FARINA MILLING:
DEVELOPMENT OF A FLOW SHEET
AND A SPECK COUNTING METHOD

by

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Dad... I remember when I came from my first class and I showed you the first thing I ever wrote in school. It was the letter " b ". I was very happy but when you looked at my book and you smiled, I had a strange feeling. I felt that you were not very happy, you were expecting more than that. You were expecting me to be able to read and write for you all that you need. However you smiled and you told me that everything was beautiful. That day I made a promise to myself, I will read, write and speak in more than one language. God wanted you before I could write my name in my native language. Dad, just rest and keep your smile but smile happily, if you were alive you'd be proud of me as Mom is proud.

Mohammed,

KANSAS STATE UNIVERSITY

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INTRODUCTION

The United States Food and Drug Administration (FDA) defines farina as "food prepared by grinding and bolting cleaned wheat, other than durum wheat and red durum wheat, to such a fineness that it passes through a No. 20 sieve, but not more than 3% pass through a No. 100 sieve. It is free from the bran coat or bran coat and germ to such an extent that the percent of ash therein, calculated to a moisture-free basis is not more than 0.6%. Its moisture content is not more than 15%." Semolina is defined similarly, except that it is obtained from durum and that its dry ash content is not more than 0.92%.

The United States, Italy, France and several other countries use semolina to produce pasta. In countries such as Tunisia, Algeria and Morocco, semolina is used to make couscous. Couscous is a traditional dish usually served on Fridays and eaten commonly with meat and vegetables. Semolina is the preferred raw material for pasta and couscous making; however, the price of durum wheat has made semolina more expensive for the average consumer in many countries. Irvine (1971) stated that almost any wheat may be milled to "semolina". Efforts have been made to provide the consumer with a product similar to semolina but at lesser cost: this product is farina. Farina has been used extensively, either alone or blended with semolina, to produce pasta both in developing countries and or in developed countries with high per capita consumption of pasta (McGee and Giles 1983a, Kim et al 1986). So far mostly hard red wheat has been used to produce farina. Only a few clean streams were selected to make farina (Shuey et al 1980). Kim et al (1986) described a laboratory procedure to use hard red winter wheat to produce 32.2% farina with 49 specks (see glossary) per ten square inches (tsi).

Hard red wheat is available in abundance, prompting it to be the raw material of choice for farina. Recent research focused on hard white wheats indicates white wheat to be a better source of farina with fewer specks. This is especially important as many authors have emphasized the appearance of the final product more than anything else (Abercrombie 1980, Banasik 1981, McGee and Giles 1983a). The purpose of this research was to investigate the feasibility of farina production from hard white wheat with a minimal speck count and to evaluate this hard white wheat against a mill mix (see glossary) of hard red winter wheat.

LITERATURE REVIEW

SEMOLINA/FARINA

Semolina and farina have similar definitions according to the FDA except that semolina is obtained from durum and its ash content is not more than 0.92%. It is stated in the Food and Drug standard of identity that semolina, durum flour, farina, flour, or any combination of two or more of these can be used to make macaroni products.

Semolina is widely used for pasta production. Irvine (1965) stated that durum wheat is the best type of wheat available for production of pasta and couscous. Granular products from other wheats can also be used for pasta production and in fact they are commonly used around the world (Irvine 1971).

It can therefore be stated that farina milling and semolina milling have the same objective: production of a pure stock in a specified granulation range with minimum flour. Aspects of semolina milling and the techniques adopted for farina milling will be reviewed here since most of the literature is devoted to semolina and semolina milling.

Macaroni, spaghetti, vermicelli, noodles, couscous, and bread are among the main products made from durum wheat (Irvine 1965, 1971; US Food and Drug 1986). All of these products may be made from semolina or flour, or both. The literature shows different characteristics for semolina since each pasta producer has individual requirements regarding moisture, granulation, color score, appearance, specks, protein and gluten qualities. Characteristics of a typical semolina are described below under separate headings.

Moisture Content

The moisture content of semolina is between 13.5 and 14.5% (Abercrombie 1980). The FDA limits the maximum moisture content to 15%.

Granulation

Granulation is among the most important factors. There is, however, no agreement upon the distribution of the particle size. Irvine (1965) stated that traditionally for batch processing, the best semolina was considered to be a pure coarse fraction which represents 30 to 40% of wheat. There is, however, a tendency toward fine particles: no overs (see glossary) of 30 W and no more than 3% through 100 W are desired (Irvine 1971, Nelstrop 1972, Abercrombie 1980, Manser 1985). Dexter and Matsuo (1978) concluded from a study on semolina milling that milling to coarse granulation did not affect the quality of spaghetti but the granulation tended to become finer as the extraction rate increased. The particle size should remain constant with tendency to coarse particles (Nelstrop 1972). Water absorption is related to granulation, where excess water absorption is associated with fine material resulting in increased drying time. The following granulation distribution was given by Nelstrop (1972) as typical in semolina milling:

overs 500 μ	maximum 2%
overs 376 μ	30 to 40 %
overs 305 μ	15 to 25 %
overs 244 μ	20 to 30 %
overs 142 μ	10 to 12 %
throughs 142 μ	maximum 2 %

A granulation factor given by Nelstrop (1972) is defined as the sum of overs 500 μ, overs 142 μ and throughs 142 μ fractions subtracted from the sum of overs 376 μ, overs 305 μ and overs 244 μ fractions. This factor should be more than 75%. Seyam et al (1974) reported that several authors suggested that the particle size of semolina must fall in the range of 488 to 142 μ. The effect of the particle size of semolina on the quality of pasta products is studied by several authors (Seyam et al 1974, Manser 1985). Seyam et al (1974) concluded from a study that the overall quality of the pasta was not affected by the semolina particle size distribution and they even used a very fine granulation containing as much as 72% flour.

Bran Specks

Specks are not desired because they spoil the appearance of the pasta. McGee and Giles (1983a) stated that specks affect the appearance of the product and compared the importance of having a final product without specks to the desire of a miller for a white and bright loaf. In addition, specks are not desired because they weaken the final product, especially the long goods. In typical semolina milling, the visual appearance takes precedence over the laboratory analysis (Abercrombie 1980, McGee and Giles 1983a).

Grits

Grits (see glossary) are not desired in semolina. Pasta manufacturers set low tolerances for grits because they stick in the die and cause streaking or tearing of the dough as it is extruded (Abercrombie 1980).

Protein Content

The protein content of semolina is desired between 11.5 to 13%. Both Irvine (1971) and Abercrombie (1980) mentioned that semolina within this range of protein is preferred by pasta manufacturers. Lower protein levels give fragile pasta products in addition to problems associated with hydration and mixing. On the other hand, higher protein semolinas produce doughs which stretch upon extrusion.

Wheat Grade

Higher grades of wheat give a higher quality of semolina and, therefore, a better quality of pasta (Irvine 1971). For a given wheat, however, the quality of semolina depends largely on the cleaning, conditioning and milling processes (Nelstrop 1972, Abercrombie 1980, Bailly 1985).

WHEAT CLEANING

Nelstrop (1972) summarized the objectives of the pasta manufacturers in having a product free from grits and free from specks. Emphasis must therefore be put on cleaning in order to remove all black and dark seeds, insects and insect fragments, dust chaff, seed hulls, light shrivelled wheat and the maximum proportion of germ in order to keep the number of specks in the finished products at the minimum level. It has been reported by Abercrombie (1980) that the visual appearance of semolina milling is a critical factor in analysis. Dick and Youngs (1988) stated that millers judge the semolina milling by the semolina extraction, total extraction (semolina plus flour), and appearance and granulation of the semolina.

In durum milling it is common to remove up to 5% screenings (see glossary) during wheat cleaning (Abercrombie 1980, McGee and Giles 1983a). Scouring (see glossary) is important for infestation control as well as for removing beeswing and crease dirt, and reducing germ and microbial count. Posner (1985) reported the importance of removing even a small proportion of the germ before milling and that the germ is more likely to be removed from dry wheat than from tempered wheat. The maximum proportion of wheat germ should be removed during cleaning because of the difficulty in removing the germ without flaking it (Nelstrop 1972, Posner 1985).

WHEAT CONDITIONING

Grosh and Milner (1957) studied the water penetration in hard wheat and concluded that peripheral absorption of water creates stress between wet and dry endosperm, causing cracks. The cracks provide a way for the water to enter and facilitates the formation of middlings (see glossary) during milling.

In a typical semolina milling process, the endosperm of wheat should be at a moisture content of 15% and the bran moisture content be at almost 18% in order to separate bran and endosperm with the minimum breakage of bran (Nelstrop 1972). Tempering time is generally a matter of wheat millability, in fact it varies between 2 and 12 hours for different wheats (Nelstrop 1972). A dry and brittle wheat crease (see glossary) splits during the break passages, resulting in fine black specks which are not removed even with an intensive purification (Lippuner 1978).

Shuey et al (1980) used HRS and HRW wheats to produce farina on a 55-cwt flour pilot mill. They tempered both wheats to 15.5% moisture content for 18 hours and increased by 2% moisture 20 minutes before milling. Kim et al (1986) concluded from a study on milling HRW wheat to farina that a tempering with two stages, 14.5% for three hours and 0.5% added 30 minutes before milling, gave the best results under the experimental conditions.

WHEAT MILLING

The objective of farina milling may be summarized as follows:

1) To separate the endosperm from the bran in the break system. 2) To separate germ and scutellum particles from the granular endosperm. 3) To separate the bran particles adhering to the farina granules and size these particles to the appropriate size. 4) To keep the production of flour at the minimum level.

To achieve these objectives, principles of semolina milling have been adopted. Compared with flour milling principles, the speed and the compression of rolls are reduced with an increase in the shearing effect. In semolina milling, Abercrombie (1980) advised that a roll speed of 400 to 500 rpm should be combined with a grinding action of sharp to sharp (see glossary) in most roll passages. Dull to dull grinding action (see glossary) should be used on the final break and sizing passages. In flour milling, meshing and tearing are the predominant process while in semolina milling shearing and cutting actions prevail.

Matsuo and Dexter (1980a) used roll gaps (see glossary) of 1.29 mm for the first break, 0.41 mm for the second break and 0.20 mm for the third break on an Allis-Chalmers laboratory mill system. The fourth, fifth and sixth break were used essentially as sizing rolls and were fed from the purifiers. The through 72 GG fraction (6.6 %) was collected and added to the final product to get a semolina yield of 69.5%. The characteristics of the final semolina, however, were not reported. Dexter et al (1982) used a Buhler laboratory mill and obtained 70% semolina by using the following settings: all rolls were run dull to dull with a speed differential of 2:1 (see glossary), the faster roll set at 500 rpm. Roll gaps were 0.86 mm, 0.30 mm and 0.20 mm for first break, second break and third break, respectively. The feed rate to the first break was 40 g/cm/min.

Lockwood (1962) recommends grading (see glossary) and dusting stocks before any purification and suggested the feed rate of 2400 lb/18in/hr for coarse farina and 1000 lb/18in/hr for coarse middlings. A range of about 200µ in size was suggested by Abercrombie (1980) as a good range for efficient purification and he stated that it is almost impossible to purify coarse stock in one purifier pass. Air requirements recommended for coarse farina were 1000 cfm and 850 cfm for fine farina (Lockwood 1962). In durum milling, the ambient temperature should be kept between 24 and 27 °C and a relative humidity at about 70% (McGee and Giles 1983b).

It has been reported by McGee and Giles (1983b) that in semolina milling the first break release (see glossary) may be set as low as 15% and stocks from different breaks may be paired to common destination. However, they suggested splitting the grading sifters to narrow the range of the particle size as much as possible. McGee and Giles (1983b) suggested that stocks feeding any purifier should fall in the range of 750 to 160 μ.

Schumacher (1966) stated that heavy loads should be applied if coarse grinding is desired. The same author suggested that an increase in the production of granular products is obtained when more pointed corrugations (see glossary) are used.

Hsieh et al (1980) studied some factors affecting the first break grinding running dull to dull and they concluded that the feed rate and roll speed were without significance under the experimental conditions. They varied the speed differential between 1.5:1 and 3.0:1 and noticed an increase of the proportion of endosperm released and bran fragments produced with an increase in the roll differential. No optimum was, however, suggested.

Nelstrop (1972) reported that grinding on rollermills with reduced space between two successive corrugations decreases the proportion of flour produced. In general, the production of granular stock free from bran particles is considered important in milling. This stock may be sacked off and sold as is or it may be reduced to produce very clean flour (McGee and Giles 1983b).

Fernandes et al (1978) found that the particle size of the millstreams and speck count were inversely related. Nelstrop (1972) stated that a flour mill converted for semolina milling produces about 10% less than a mill set up originally for durum milling. The percent extraction of farina cannot be used accurately to estimate the true milling potential. As a consequence, the total extraction and the farina extraction should both be mentioned (Shuey et al 1977). Mousa et al (1983) have used the 55-cwt flour pilot mill described by Shuey et al (1980) to produce 13% farina from HRW wheat and 16% farina from HRS wheat (percentages calculated on total products basis) with a total extraction of 77.2 and 77.1%, respectively.

Shuey et al (1980) milled HRS wheat on a 55-cwt pilot mill and obtained 28.3% farina and a total extraction of 74.4% based on total products. The farina obtained was described by the authors as clean, sharp and with good appearance with a particle size distribution of:

range	percentage
> 840 μ	3.1%
590 - 840 μ	41.1%
420 - 590 μ	43.4%
< 420 μ	12.4%

However, no speck count was reported. In this study five breaks, three sizings, five middling, one tailing, one low grade and four purifiers were used. The roll settings were:

first break	0.030"	first sizing	0.008"
second break	0.015"	second sizing	0.022"
third break	0.009"	third sizing	0.007"
fourth break	0.009"		
fifth break	0.005"		

The feed rate was set at 180 pounds per hour. The authors concluded that roll corrugations required for milling granular products were not as critical as previously expected.

Kim et al (1986) reported that when HRW wheat is milled to produce flour, about 2 to 5% farina is produced by selection of given streams. They also reported that typical farina has about 125 specks per ten square inches with a coarser granulation than that of semolina. Kim et al (1986) described a procedure for production of farina with variable yield and variable speck counts. The yields achieved were 14.3%, 21.8%, 27.3% and 32.2% with 46, 65, 84 and 95 specks, respectively. All rolls in the primary break system had 14 corrugations and 1/4" spiral (see glossary) and were run dull to dull at 2.5:1 differential. In the secondary break system and chunk rolls (see glossary), 22 corrugations and 1/2" spiral were used for all the rolls. For sizings and middlings, smooth rolls running at 1.5:1 differential were used.

Large semolina units are more versatile than small ones (Matsuo et al 1980). The authors reported that with lab mills the semolina yield is lower than the yield obtained in a commercial mill. The authors also reported that a commercial yield is between 63% and 68%. Shuey et al (1980) stated that the results obtained on the pilot mill compare favorably with those of a commercial mill. Dick and Youngs (1988) reported that values obtained in semolina milling of small samples correlate with those obtained in milling larger samples. Cubadda (1988) stated that it is difficult to obtain lab results comparable to those in an industrial mill due to the difference in the purification process used. The laboratory results can be employed to compare different wheats. Small variation in the laboratory results could, however, be a significant factor in the industrial process. Irvine (1965) reported that Romana, a hard white spring wheat from the west coast, gives a better farina yield than many other hard wheats.

SPECK COUNTING METHODS

Vasiljevic et al (1977) used a 3 X 4 inch glass plate with a one-inch square marked in the center. The sample was pressed down and the count was repeated three times. The number of specks was counted and the final count was expressed as the number of specks in ten square inches Abercrombie (1980) reported that a 1/4" thick clean plexiglass sheet with a one square inch block etched onto the surface is a common procedure in counting the specks. The plexiglass is placed on the sample and the specks are counted in given squares but no number was specified. Dick and Youngs (1988) reported that semolina speck count is determined for 10 square inches of surface area of semolina by summing up three readings from one square inch areas and multiplying the total by 3.33.

Banasik (1981) reported satisfactory results obtained with semolina when the specks were fewer than seven per square inch. Kim et al (1986) stated that acceptable spaghetti was obtained with farina with fewer than 50 specks per 10 square inches. Dick and Youngs (1988) reported that pasta with a relatively good appearance is given by semolina with fewer than 50 specks per 10 square inches.

PASTA AND COUSCOUS MAKING

Pasta

The best pasta products are made from 100% durum wheat semolina. However, for different reasons, various products from various cereals are widely used. During pasta making, semolina/farina is sifted and sent to the automatic press where it is subjected to mixing, kneading, and extrusion. After extrusion the pasta products are dried and cooled. Baroni (1988) reported that the most important recent innovation has been the use of high-temperature drying for short and long pasta (for long goods, drying times used to be between 20 and 30 hr but the recent drying times vary only from 6 to 14 hr; for short pasta products, the old drying times were between 6 and 9 hr and are reduced by almost 50%).

From a study on a 55-cwt flour pilot mill, Fernandes et al (1978) concluded that the millstream collected from a second sizing (through 368 μ and over 119 μ) was the optimum acceptable for pasta production. Abecassis (1985) stated that an improvement in the quality of pasta has been noticed with an increase in semolina extraction. Manser (1985) reported that fine granulation less than 350 μ and even less than 250 μ is most suitable for pasta production. This is attributed to easy-to-hydrate particles and end products which are free from checking. Mousa et al (1984) concluded that blends of granular mill streams from bread wheats and durum wheat produce a pasta product with better appearance and cooked properties than pasta products processed from bread wheat alone.

The cooking quality of pasta is mainly seen as the potential of the product to maintain an acceptable texture after cooking and not to become a sticky, thick mass. The sensory evaluation is still the best tool in judging the final quality of the pasta products.

According to Feillet (1984), protein levels below 11.0% could lead to processing and cooking problems in spaghetti made of durum semolina and therefore protein levels between 12.0 and 15.0% should be used. However, a correlation between high protein and good pasta-making values does not always exist but strong gluten is a major quality requirement (Cubadda 1988). Fortini (1988) concluded that both quality and quantity of protein are critical for pasta quality. Cubadda (1988) stated that differences in cooking quality of pasta in terms of physical or chemical properties of gluten have not been explained yet.

According to Cubadda (1988), the most popular rheological tests, alveograph and farinograph, are inadequate for predicting the cooking quality of durum wheat semolina. Useful information about rheological properties of dough, however, are obtained after some modification of the farinographic procedure. The same author reported that the viscoelastographic and the aleurographic tests were proposed for testing rheological properties of durum dough.

Fabriani (1988) outlined 3 steps in cooking pasta and considered them the fundamental rules:

1) An excess of water: a ratio of about 10 to 1.

2) Addition of salt at the beginning of boiling.

3) Addition of pasta to boiling water and cooking on high heat with stirring once in a while to prevent pasta pieces from sticking together.

The right time to stop cooking is immediately before the nerve (inside) is completely cooked. An undercooked pasta is always better than an overcooked one. In addition, that pasta should be served to waiting people. Pasta is served in many as thousand different ways (Fabriani 1988).

Couscous

Farina and semolina are not only used to make pasta, but they are extensively used in North Africa in couscous making (Kaup and Walker 1986). The following granulation distribution was selected by Guezlane et al (1986) in making couscous.

r a n g e	percentage
over 800 μ	29 %
over 630 μ	38 %
over 560 μ	7 %
over 500 μ	13 %
over 380 μ	4 %
over 250 μ	2 %
less than 250 μ	7 %

Traditionally, couscous is prepared by the agglomeration of farina or semolina in a large wooden or clay dish. Farina or semolina is sprinkled with a small amount of cold water and salt and rolled by fast motion of the palm of the hands. A little flour is added while rolling the semolina with the palm of the hands in order to make small and separate grains. These grains are sorted according to their size by using a sieve. Large grains are crushed and rolled with a little flour, followed by another sorting. The smallest grains are put together while the largest are recycled into the rolling process to make small grains. The grains should be about the same size; agglomerations of many grains are not desirable. The grains are steamed and either served or dried for later consumption. Couscous is served in Morocco according to recipes described by Benani-Smires (1984).

MATERIAL AND METHODS

MATERIALS

Wheat samples used in this experiment were:

1) hard red winter mill mix wheat, obtained from CARGILL FLOUR MILL, WICHITA, KS. This wheat will be referred to as "mill mix" or "red wheat".

2) hard white wheat, W81-162 NAPB, obtained from AGRIPO SEEDS INCREASES, FORT MORGAN, CO. This wheat will be referred to as "H.W.Wheat" or "White Wheat".

Pertinent data regarding the characteristics of the two wheat samples as received are shown in Table I.

M E T H O D S

Wheat: Physical and Chemical Tests

These characteristics were determined according to the following methods:

Moisture: AACC method 44-15A; revised 10-28-81.

Wheat Test Weight: Test weight is the weight per Winchester bushel with the weight expressed to the nearest tenth of a pound. Test weight was determined in accordance with the procedure described in Circular No. 921 issued by the United States Department of Agriculture.

1000 Kernel Weight: The weight in grams of 1000 kernels of wheat was determined with an electronic seed counter, using a 40-g sample from which all foreign material and broken kernels (see glossary) had been removed. 1000 kernel weight is reported on 14% moisture basis.

Pearling Value: 20 g of wheat from which all foreign material and broken kernels have been removed is retained for one minute in a Storng Scott Laboratory Barley Pearler equipped with a No. 30 grit stone and a 10 mesh screen made of wire 0.041 inches in diameter (Tyler Code "Fijor"). Pearling value is the percent of the original sample remaining over a 20 mesh wire after pearling.

Wheat Size Test: Two hundred grams of wheat are placed on the top sieve of a stack of 3 Tyler standard sieves (Nos. 7, 9, and 12). The stack of sieves is placed in a Ro-Tap sifter and sifted for 60 seconds. The percentage remaining on each sieve is then determined.

Protein: The AACC approved Method 46-12; revised 10-8-86. The total nitrogen content determined was multiplied by 5.7 and the result was expressed as percent protein on a 14% moisture basis.

Ash: The AACC approved Method 08-01; issued December 1962. The percent remaining after ignition was expressed as percent ash on a 14% moisture basis.

Wheat Cleaning

Wheat samples were first cleaned using the Carter Dockage Tester (riddle No. 2 and sieve No. 2, feed rate and aspiration were those recommended and are indicated on the

Table I. Wheat Sample Specifications

	H.W. WHEAT		MILL MIX	
	AVG	S.D	AVG	S.D
Test Weight(Lb/Bu)	62.3	0.10	60.3	0.21
Pearling Value (%)	57.93	0.04	60.78	0.25
1000 Ker. Weight (g)[a]	34.45	0.13	24.10	0.34
Moisture content (%)	10.80	0.05	10.30	0.06
Ash (14% m.b.)	1.50	---[b]	1.39	---[b]
Protein (14% m.b.)	12.80	---[b]	13.00	---[b]
Wheat Size Distribution (%)				
Over 7W	76.10	0.07	29.43	0.81
Over 9W	23.90	0.07	68.00	0.63
Over 12W	0.00	0.0	2.57	0.24

a/ 14% m.b.

b/ data are not available

machine for each type of wheat) to remove large foreign material (dockage) and then subjected to the cleaning steps indicated in the schematic Figure 1. The main objective of scouring was to release the maximum proportion of germ, beeswing and dirt located in the crease and on the surface of wheat kernels. The Carter Dockage Tester was used to remove the released germ and all the small broken parts of the endosperm.

Wheat Conditioning

Kim et al (1986) have suggested a method for tempering wheat for production of farina from hard red winter wheat. In the present work, the method was slightly modified. Wheat (12 Kg) was scoured twice at 2080 rpm and tempered to 14.5% moisture, let rest in a sealed plastic bag for 3 hours and scoured three times at 2290 rpm. The sample was split into lots of 2 kilograms each for convenience in the further milling and sifting steps. One lot was used for the equipment warm-up. The moisture content of each lot was adjusted to 15% before the wheat was let rest in covered metal cans for about 20 to 30 minutes before milling. A rotating metal drum was used to evenly distribute water throughout the wheat. The amount of water required to raise the moisture of the wheat was calculated according to the following equation:

$$\text{water (ml)} = \text{wheat (g)} \times \frac{\text{desired m.b.(\%)} - \text{initial m.b.(\%)}}{100 - \text{desired m.b.(\%)}}$$

Figure 1. Sample Preparation Procedure

DRY WHEAT (DOCKAGE FREE)

▼

2 X SCOURING @ 2080 rpm

▼

CARTER DOCKAGE TESTER

▼

CONDITIONING
@ 14.5% m.b. FOR 3 HOURS

▼

3 X SCOURING @ 2290 rpm

▼

SEPARATION IN 5 LOTS
2 KG EACH

▼

ADDITION OF 0.5% m.b.
LET REST FOR 30 min

▼

GRINDING

Wheat Grinding

The wheat was milled in the Department of Grain Science and Industry. The flow sheet set up especially for this experiment is shown in Figure 2. Pertinent information regarding the corrugations, differential, roll gaps, spiral, grinding actions, feed rate and sifting time of the flow diagram in Figure 2 are presented in Table II. All sharp to sharp grindings were done on a batch type experimental milling system (Figure 3). The dull to dull grindings were done on different rollermills with the appropriate setting indicated on the flow sheet. This flow sheet was developed based on the literature review and on preliminary work on a commercial HRW wheat sample.

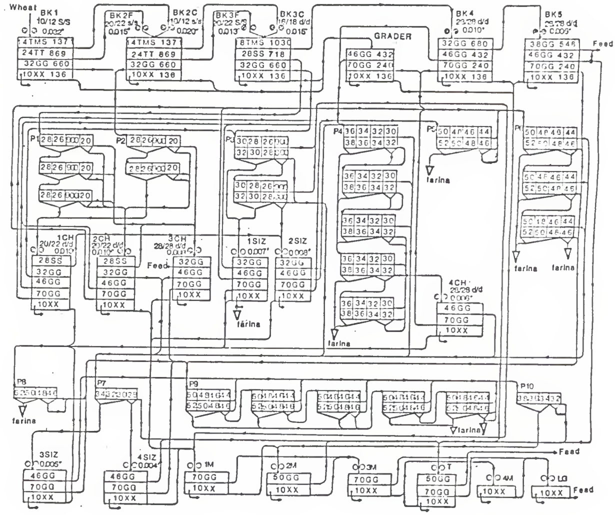
Sifting

The sifters used in this experiment were Great Western Laboratory sifters obtained from Manufacturing Company Incorporated, Leavenworth, Ks. All stocks from the break system were sifted on a sifter running at 160 rpm with 100 mm throw (see glossary). Stocks from the sizing and reduction (see glossary) were sifted on a sifter running at 175 rpm with 105 mm throw. The sifting time of each stock is shown in Table II.

Purification

The purification process was carried out using a Miag laboratory purifier type 7.5 d, Braunschweig, Germany (Figure 4). The purifier consists of two sections with

Figure 2. Experimental Flow Sheet for Farina Production



Wheat
BK1
BK2F
BK2C
BK3F
BK3C
BK4
BK5
GRADER
Feed
1CH
2CH
3CH
1SIZ
2SIZ
3SIZ
4SIZ
4CH
P1
P2
P4
P7
P8
P9
P10
farina
1M
2M
3M
T
4M
LG

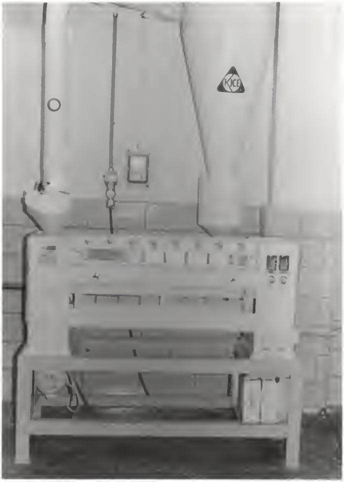
Table II. Settings of the Equipment

	CORRUG	SPIRAL	ACTION	GAP	RPM	DIFF	FEED*	SIFTIME
BK1	10/12	0.4"	s/s	0.032"	471:189	2.49:1	175	2 min
BK2C	10/12	0.4"	s/s	0.020"	471:189	2.49:1	95	2 min
BK2F	20/22	0.4"	s/s	0.015"	471:189	2.49:1	285	
BK3C	16/16	0.1"	d/d	0.015"	370:150	2.47:1	232	2 min
BK3F	20/22	0.4"	s/s	0.013"	471:189	2.49:1	110	
BK4	28/28	0.5"	d/d	0.010"	365:150	2.43:1	140	2 min
BK5	28/28	0.5"	d/d	0.005"	365:150	2.43:1	120	1 min
CH1	20/22	0.2"	d/d	0.010"	370:145	2.55:1	245	2 min
CH2	20/22	0.2"	d/d	0.010"	370:145	2.55:1	140	1 min
CH3	28/28	0.5"	d/d	0.008"	365:150	2.43:1	175	1 min
CH4	28/28	0.5"	d/d	0.006"	365:150	2.43:1	370	2 min
SIZ1	0	----	----	0.007"	370:260	1.42:1	160	1 min
SIZ2	0	----	----	0.008"	370:260	1.42:1	90	1 min
SIZ3	0	----	----	0.005"	370:260	1.42:1	190	1 min
SIZ4	0	----	----	0.004"	370:260	1.42:1	130	1 min
MID1	0	----	----	----	370:260	1.42:1	---	2 min
MID2	0	----	----	----	370:260	1.42:1	---	2 min
MID3	0	----	----	----	370:260	1.42:1	---	2 min
MID4	0	----	----	----	370:260	1.42:1	---	1 min
TAIL	0	----	----	----	370:260	1.42:1	---	2 min
LG	0	----	----	----	370:260	1.42:1	---	1 min

* feed is in gram/min/inch

Figure 3. Experimental Batch Mill

Figure 4. Experimental Batch Purifier



double decks (see glossary). Each deck has four sieves and provides a purifying area of 4 X (225 mm X 75 mm). A Kice aspirator (see glossary) was used for aspiration on the purifier. Only half a purifier was used at each run. A single or a double deck was used depending on the amount and the quality of stock available. The unused aspiration channel on half of the purifier was sealed in order to supply the desired quantity of aspiration air on the working half.

For the purification of each stock, the appropriate sieves were selected and the purifier was switched on. After ensuring that all brushes were running, the stock was fed. With the purifier fully loaded and all brushes running, the aspiration was adjusted. Next, purifier and aspiration were shut off at the same time. The throughs were removed, added to the original stock and subjected to final purification with both purifier and aspiration turned on at the same time. During purification particular attention was paid to having all brushes running and sieves fully covered with stock.

Speck Count

The tool used in determination of specks in the present work consists of an upper and a lower clear glass plate (Figure 5). The upper glass is built up of two pieces of 10½ inches by 10½ inches each. One hundred one-square inches are marked onto the surface of one of the two pieces

Figure 5. Speck Counting Equipment

and then the two pieces are put together in such a way that the grid is set between them. Duct tape was used along the borders to fasten the two pieces together. The quarter-inch border is divided into inches and marked from 0 to 9 to obtain one hundred one-square inches coded from 00 to 99. The lower glass is a simple glass sheet with edges built up on three borders in order to prevent any sample spillage. A table of random numbers was used to select the squares to be counted for specks. The specks were counted by looking through a magnifying glass. A daylight fluorescent tube was used to light the sample to better distinguish the specks.

The sample to be examined is homogenized and poured onto the lower glass piece. The upper glass is cleaned of any particles which may have stuck to the surface from a previous count. The upper piece is put onto the sample and a back and forth motion alternately along the diagonals is given until the sample is completely spread and no space is left under the squares. Two series of 10 random numbers between 00 and 99 are selected from the table of random numbers. Through the magnifying glass all the brown and black spots are counted. The square to be checked is covered with a paper and the paper is moved down slowly showing the specks. The mean is calculated and the final count is expressed as the number of specks per ten square inches.

Farina Granulation

A representative sample was obtained by successive division using the Boerner Divider. Approximately 100g was placed on the top of a stack of sieves. The sieves were shaken for 1 min. The amount of farina on each sieve was weighed and the percentage calculated. Each determination was conducted in duplicate. The set of sieves used were: US30 US40 US45 US60 US100.

Flour Production

All the throughs of 10XX (136μ) were collected to make flour. All fine and specky stocks were ground to flour and added to flour previously collected during farina production. The flow sheet used for this purpose is the part of Figure 2 between 1M and LG.

Baking Test

The flours obtained from the rest of the stock beyond farina extraction were tested for bread making potential. A straight grade flour, milled from the same wheat, was used to make the control loaves. The straight grade flours were obtained by blending re-ground farina fraction and the left-over flour. The baking procedure followed was AACC Method 10-10B revised 9-25-85. The procedure employed a 180-minute fermentation time, a 55-minute proof time and a bake time of 25 min at 425 °F.

Spaghetti Test

Spaghetti made of hard white wheat farina and mill mix farina were compared with spaghetti made of durum semolina. All samples were extruded according to the method described by Kim et al (1986) and dried according to the procedure outlined in the following table:

Temperature °C	°C (dry bulb - wet bulb)	Time(hr)
40	3	1
45	5	2
55	7	10

The processed spaghetti was subjected to the following tests in order to check its characteristics.

Thickness is the diameter of spaghetti strands. Thickness is related to the strength of gluten and is an indication of the expansion of the dough after the extrusion. It is measured using calipers (Mitutoyo Japan).

Breaking Strength was measured on dry spaghetti using the Instron Universal Testing instrument (model 1130 Instron Co., Candton, MA) as described by Voisy and Wasik (1978) and Oh et al (1985).

Cutting Stress was performed on spaghetti cooked in distilled water. The method described by Oh et al (1985) using the Instron was followed, except three strands of spaghetti were used and the blade was set to cut within 1 mm of the bottom of the spaghetti strands. The assumption was made that no change in the width of clustered spaghetti happened during the cutting process.

Stickiness is usually an evaluation of the superficial property of the cooked pasta. It is defined as the force needed to retract a metal plate that had been compressed onto nine spaghetti strands to a force of 24,500 N/m^2.

Total Organic Matter (TOM) was determined according to the method described by D'Egidio et al (1982), except the sample size and volume of cooking water were reduced by one-fourth (Dexter et al 1985). This method is based on the determination of the TOM released by cooked pasta after a given period of time in water. Values below 1.4 indicate excellent quality and values above 2.1 indicate low quality (Cubadda 1988).

Cooked Weight and Cooking Loss were determined according to AACC method 16-50; approved April 1961. Hard water (Dexter et al 1985) was used in performing this test.

Cooking Time. Minimum cooking time is attained when the continuous white line, seen at the center of the spaghetti strand (nerve), disappears. The optimum time is usually defined as minimum cooking time plus 1 to 3 minutes depending on shape and diameter of spaghetti strand (Cubadda 1988).

RESULTS AND DISCUSSION

A complete experimental farina milling procedure was designed entailing wheat preparation and milling methods. In addition, a speck count procedure for farina or semolina was developed.

Wheat Preparation

Emphasis was placed on cleaning wheat in order to start the grinding process with clean wheat. The amount of screening discarded during this step was 3%. About 2% was removed during dry cleaning and 1% after wheat conditioning. The screening consisted mostly of beeswing, dust, broken kernels, seeds and germ. About 1% can be recovered from screening in the form of broken kernels and may be channeled to the flour production stages in the mill.

Since semolina and farina are still graded by their appearance, the cleaning process is critical to the final product. The 3% removed in cleaning is in an acceptable range. Abercrombie (1980) reported 5% screening discarded during durum cleaning to be a common feature. Presently with improved cleaning equipment, the amount of screening in durum mills has been reduced to about 3% (Abercrombie 1980).

Wheat Milling

The flow sheet established (Figure 2) produces not only farina but also flour. The stocks were separated into coarse and fine at the first break. This early split helps maintain grinding stocks in a narrow particle size range. The grader, after the primary break, was used to reduce the particle size distribution range of stocks to purifiers. It also redusts the stocks going to the purifiers as floury stocks are difficult to purify. Fine particles are easily subjected to aspiration and readily exhausted. A range of about 200 μ was considered for stocks going to a purifier, as recommended by Abercrombie (1980). The secondary break system was used mostly to finish bran and consequently increase the global extraction. Stocks from breaks were either sifted or purified together in cases where not enough stock was available. This is a common practice in small semolina milling plants but is rarely encountered in large plants where almost every stock is sifted and purified separately.

Runarounds were included in this flow sheet. Runarounds consist of sending a stock from a purifier to re-feed to the same purifier in order to keep it loaded. A purifier works efficiently when the sieves are fully and evenly covered, otherwise air will rush through the uncovered sieves. In this case air flows at higher speed through the bare patches, lifting chunks of pure endosperm. In the covered part of the sieves air speed is too low to stratify the stocks on the sieves. Therefore no clean separation takes place (Lockwood 1962).

According to Abercrombie (1980), runarounds are very common in semolina milling where stocks are also channeled from a purifier to another purifier. There is no theory, however, regarding the best cut for runarounds. It is not yet decided if it is better to re-feed a purifier with a clean stock from the head or with a medium stock from the tail.

The appearance of the same purifier several times in the flow sheet symbolizes the number of times a stock was re-purified. In an automatic mill the flow would be easier and is represented by an arrow to symbolize re-feeding the purifier. In a batch process the re-purification is very tedious and less efficient. This is because each time the purifier has to be stopped and the stocks under purification are allowed to settle, the particles of bran from the top of stock go through the sieve, affecting the quality of farina by increasing the number of specks.

The number of re-purification steps depends on the stock quality. The most difficult stock to purify was the fine stock going to purifier 9. Problems were encountered with both fine and coarse stocks containing germ. The sharp to sharp milling action was used to reduce the amount of break flour and to produce chunks with a glassy appearance.

The final section of the flow sheet deals with flour milling. All fine and specky stocks remaining after purification were reduced to flour.

Milling Results and Discussion

Hard white wheat testing was performed in four replicates and mill mix wheat was performed in three replicates. Both hard white wheat and mill mix wheat were milled under similar conditions. This did not, however, prevent several differences which are traced to the inherent differences in the two wheats.

Releases obtained with hard white and mill mix wheat are shown in Table III. The data from Table III are presented graphically in Figure 6. The release of the first break was in the range of 15% reported by McGee and Giles (1983b) as normal in semolina milling. The high values of release observed in BK2 and BK3 for both wheats were mainly because the fine and coarse stocks were sifted together and not because of to a severe milling action. At the 5% level of significance, different releases were obtained for BK1 and BK3. The mill mix showed higher release at BK1 and lower release at BK3.

The particle size distribution of the primary break (BK1, BK2 and BK3) is shown in Figure 7. The granulation curves are somewhat convex indicating coarseness of the stock. The production of flour and fine material in the breaking process was kept to a minimum. No significant difference ($P > 0.05$) was observed between H.W.Wheat and mill mix wheat in the particle size distribution of the grader (Figure 8) or in BK4 and BK5 shown in Figure 9.

Table III. Releases of the Break System

	H.W.WHEAT		MILL MIX WHEAT		
	avg (%)	s.d	avg (%)	s.d	P value
BK1	13.0	0.20	15.5	0.26	0.0001
BK2	30.2	2.26	28.9	2.49	0.5293
BK3	54.4	1.51	46.3	1.20	0.0006
BK4	33.7	1.73	31.7	2.84	0.3076
BK5	35.5	3.52	25.4	7.15	0.0537

Figure 6. Comparative Break Releases

H.White Wheat vs. Mill Mix Wheat

error bars are 95% confidence intervals

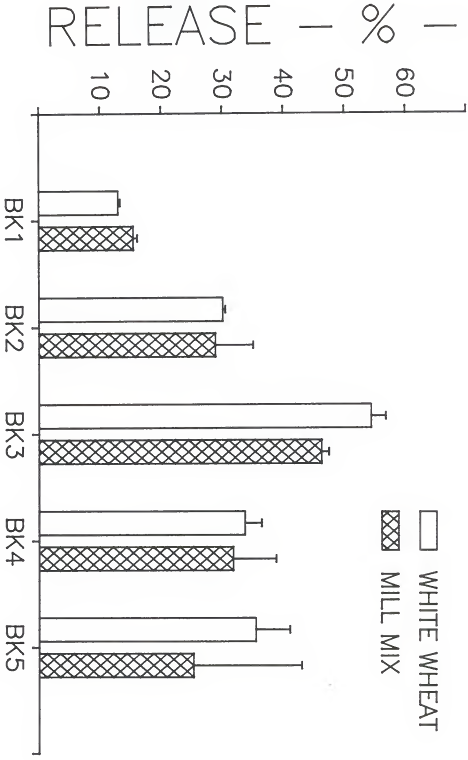

RELEASE — % —
10
20
30
40
50
60
BK1
BK2
BK3
BK4
BK5
WHITE WHEAT
MILL MIX

Figure 7. Particle Size Distribution of the Primary Break System

error bars are 95% confidence intervals

CUMULATIVE OVERS -%-
100
80
60
40
250
500
750
1000
1250
OPENING -microns-
WHITE WHEAT
MILL MIX
BK1
BK2
BK3

Figure 8. Particle Size Distribution of the Grader

error bars are 95% confidence intervals

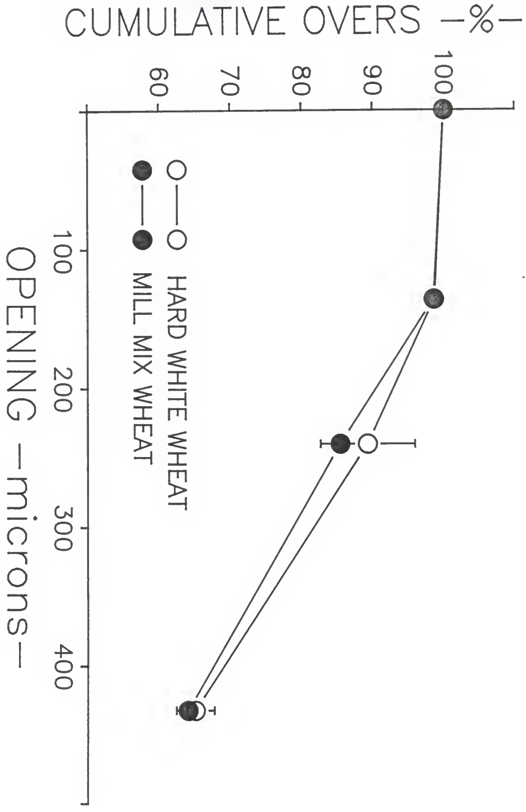
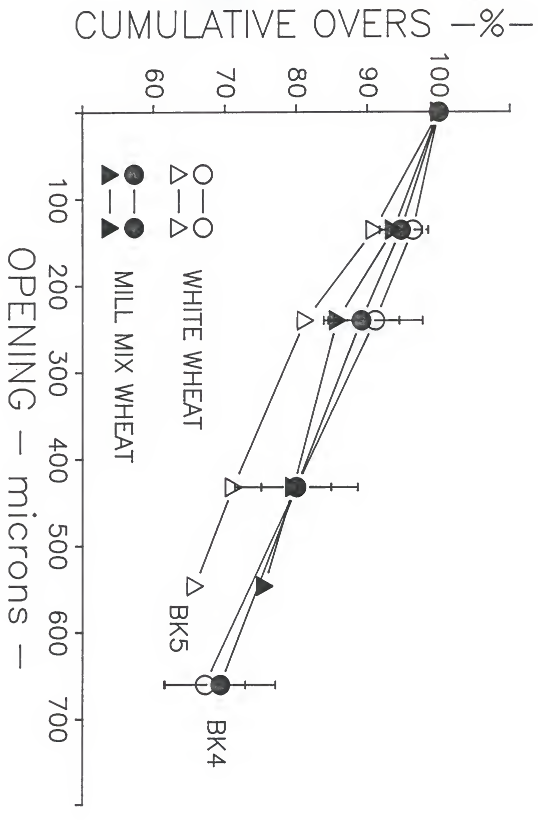

CUMULATIVE OVERS -%-
100
90
80
70
60
HARD WHITE WHEAT
MILL MIX WHEAT
100
200
300
400
OPENING -microns-

Figure 9. Particle Size Distribution
of the Secondary Break System

error bars are 95% confidence intervals



CUMULATIVE OVERS -%-
100
90
80
70
60
100
200
300
400
500
600
700
OPENING - microns -
WHITE WHEAT
MILL MIX WHEAT
BK5
BK4

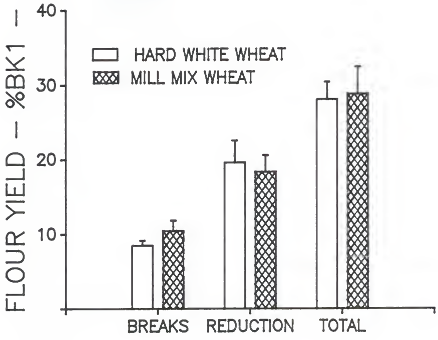
Hard white wheat produced less break flour (8.5%) and less break feed (11.8%) than mill mix (10.5% flour and 16.4% feed) (Figure 10). This has resulted in the amount sent to purification from hard white wheat (70.6%) being significantly greater (P=0.0012) than from mill mix (62.6%). The amount sent to purification may be used as an indication of performance in purification and therefore in the amount of farina. This needs further investigation.

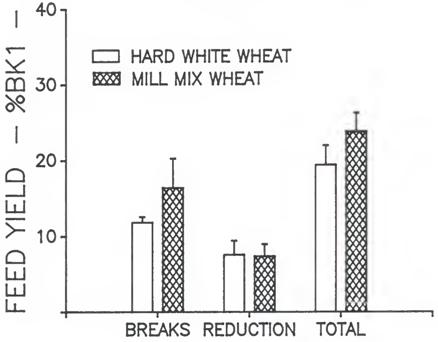
The total amount of stock released from the wheat kernel during the break system was 84.2% for hard white wheat and 78.9% for hard mill mix wheat. This difference is attributed to the fact that hard white wheat had larger kernels than mill mix wheat. Li and Posner (1987) found that the larger the kernel the greater the tendency to produce high cumulative extraction.

No significant difference was observed in the amount of flour (P=0.3322) and feed (P=0.7866) produced during the reduction process (Figure 10). No significant difference (P=0.5564) could be determined between total amount of flour produced by hard white wheat (28.1%) and mill mix wheat (28.8%), as shown in Table IV. On the other hand, a significant difference (P=0.0097) was observed in the amount of total feed obtained: 23.8% and 19.8% for mill mix and hard white wheats, respectively.

No significant difference (P=0.7622) was observed between the wheats for losses due to the milling process.

Figure 10. Comparative Flour and Feed Yield
H.White Wheat vs Mill Mix Wheat


FLOUR YIELD — %BK1 —
40
30
20
10
HARD WHITE WHEAT
MILL MIX WHEAT
BREAKS
REDUCTION
TOTAL


FEED YIELD — %BK1 —
40
30
20
10
HARD WHITE WHEAT
MILL MIX WHEAT
BREAKS
REDUCTION
TOTAL

Hard white wheat showed a 7.3% loss while mill mix had a 7.0% loss. These losses are higher than in a commercial flour milling operation where normal loss is between 1.5% and 2%. The higher values obtained in this experiment can be explained: stocks were subjected to an intensive purification with a batch system. Inherent characteristics of the batch milling process, where the stocks are subjected to many weighing operations with consequently high exposure to drying, is another reason. Also, grinding and purification of a sample required as much as 8 to 10 hours using the suggested procedure. Precautions were taken to minimize these losses by using metal cans with fitted covers.

Hard white wheat farina yield (45.1%) was significantly higher (P=0.0023%) than mill mix farina yield (40.4%) (Table IV). These yields are higher than those reported by Shuey et al (1980) and Kim et al (1986). Average yield in farina mill plants is in the range of 32% to 38% while semolina yield ranges from 62% to 70%. A comparison of the global yield obtained from the wheat kernel is reported in Figure 11. No significant differences (all P values were greater than 0.05) were observed in the granulation distribution as shown in Figure 12.

Uniform granulation of farina aids flowability and is critical in continuous presses. Different particle sizes absorb water at different rates resulting in a loss of

Table IV. Global Yield Based on Wheat to First Break.

	H.W. WHEAT		MILL MIX WHEAT		
	avg (%)	s.d	avg (%)	s.d	P value
FARINA	45.1	2.18	40.4	1.02	0.0023
FLOUR	28.1	1.48	28.8	1.46	0.5564
FEED	19.4	1.63	23.8	0.98	0.0097
LOSS	7.34	1.72	6.98	1.07	0.7622

Values in table are % of wheat to BK1. Averages of 4 replicates for hard white wheat and 3 replicates for mill mix wheat.

Figure 11. Comparative Total Products Yields of H.White Wheat vs Mill Mix Wheat

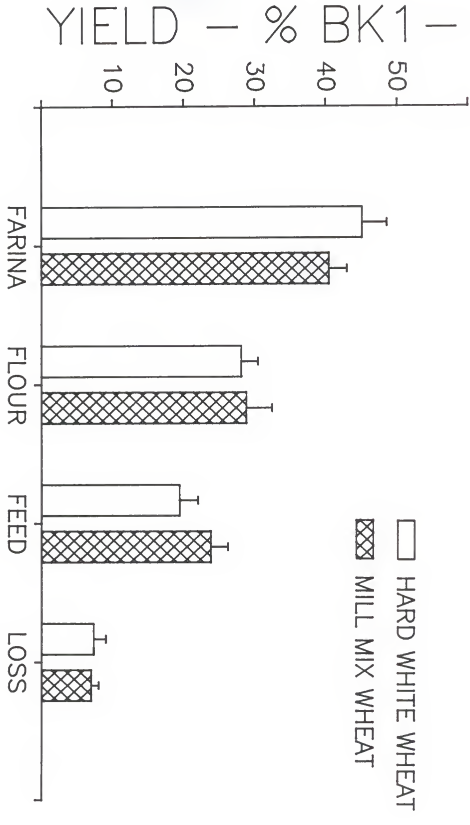
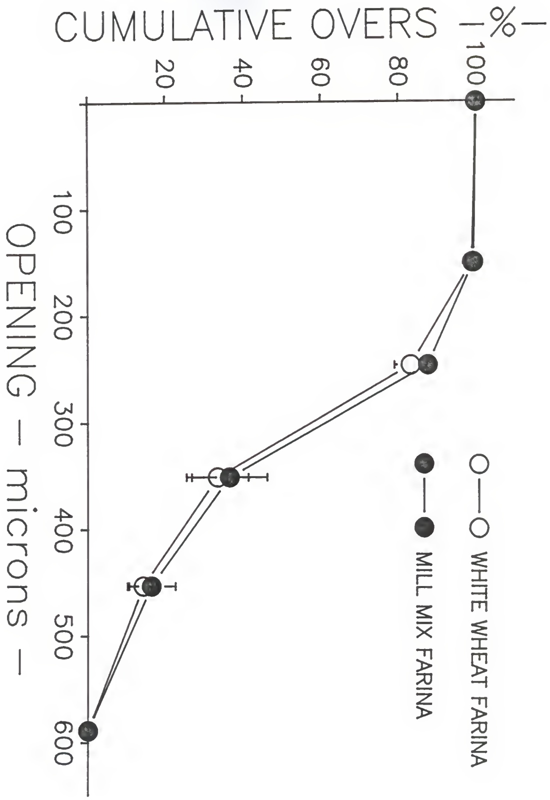

YIELD — % BK1 —
10
20
30
40
50
FARINA
FLOUR
FEED
LOSS
HARD WHITE WHEAT
MILL MIX WHEAT

Figure 12. Comparative Particle Size Distribution of White Wheat Farina vs Mill Mix Farina

error bars are 95% confidence intervals


CUMULATIVE OVERS -%-
20
40
60
80
100
100
200
300
400
500
600
OPENING - microns -
WHITE WHEAT FARINA
MILL MIX FARINA

homogeneity. Farina produced in this experiment contained less than 3% flour (Table V). Matsuo (1988) reported that the conversion from batch to continuous machines in pasta making has decreased the demand for coarse semolina. Semolina with as much as 20% flour is used by some processors. The FDA regulation limits the amount of flour in farina to 3%.

The speck count was 47 per 10 squares inches for both wheats. This speck count is lower than the 50 reported by Dick and Youngs (1988) as desirable in semolina to give pasta with a relatively nice appearance. Kim et al (1986) found that acceptable spaghetti was made from farina with fewer than 50 specks per 10 square inches. With a continuous purification system on the experimental milling setup, the speck count is still likely to be reduced.

Hard white wheat and mill mix have shown inherent differences in the amounts of stock going to different stages of the process. A significant difference was observed in farina yield ($P < 0.05$) but no significant differences were observed either in the granulation or in the speck count. ($P > 0.05$) (Table VI). These two characteristics are major criteria in selecting farina or semolina. Therefore, it can be stated that the flow sheet developed was able to produce farina with the same granulation and same speck count but depicts potential different yields. This difference in farina yield can make

Table V. Distribution of Farina Particle Size

		H.W. WHEAT		MILL MIX WHEAT		
Sieves	Opening (μ)	avg (%)	s.d	avg (%)	s.d	P value
US30	589	0.0	0.0	0.0	0.0	----
US40	453	14.3	2.3	19.3	2.5	0.2884
US45	351	19.1	3.2	21.5	1.5	0.6534
US60	246	49.8	2.8	46.6	4.0	0.6462
US100	150	15.8	2.7	11.9	0.1	0.0649
PAN	0	1.0	0.3	0.7	0.1	0.1197

Values are percentages of farina held on each sieve.

Table VI. Comparison of White and Red Farina.

	H.W WHEAT		MILL MIX WHEAT		
	avg	s.d	avg	s.d	P value
YIELD (% BK1)	45.1	2.18	40.4	1.02	0.0023
SPECKS (10 in^2)	47.0	6.7	46.7	0.6	0.9271
PROTEIN 14% m.b	10.35	0.29	10.97	0.06	0.0162
ASH 14% m.b	0.263	0.039	0.332	0.027	0.0474
MOISTURE	11.8	0.4	11.9	0.4	0.6975
GRANULATION %					
over 589μ	0.0	0.0	0.0	0.0	---
over 453μ	14.3	2.3	19.3	2.5	0.2884
over 351μ	19.1	3.2	21.5	1.5	0.6534
over 246μ	49.8	2.8	46.6	4.0	0.6462
over 150μ	15.8	2.7	11.9	0.1	0.0649
over 0μ	1.0	0.3	0.7	0.1	0.1197

the difference among wheats. The granulation size and the speck count influence the appearance of farina and the resulting pasta products. Its impact on couscous quality has yet to be investigated. Nevertheless, the specks effect on couscous quality may not be important because couscous is not subject to any further breakage, and the surface of couscous particles is not smooth. High-grade semolina is not essential for couscous (Kaup and Walker 1986).

Total product yield for both wheats is shown in Figure 11. Hard white wheat produced more farina and less feed with a similar flour yield than did the mill mix wheat. Hard white had higher total extraction, 73.1% versus 69.2% for mill mix. The protein and ash content are shown in Table VII. Ash values are low but explained due to the fact that farina particles are chunks of the endosperm. Endosperm is low in ash and protein content compared with the outer layers of the wheat kernel (Pomeranz 1987). A global comparison of hard white wheat farina and mill mix farina is shown in Table VI.

Baking Test

Straight grade flour and left-over flour were baked into bread. Results of the baking test are shown in Table VIII. White wheat left over flour had a high water absorption. Left over flours had higher absorption than straight grade flours. This is probably because left over flours contain more damaged starch than straight grade

Table VII. Chemical Composition of Farina, Let-Over Flour and Straight Grade Flour

	Protein[a]		Ash[a]	
	Average (%)	s.d	Average (%)	s.d
Farina				
Hard White Wheat	10.4	0.28	0.26	0.02
Mill Mix Wheat	11.0	0.02	0.33	0.03
Left-Over Flour				
Hard White Wheat	13.7	0.43	0.55	0.14
Mill Mix Wheat	13.1	0.36	0.53	0.06
Straight Grade Flour[b]				
Hard White Wheat	11.6	0.13		
Mill Mix Wheat	11.9	0.20		

a/ 14% m.b
b/ protein calculated based on farina and left-over flour proteins.

Table VIII. Results of the Baking Test

LEFT-OVER FLOUR

	H.W WHEAT		MILL MIX WHEAT		
	avg	s.d	avg	s.d	P value
ABSORPTION %	60.1	1.8	58.5	0.5	0.1869
MIX TIME (min)	3.53	0.36	4.81	0.06	0.0053
LOAF WEIGHT (g)	141.1	0.7	139.3	0.5	0.0127
LOAF VOLUME (cc)	951.5	41.7	984.0	21.2	0.2778
PROOF HEIGHT (mm)	80.3	1.3	80.3	1.2	0.9321
OBSERVATION[a]	QUESTIONABLE		GOOD		

STRAIGHT GRADE FLOUR

	H.W WHEAT		MILL MIX WHEAT		
	avg	s.d	avg	s.d	P value
ABSORPTION %	57.6	0.5	56.7	0.8	0.0944
MIX TIME (min)	3.40	0.16	5.20	0.25	0.0001
LOAF WEIGHT (g)	139.6	0.6	138.2	0.6	0.0321
LOAF VOLUME (cc)	893.3	10.4	943.3	13.5	0.0025
PROOF HEIGHT (mm)	77.3	1.0	76.3	1.5	0.3697
OBSERVATION[a]	EXCELLENT		EXCELLENT		

[a]/ Based on Protein-Loaf Volume relationship (Finney 1985).

flours. White wheat left over flour showed longer mixing time than straight grade flour. Higher loaf weight was observed for hard white left over flour and straight grade flour than for from mill mix. This may be attributed to the high water absorption. The left over flours showed higher loaf volume than straight grade flour; both left over flours had loaf volume greater than 950 cc while both straight grade flours had loaf volumes less than 950 cc. Crumb and grain were acceptable.

Mill mix left over flour produced loaves with nice exterior, fine to slightly coarse grain with elongated cells. Left over flour from hard white wheat gave loaves with slightly coarse grain and slightly elongated cells. Straight grade flours from both hard white wheat and mill mix gave loaves with slight to rough break and slightly coarse grain.

Finney (1985) presented a correlation chart for protein content and loaf volume. The left over flours and straight grade flours were evaluated based on these correlations. Straight grade flours are ranked excellent, left-over flour from mill mix was judged good while flour from hard white wheat was ranked in the upper range of questionable. Therefore it can be concluded that these left over flours can be used as bread flour. Ash content (Table VI) is slightly greater than US commercial flours. This shortcoming can be overcome by blending these left over flours with flours having lower ash and lower protein contents. All the same, these left over flours can be used as they are in Morocco where flours with higher ash content (0.80 to 1.00% d.b.) are commonly baked.

Spaghetti Results

Thickness measures the increase in spaghetti strands after extrusion. It is related to the strength of gluten. Lower values indicate better quality. Hard white wheat farina showed lower values than durum semolina but higher than mill mix wheat farina.

Breaking Strength is an indication of resistance to breakage. The higher the values, the better the quality. Higher breakage strength is commercially desired. Semolina spaghetti had the highest value (2343 g/mm^2) and was physically far away from the results of farina (1714 and 1609 for white and mill mix, respectively). Hard white wheat farina produced stronger spaghetti than mill mix wheat farina (Table IX).

Stickiness is an important factor to the consumer (Fortini 1988). Surface water may have interfered with the results when the metal plate of the Instron Universal Instrument squeezed spaghetti strands. Low values (below 1000 N/m^2) indicate either an overcooked spaghetti or a firm spaghetti with a non-sticky surface. Values higher than 1000 N/m^2 indicate a sticky surface. Difficulties in concluding from this test are overcome by the total organic matter test

(D'Egidio et al 1982). Farina showed higher values (1495 and 1533) than durum semolina 1201 (Table IX). Mill mix wheat farina produced stickier spaghetti than that made of hard white wheat farina.

Cooking Time. The lower the cooking time value up to a point, the better the spaghetti quality. Processing spaghetti with low values in cooking time is a desired criterion in saving energy and time. Hard white wheat spaghetti had a cooking time comparable to spaghetti made of durum semolina, while spaghetti made of mill mix wheat farina had a cooking time 2.5 min higher than that of hard white wheat (Table IX).

Cooked Weight is an indication of water absorption during cooking. High cooked weight values are related to higher stickiness. Spaghetti made of farina showed higher values than semolina. Farina from hard white wheat had lower cooked weight than spaghetti made from mill mix wheat.

It is shown by the characteristics of spaghetti made of durum semolina, hard white wheat farina and mill mix wheat farina (Table IX) that semolina gave better spaghetti than farina. Based on the values presented in Table IX, it can be concluded that hard white wheat produced better results than mill mix wheat. In addition to a significant higher yield previously shown, hard white wheat produced spaghetti with better results than mill mix wheat.

Table IX. Spaghetti Results

	Durum	H.W. Wheat	M.M. Wheat
Thickness (mm)	1.77	1.80	1.83
Breaking Strength (g/mm^2)	2343	1714	1609
Cooking Time (min)	11.5	12.0	14.5
Cooked Weight (g)	25.37	25.58	25.60
Cooking Loss (%)	5.76	7.56	7.36
Cutting Stress (KN/m^2)	37.92	35.54	28.00
Stickiness (N/M^2)	1201	1495	1533
Total Organic Matter (g)	1.6	2.4	3.5

CONCLUSIONS

The ultimate purpose of this investigation was to develop a laboratory scale farina milling procedure and to compare the potential of two wheats for farina production. Though tedious, it would be beneficial for the commercial operator to use this procedure as a means for understanding a wheat's potential. The potential of hard white wheat and a mill mix wheat for farina and total extraction were determined.

A procedure for speck counting was developed. Random number tables were used to select the squares to be counted, to provide an unbiased procedure.

Hard white wheat and mill mix wheat gave promising farina yield and global product extraction. Farina granulation was comparable to the semolina granulation reported by Abercrombie (1980) as typical granulation. Fewer than 50 specks per ten square inches were obtained, established by Kim et al (1986) as a limiting factor. Hard white wheat, however, had the advantage of producing 45% farina compared to 40% for the mill mix with 47 specks.

The pasta making potential of farina and the baking potential of left-over flour were determined. Left-over flours produced loaves showing coarse grain but with overall good characteristics. The spaghetti obtained had acceptable appearance. Hard white wheat spaghetti was better than mill mix wheat spaghetti but not as good as spaghetti made of durum semolina.

The overall results obtained with the flow sheet and hard wheat were encouraging with high farina yield, high global extraction, and acceptable loaves made of left-over flour. These values show greater promise in an industrial plant because of lower loss level and the better performance of the continuous equipment compared to the batch milling process.

RECOMMENDATIONS

Many topics in milling are still poorly studied. Their investigation will bring a great deal of information and great support to this subject of farina production.

Common definitions for speck should be made, in order to standardize any counting method. The computer image analysis can be used to determine the total surface of specks in 10 square inches instead of counting the number of specks. The size of specks is not considered in current practices.

Batch purification is time consuming. The use of a simple pneumatic system on the laboratory purifier, in the Department of Grain Science and Industry, will reduce the purification time and lower the number of specks. This can also reduce the amount of wheat required in the original wheat sample and simulate a continuous purification system.

An investigation on the relationship between the stock going to the purification system and the percent farina yield can generate a quick tool to the farina potential determination.

Several authors have reported the impact of specks on pasta products but the effect of specks on couscous is still to be investigated. Investigation on couscous making from hard white wheat needs to be initiated, especially there is an increasing market in North Africa, the Middle East and Europe.

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GLOSSARY OF MILLING TERMS

Aspirator
A machine, apparatus or device employing aspiration to extract dust, light chaff, particles of bran.

Break Release
Includes all the stock that is not sent on to the next break. It is expressed as a percent of the feed entering each stage of the break system.

Broken Wheat
Kernels separated into two or more pieces, exclusive of insect boring or surface consumption.

Chunk Roll
Grinding rolls with corrugations or roll surface modified to more effectively grinding particles of grain intermediate in size between break-scalp stock and sizings. i.e. fragments of endosperm with small pieces of bran still attached which are too small for break stock and too large for sizings.

Cleaning House
A building or area which contains equipment for removing undesirable material and foreign substances from wheat prior to milling.

Corrugation
or flutes, are the cuts on the surface of a rollermill.

Crease
The lengthwise folded indentation characteristic of wheat kernels.

Dockage
The foreign matter in a sample of wheat removed by appropriate sieves and cleaning devices. The Carter Dockage Tester is used by official inspectors in U.S.A. to determine dockage.

Dull to Dull
The arrangement of fast and slow rolls whereby the long side of the sawtooth of the fast roll acts against the long side of the slow roll corrugation.

Fast roll
The roll which operates at higher rpm in a pair of grinding rolls which normally operate at different speeds.

GG
Grit gauze (always silk).

Grading
Separation according to particle sizes, as for instance, the grouping of the middlings for the purifiers.

Grits
Rough granules as of sand or stone or any other tough material which sticks to the die during extrusion and tears the surface of the dough. Grit count is important in the milling semolina. A count of over 0.007% is considered a warning that additional cleaning is necessary.

Middling or Midds
Particles of endosperm which have been extracted from the bran as on break rolls which have yet to be reduced to flour.

Mill Mix
Wheats that have been blended for milling ready to supply the wheat cleaning processes in the mill.

Overs
Material that goes over the sieve.

Pitch
Number of corrugation per inch, measured perpendicularly to spiral.

Reduction System
The part of a mill flow made up of reduction rolls and sifters which follow the break system and reduce endosperm to flour.

Roll Differential
The ratio of peripheral speed of the fast roll to that of the slow roll.

Roll Gap
Minimum distance between two rolls.

Scourer
A machine designed to remove by abrasion, impact and aspiration, the extreme outer layer, beard, or any foreign material that is on the surface or lodged in the crease of the kernel.

Screenings
The undesirable, non-millable materials such as dust, hulls, foreign grain, weed seeds, cracked grain, rocks, etc., separated from the grain prior to milling or other processing.

Sharp to Sharp
A mode of corrugated roll grinding in which the grinding is one by the sharp front or cutting side of the corrugation on the fast roll against the sharp side of the corrugation on the slow roll.

Sifter Area
The total area of cloth in a sifter that is not blinded.

Sifter Throw
Diameter of circle in inches that the sifter makes while running.

Single Deck
A purifier in which there is a single sieve layer by opposition to a double or triple Deck which has two or three sieve layers.

Specks
Colored particles (black or brown)other than pure parts of the endosperm.

Spiral
Lead in inches per linear foot of roll length.

Throughs (Thrus)
Material that goes through the sieve.

W
Light wire.

FARINA MILLING:

DEVELOPMENT OF A FLOW SHEET

AND A SPECK COUNTING METHOD

by

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ABSTRACT

Durum semolina and hard wheat farina are raw materials in pasta and couscous making. Durum semolina is the choice raw material for pasta and couscous making; however, hard wheat farina is less expensive and therefore more affordable to the average consumer around the world.

An experimental farina procedure was developed in addition to a rational speck counting method. Farina produced using this experimental procedure showed non-significant difference (at level 5%) in granulation and speck count. Farina yield was encouraging with a speck count below 50 per ten square inches.

Two wheats, a hard white wheat and a mill mix wheat with similar protein contents, were tested. Hard white wheat produced 45% farina and mill mix wheat produced 40%. Both wheats produced 28% of left-over flour. The flour was suitable for baking and farina produced acceptable spaghetti.

Farina has good potential as the raw material for pasta and couscous.