In 1984, cereals provided 1308 cal/day and 36.3 gm protein/day to the consumer in Saudi Arabia. The caloric and protein contribution of cereals to the daily diet were 40 and 41%, respectively [2]. In 1986 the Kingdom of Saudi Arabia produced 2,070,000 tons of bread wheat, mostly *Yecora rojo* variety, compared to 3,000 tons in 1980 [3]. The flour milling industry is expanding rapidly as it is given top priority by Saudi Government. There are ten large silos of total 2,380,000 tons grain capacity, mostly wheat, and five modern flour mills of 5,400 tons per 24 hr. The largest silos with a capacity of 535,000 tons are located in Riyadh and the largest flour mills with a production capacity of 1680 tons per 24 hr. are in Jeddah [4]. Approximately two thirds of the total flour production of different extraction percentages are used for breadmaking in Saudi Arabia [5].

The extraction rates of locally milled flours are fixed by the Grain Silos and Flour Mills Organization as 75, 85 and 95% for *bodra, aidy* and *burr* flours, respectively [4]. Flour of extraction rates between 75 and 100% can be milled by adding a proportion of the reground by products to white flour [1].

Today's higher flour extraction rates have influenced the content of several important nutrients [6]. Neshein [7] empasized the need to study the feasibility of retaining in flour as much as possible of the indigenous nutrient content of wheat without impairing its end-use quality i.e. milling to a longer extraction, is necessary [8]. Flours of lower extraction rate, viz. white flour and brown flour as milled, differ from wheat in nutritive value because of the removal of varying amounts of bran, germ, and outer endosperm [1]. Nevertheless, in some countries, including Saudi Arabia, these differences in nutritive value are reduced by enrichment of white flour of 75% extraction with the most important nutrients that have been removed viz. vitamin B_1 (thiamin), vitamin B_2 (riboflavin), nicotonic acid (niacin) and iron.

Mousa and Al-Mohizea [9] investigated the technological aspects and physical characteristics of widely consumed bread types in Saudi Arabia, produced from local commercial flours of 75, 85 and 95% extraction rates.

The chemical composition and rheological properties of flours milled from two wheat varieties grown in Saudi Arabia were studied by Khatchadourian *et al.* [10], using a Buhler laboratory mill to obtain a flour extraction of 64 to 66%. No rheological and chemical studies were undertaken on local wheat flours of various extraction rates, commercially used in breadmaking in Saudi Arabia.

Therefore, the objective of this study was to evaluate the rheological characteristics and chemical compositions of the three major wheat flour extractions locally milled in Saudi Arabia. The results obtained are expected to serve as overall quality criteria of these local flours, and should help national bakeries to utilize the different flours according to their rheological properties and chemical compositions for making various types of bread and bakery products in Saudi Arabia.

Materials and Methods

Flour samples

For this study, 35, 25 and 35 flour samples of *bodra, aidy* and *burr* of 75, 85 and 95% extraction rate, respectively, were collected from commercial bakeries in Riyadh city from September 1984 through May 1985. Flour samples of each extraction were well mixed and representative samples were stored at 4°C in sealed polyethlene bags until they were used for rheological tests and chemical analysis. All samples were analyzed in duplicate.

Farinograph test

Farinograms were produced in a Brabender farinograph (C.W.Brabender Instruments, Inc., USA) according to AACC methods [11]. The 50 gm small bowl, constant flour weight method and curves were centered at 500 Brabender Unit (BU) line.

Chemical analysis

Moisture, crude protein (N × 5.7), crude fat, ash and wet gluten weights were determined by AACC methods [11]. Crude fiber was determined and carbohydrate value was estimated by difference according to the AOAC methods [12].

Flour samples for minerals analysis were prepared by wet ashing as described by Osborne and Voogt [13]. Concentrations of Na, and K were determined using EPPENDORF 700 flame photometer. Ca, Mg, Fe, Cu, Zn and Mn were determined using an atomic absorption spectrophotometer (Instrumentation Laboratory, model 251).

Amino acids, with the exception of tryptophan, were determined after hydrolysis of protein with 6 N HCl for 24 hr at 110°C in vacuo according to LKB Method [14], Using LKB Amino Acid Analyzer Model 4150 ALPHA.

Results and Discussion

Farinograph characteristics

Data summarizing farinograph characteristics of flour samples are presented in Table (1). There was an increase in farinograph water absorption with the increase in flour extraction. All flours showed farinograph water absorption between 68 – 77%. The results are in agreement with the findings of Bloksma [15], Mousa *et al.* [16], Orth and Mander [17], and Watson *et al.* [8]. Dough development time (DDT) of *aidy* flour was generally slightly longer than those of *bodra* and *burr* flours. Mousa *et al.* [16] showed a decrease in the stability with increased flour extraction, while farinograph data given in Table 1 showed a decrease of about 5 min. in stability with increased flour extraction from 75 to 95%. Some of the remarkable differences among the local commercial flours assessed with the farinograph are shown in Fig. 1.

Table 1. Farinograph characteristics of commercial flours

Characteristics	Bodra* 75**	Aidy* 85**	Burr* 95**
Water absorption %	68	72	77
Dough development time, min.	9.5	10	9
Stability, min.	16.3	10	11.5

* Type of flour ** Extraction rate, %

Chemical composition

a) **Proximate analysis**

Because of the marked differences in composition between the bran and endosperm and within the endosperm itself [18] flours representing varying extraction rates are expected to differ in composition [7]. Data presented in Table 2 show the proximate analysis of different flour samples. The protein content was found to increase from 12.2 to 13.6% when increasing flour extraction which is in agreement with the findings of Kent [19 and 1], Orth and Mander [17], and Watson *et al.* [8]. This protein content is considered acceptable for baking different types of flat and European breads in Saudi Arabia [10].

Also, the results showed that flour ash content increased from 0.64 to 1.55% with increase in extraction rate, the same findings were reported by Kent [19], Mousa *et al.* [16], Orth and Mander [17], Shuey *et al.* [20], and Watson *et al.* [8]. This increase in ash which is influenced by the extraction rate is related to the degree of contamination by outer portions of wheat kernel and powdered bran fragments.

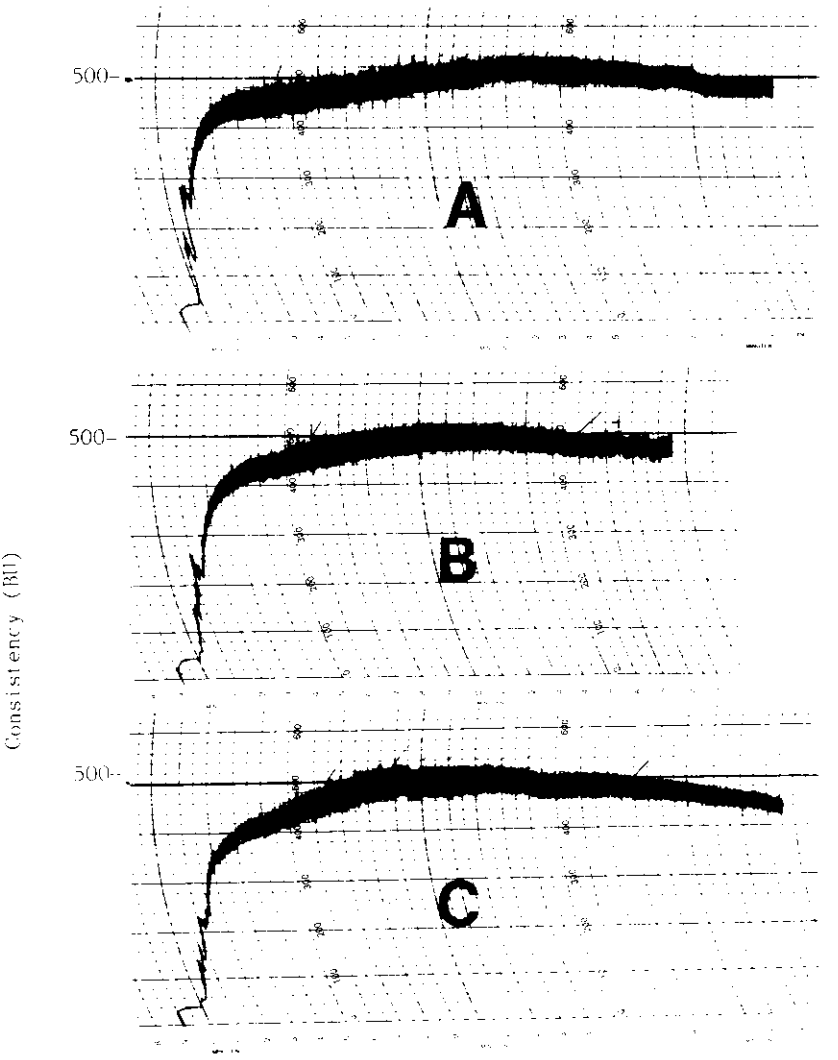

Fig. 1. Farinogram curves of the three commercial extraction flours. A: bodra (75%), B: aidy (85%), C: burr (95%)

Table 2. Proximate analysis of commercial flours

Analysis %	Bodra* 75**	Aidy* 85**	Burr* 95**
Crude protein[a]	12.2	12.8	13.6
Ash[a]	0.64	0.91	1.55
Crude fat[a]	1.1	1.7	2.0
Crude fiber[a]	1.4	1.7	3.0
Carbohydrates[a]	84.7	82.7	79.8
Wet gluten	33.9	33.9	29.3

[a] Dry basis. * Type of flour ** Extraction rate, %

Fat content of the flour samples increased from 1.1 to 2.0%, with increase in flour extraction due to the presence of germ in the higher flour extractions. The results are in agreement with the findings of Shuey *et al.* [20].

The present study shows that crude fiber increased from 1.4 to 3.0% as the flour extraction increased. The results are in agreement with Kent [1] who found that increasing proportions of bran at extended flour extraction tend to steeply increase fiber content at extraction rates between 85 and 100%. The results also confirm those of Watson *et al.* [8] who reported that milling to a longer extraction is necessary to retain more minerals and dietary fiber of wheat, and those of Shuey *et al.* [20] who found that fiber contents were higher in extended flours than in straight grade flours.

Carbohydrate content of the three flour samples showed a moderate decrease from 84.7 to 79.8% with the increase of flour extraction. This loss is perhaps due to the loss in fiber content and also to the increase in protein content. The findings tend to agree with those of Kent [1] who found that flour of 85% extraction had a higher content of all nutrients (except carbohydrate) than 75% flour extraction.

Wet gluten content showed a decrease of 4.6% between 85 and 95% extraction. This agrees with Mousa *et al.* [16] who found a decrease of 1% in wet gluten with increase in extraction rate from 85 to 95%.

b) **Mineral elements**

The mineral contents of the flour samples are presented in Table 3. Sodium, potasium and manganese increased with the increase of flour extraction rate. No major changes however were observed between the flour samples of different extraction rates in iron and calcium contents. This may be ascribed to the enrichment of

white flour (*bodra* 75% extraction) with iron in the flour mill. *Burr* flour (95% extraction) gave the highest mineral content, except for zinc which was highest in *aidy* flour (85% extraction), due to the fact that higher extraction flours contain more bran particles, as reported by Shuey and Skarsaune [21]. Potassium was found to be the highest determined element; 114.6, 158.5 and 265.3 mg/100 gm for *bodra, aidy,* and *burr* flours, respectively.

Table 3. Mineral contents of commercial flours

Minerals[a] (mg/100 gm)	Bodra* 75**	Aidy* 85**	Burr* 95**
Na	4.5	7.5	9.5
K	114.6	158.5	265.3
Ca	7.3	8.2	8.3
Mg	5.1	83.4	97.0
Fe	3.1	3.8	3.3
Zn	0.5	2.8	1.7
Cu	0.3	0.3	0.6
Mn	0.6	1.5	3.2

[a] Dry basis. * Type of flour ** Extraction rate, %

c) **Amino acids**

Amino acid compositions of the flour samples are presented in Table (4). Data indicate that the total essential amino acids (E) decreased as the flour extraction increased, being 44.2, 30.7, and 22.9 gm/100 gm for 75, 85 and 95% extraction, respectively. Total non essential amino acids (N) are much higher than their corresponding (E) values of the flour samples. *Aidy* flour had the highest (N) value, 80.4 gm/100 gm and *bodra* flour had the highest (E) and (E/N) values of 44.2 gm/100 gm and 0.6, respectively. Glutamic acid, proline, and leucine were the highest amino acids of the flour samples.

In conclusion, the rheological properties and chemical compositions of the three commercial flour extractions, locally milled from *Yecora rojo* variety, are of acceptable quality for making different types of bread in Saudi Arabia. The present findings support the previous investigation on bread baking in Saudi Arabia undertaken by Mousa and Al-Mohizea [9]. Further study on chemical compositions and nutritive values of six types of bread produced from these three major flour extractions is submitted for publication.

Table 4. Amino acids of commercial flours

Amino acids (gm/100 gm protein)	Bodra* 75**	Aidy* 85**	Burr* 95**
Essential amino acids			
Cys	0.8	0.6	0.4
Ile	5.0	3.1	1.8
Leu	10.9	7.5	5.7
Lys	2.6	2.0	1.7
Met	2.9	1.0	1.5
Phe	8.3	5.8	4.3
Thr	4.2	3.0	2.0
Tyr	3.0	2.8	2.1
Val	6.5	4.9	3.4
Total essential amino acids (E)	44.2	30.2	22.9
Non-essential amino acids			
Ala	4.8	3.8	3.5
Arg	5.5	4.3	3.7
Asp	7.2	5.4	4.3
Gly	5.5	4.2	3.7
Glu	19.4	40.1	29.3
His	3.7	2.9	2.0
Pro	19.2	14.3	11.6
Ser	7.4	5.4	4.1
Total non-essential amino acids (N)	72.7	80.4	62.2
E/N	0.6	0.4	0.4

* Type of flour ** Extraction rate, %

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الصفات الريولوجية والتركيب الكيميائي لدقيق الخبز التجاري في المملكة العربية السعودية

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المملكة العربية السعودية

ملخص البحث . تطورت صناعة الطحن في المملكة العربية السعودية تطورًا سريعًا، حيث يوجد الآن عشرة صوامع للغلال بطاقة تخزين إجمالية قدرها ٢ر٣٨٠ر٠٠٠ طن من الحبوب وخمسة مطاحن حديثة للدقيق بطاقة طحن قدرها ٤٠٠ , ٥ طن دقيق/ ٢٤ ساعة.

أجريت الدراسة بهدف معرفة الصفات الريولوجية والتركيب الكيماوي لثلاثة أنواع رئيسة من الدقيق المنتج محليًا وهي دقيق بودرة، عادي، بُر بنسب استخلاص ٧٥، ٨٥، ٩٥٪ على التوالي.

جمعت ٣٥، ٢٥، ٣٥ عينة من الدقيق البودرة، العادي، البُر على التوالي من المخابز التجارية في مدينة الرياض. وتشير النتائج إلى الارتفاع في درجة الامتصاص للماء، البروتين، الرماد، الدهن، الألياف الخام، محتوى المعادن للدقيق مع الارتفاع في معدل الاستخلاص، بينما انخفضت درجة ثبات العجين، الكربوهيدرات، الجلوتين الرطب، الحموض الأمينية مع الارتفاع في معدل استخلاص الدقيق.

من المتوقع أن تساهم نتائج البحث في تقويم درجة الجودة لأنواع الدقيق المنتجة محليًا، وتوجيه القائمين بصناعة الخبيز لاستعمال أنواع الدقيق المختلفة، طبقًا لصفاتها الريولوجية وتركيبها الكيماوي، في إنتاج الخبز بأنواعه المتعددة وكذلك المخبوزات الأخرى المنتجة محليًا في المخابز الوطنية السعودية.