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Evaluation of Some Imported and Local Wheats for Spaghetti-Making

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FIVE IMPORTED wheats (Australian, French, Canadian, American and Pakistani), and three local wheat cultivars were subjected to physical, chemical, rheological and spaghetti quality evaluation. Results indicated that the local soft wheat grains had higher total physical defects. Flour yields were about 70 % for all tested wheat samples except for the local durum wheat, which was as low as 65.5%. A wide range of protein content (8.30 - 13.70 %) of flours was recorded. The Canadian wheat flour had the highest protein content and the French wheat flour was the lowest in protein content. Wet and dry gluten contents of wheat flour samples were consistent with their protein contents. Rheological evaluation data indicated that Australian, Canadian, American and Egyptian durum flours had more suitable properties for spaghetti- making than the French and Pakistani flours. Quality evaluation of the manufactured spaghetti samples from the different tested wheat flours indicated that those made from Egyptian durum wheat, Canadian wheat and American wheat flours were superior.

Keywords: Wheat, Flour, Physical, chemical, rheological properties, Spaghetti, Quality evaluation.

Most wheat varieties presently cultivated are grouped under the broad category of common or bread wheat *(Triticum aestivum)*, which accounts for approximately 95 % of world production, and durum wheat (*Triticum durum)* used for pasta production (Peressini *et al.*, 1999). In Egypt, 10.9 million tons of different wheat varieties are milled per year (2003 data). Millers buy wheat with a wide range of quality characteristics. About 4, 057, 234 tons (37.2%) of imported wheats and 6, 844, 692 tons (62.8%) of local wheats were used during the season of 2003 (FAO, 2004). Most of these amounts are used for bread making, while the rest are used for other baked products and pasta production. Wheat grading is carried out by evaluating a representative sample from the whole quantity of wheat to check for off-odor and insects, determine dockage, test weight, defects and wheat of other classes. Optional analysis for protein determination, mycotoxins, falling numbers, and hardness are determined if specified. These grading procedures help to insure end users and consumers that they will receive consistent quality and sound wheat (Hamza, 2003). The wheat variety influences processing parameters, dough properties and the final product characteristics. As wheat- derived staple food, pasta is second only to bread in world consumption (Mariani-Constantini, 1988). Its worldwide acceptance is attributed to its low cost, ease of preparation, versatility, sensory attributes, and long shelf life (Riley, 1987). Durum wheat *(Triticum durum),* the primary ingredient in "Italian style" pasta, contributes only 5 % of the world's wheat production, and it generally trades at a higher price than common wheat (*Triticum aestivum)* does (Dick and Matsuo, 1988). Economically speaking, the use of soft wheat flour for pasta production could be valuable; however, the poor sensory attributes and cooking quality of such products have dictated that durum semolina can be used (Bergman *et al.*, 1994). Because of the high price of durum wheat, some countries such as Egypt, use semolina from durum wheat and flour from bread wheat as raw materials for production of macaroni. Different sources of these raw materials show notable differences in their physical quality characteristics regarding their ability to produce good quality macaroni (Tawfik and Mansour, 1983). Several researchers (D'Egidio *et al.,* 1990 and Liu *et al.,* 1996) have established that the quantity and quality of proteins are very important factors for determining the cooking performance of pasta. Durum wheat semolina usually has higher protein and gluten contents than found in common wheat flour (Lindahl & Eliasson, 1992 and Boyacioglu & D'Appolonia, 1994). De Stefanis *et al.* (2000) demonstrated that both product color and cooked spaghetti quality depend on the characteristics of raw material and the drying process employed.

This study was designed to evaluate the most common imported wheats (Australian, French, Canadian, American and Pakistani) as well as some local wheat cultivars for spaghetti- making. The physical, chemical, rheological as well as the manufactured spaghetti quality characteristics were examined.

Material and Methods

Wheat samples

Five imported wheat grains (Australian standard white wheat, French soft red wheat, Canadian red spring wheat, American hard red winter wheat, Pakistani hard red spring wheat) obtained from North Cairo Flour Mills Company, El-Hoda mill, Shoubra El-Kheima, Cairo, Egypt, and three local wheat cultivars, two of soft wheats (Gemmeiza 9 obtained from Crop Sieving Station, Ministry of Agriculture, Bahteem, Kalioubia, Egypt; and Sakha 69 obtained from Field Crops Institute, Agriculture Research Center, Giza, Egypt), and one of durum wheat (Bany Sweaf 1 obtained from Souhag National Company for Food Industries, Semolina mill, Souhag, Egypt) were used. Different samples were obtained during 2001/2002 season.

Preparation of wheat flours

A 10-kg of each wheat sample was cleaned manually to remove dirt, impurities and other strange grains. The wheat samples were tempered to 16.0 %

moisture and allowed to condition for 24 hr, then milled using Buhler experimental mill according to method described in A.A.C.C. (1994). The extraction rate of any flour sample was adjusted to the required extraction rate (72 % extraction). All prepared flours were placed in polyethylene bags and stored at 4-5°C until analyzed within three months. All flour samples were drawn for analysis at the same time.

Spaghetti processing

Spaghetti was prepared from different wheat flour samples by using a Pasta Matic 1000 (Simac Machine Corporation, Milano, Italy) according to the method described by Breen *et al.* (1977). The distilled water added was calculated by a farinograph test, and then added stepwise to get the required dough consistency. The dough was extruded through a special die. The thickness of spaghetti was 2.0 mm and the length was 20 cm. Samples were dried in a cabinet at 40°C for 16hr, then packed in polyethylene bags and stored at room temperature (23-28°C) until analyzed within three months.

Analytical methods

Physical and chemical properties

Cleanliness, dockage, shrunken and broken, foreign materials, total damaged kernels and total defects were separated and determined manually (hand picking). Test weight was determined by EASI- Way Hectoliter, Test Weight machine, Ravencourt Digital Scale, FARM-TEC (England), by weighing the contents of a quart bucket full dockage - free wheat on a specially calibrated scale which reads directly in Kg/hectoliter. A thousand kernel weight was determined by counting the kernels in a 10 g wheat sample (A.A.C.C. 1994). Moisture, crude protein (N x 5.7), ash, crude fiber, fat, wet and dry gluten, and falling number were determined according to A.O.A.C. (2000). The nitrogen free extract was calculated by difference.

Rheological properties

All samples were tested by macro Farinograph, Extensograph and Amylograph (in Egyptian Baking Technology Center, Giza, Egypt) to determine the rheological properties of the different types of flour according to the methods described by A.A.C.C.(1994).

Spaghetti cooking quality

The cooking quality of the spaghetti was determined according to the method described by Walsh and Gilles (1971). The increase in cooked weight (in g) and volume (in cm^3) were determined after the spaghetti was drained and rinsed. The cooking loss in the cooking and rinse waters of each sample was determined by evaporation to dryness in an air oven at 105^0C. The residue was weighed and reported as percentage of original spaghetti sample. The optimal cooking time was carried out according to A.A.C.C. (1994). Spaghetti was considered cooked when the observed core had disappeared after the spaghetti was passed between two Plexiglas plates.

Sensory evaluation

Seven of spaghetti samples for sensory evaluation were cooked to optimal cooking time in distilled water, drained, and served warm to sensory panelists (semi trained). A score sheet was developed for judging the spaghetti for appearance, color, flavor, tenderness, stickiness and general acceptability according to Walsh and Gilles (1971).

Statistical analysis

Data of three replicates were computed for the analysis of variance and the differences among the means were determined by Duncan's multiple range test using SAS programs (SAS, 1996).

Results and Discussion

Physical and chemical properties of wheat kernels and their flours

Duncan's multiple range tests applied to compare mean values of physical properties of different tested wheat kernels are shown in Table 1. No significant difference was observed in cleanliness among all samples, which ranged from 96.11 % to 99.18 % .With respect to the dockage, shrunken and broken, foreign materials, total damaged kernels and the total defects, all samples differed significantly. The local wheats (Gemmeiza 9 and Sakha 69) had significantly higher total defects (2.260 % and 2.160 %) than the other samples such as Australian standard white wheat (0.212 %) and American hard red winter wheat (0.880 %). The local wheat (Sakha 69) had significantly higher dockage than the imported wheats (Australian, French, and Canadian) (Table 1). These results are consistent with the Egyptian ministerial decision no. 712 / 1987 that requires that the imported wheats must have total defects not exceeding 5 % and dockage not exceeding 0.4%, and if exceeded, the price must be lower. Test weight kg / hl ranged among samples from 71.63 to 84.23 kg / hl. No significant differences were observed in test weight between the Egyptian wheat (Gemmeiza 9, Sakha 69), Australian wheat, and Pakistani wheat. The French soft red wheat had significantly lower test weight among the tested samples (71.63 kg / hl). The 1,000- kernel weight ranged from 30.3 g for American hard red winter wheat to 48.2 g for Egyptian durum wheat (Bany Sweaf 1). Dick and Matsuo (1988) stated that wheat samples with low kernel weight tend to give low-test weight. A strong relationship between test weight and 1,000-kernel weight was also reported by Dexter *et al.* (1987). The flour yield differed slightly among the tested samples and ranged from 65.50 to 70.62 %. Schuler *et al.* (1995) concluded that none of the kernel properties including test weight and 1,000-Kernel weight was correlated with flour yield, despite the fact that test weight is widely regarded as an indicator of milling quality. Hook (1984) and Finney *et al.* (1987) showed that test weight influences market grade and price, and is used as a quality parameter because it may predict potential flour yield.

TABLE 1. Physical properties of eight different wheats.[1]

Quality parameters[2]	AuW	FW	CW	AmW	PW	EG-9	ES-69	EDW
Cleanliness (%)	99.15 a	98.33 a	98.42 a	97.50 a	97.31 a	97.37 a	96.11 a	99.18 a
Dockage (%)	0.85 c	1.67 c	1.58 c	2.50 ab	2.69 ab	2.63 ab	3.69 a	0.82 c
Shrunken & Broken (%)	0.032 e	0.45 d	0.80 b	0.80 b	0.71 c	0.93 a	0.75 bc	0.018 e
Foreign materials (%)	0.100 d	0.03 e	0.25 c	0.020 e	0.71 b	0.93 a	0.75 b	0.018 e
Total Damaged Kernels (%)	0.080 d	0.51 b	0.002 e	0.06 d	0.003 e	0.40 c	0.66 a	0.08 d
Heat Damaged Kernels (%)	0.08 d	0.45 b	0.002 e	0.06 d	0.003 e	0.21 c	0.61 a	0.08 d
Sprouted Damaged Kernels (%)	-[3]	-	-	-	-	-	-	-
Insect Damaged Kernels (%)	-	0.06 b	-	-	-	0.19 a	0.05 b	-
Mould Damaged Kernels (%)	-	-	-	-	-	-	-	-
Total Defects (%)	0.212 e	0.990 d	1.052 c	0.880 d	1.423 b	2.260 a	2.160 a	0.116 e
Test Weight (Kg / hl.)	83.47 a	71.63 d	80.50 b	80.00 c	83.33 a	84.23 a	84.15 a	81.00b
1000 Kernel weight (g)	34.9 d	38.0 c	34.3 d	30.3 d	33.2 d	44.6 b	43.7 b	48.2 a
Flour yield (%) (14 % moisture basis)	70.62 a	69.04 ab	69.33 ab	69.31 ab	70.47 ab	70.3ab	70.10 ab	65.50b

[1]Different wheats: **AuW** = Australian Standard White Wheat; **FW** = French Soft Red Wheat; **CW** = Canadian Red Spring Wheat; **AmW** = American Hard Red Winter Wheat; **PW** = Pakistani Hard Red Spring Wheat.; **EG-9** = Egyptian Soft Wheat Gemmeiza 9.; **ES-69** = Egyptian Soft Wheat Sakha 69; **EDW** = Egyptian Durum Wheat Bny Sweaf 1

[2]Means followed by the same letter in each row are not significantly different ($\alpha = 0.05$) by Duncan's multiple range test.

[3]Not detected

Data in Table 2 indicated that there were significant differences in chemical constituents for all samples. Canadian red spring wheat had the highest percent of protein (15.27 %), ash (1.96 %) and the lowest total nitrogen free extract (78.06 %). However, French soft red wheat showed lower protein content (9.70 %), ash (1.52 %), and fat (1.21 %); highest moisture contents (10.35 %), and total nitrogen free extract (85.23 %) among all samples. The falling number of different wheat samples ranged from 231(FSRW) to 515(ASWW) sec. Staudt and Ziegler (1973) reported that falling number decreased due to the increments of an amylase activity of aleurone layer particles. The physical and chemical properties of wheat flours prepared from different wheat kernel samples are given in Table 3. Canadian flour had the highest percent of protein (13.70 %), and the lowest percent of nitrogen free extract (83.88 %) among all samples. However, French soft red wheat flour showed lower protein content (8.30 %), and higher total nitrogen free extract (89.99 %).

The falling number values ranged from 296 to 527 sec. The Australian standard white wheat flour had significantly the highest value (527 sec.), and the French soft red wheat flour had the lowest value (296 sec.) among all samples. Kruger and Matsuo (1982) observed that amylase levels were substantially higher in germinated than in sound durum wheat. Economic European Community recommendation that the falling number of flour should exceed than (>230 sec.) was met by all flours.

The wet and dry gluten contents and the hydration ratio % of different flour samples are given in Table 4. The increase in protein content was accompanied by an increase in wet and dry gluten contents. The Canadian red spring wheat flour and Egyptian durum wheat flour (Bany Sweaf 1) showed protein contents of 13.70 % and 12.10 %, respectively. These high contents of proteins of the two samples were accompanied by an increase in their wet and dry gluten contents, which were (38.60 %) and (11.52 %) for Canadian flour, and (35.20 %) and (10.93 %), for Egyptian durum flour, respectively. The high percentage of wet and dry gluten in wheat flour reflected the high amount of protein and lower ratio of water-soluble protein to gluten (Pomeranz, 1971, Matsuo *et al.*, 1972, Refai, 1982 and Autran *et al.,* 1986). Pomeranz, (1978) showed that high protein semolina will have a minimum number of starch particles and will hydrate more evenly during mixing.

It is a common knowledge that the higher the protein content, especially gluten with good rheological characteristics, the higher the pasta resistance to cooking is while stickiness is reduced and the tendency to massing becomes very small (Milatovie and Mondelli, 1991).

From the technical standpoint, semolina or flour with sufficient protein and gluten to give pasta that dose not stretch or fall during processing is preferred and also has good cooking quality.

TABLE 2. Proximate analysis of eight different wheats[1].

Component[2]	AuW	FW	CW	AmW	PW	EG-9	ES-69	EDW
Moisture (%)	9.34 b	10.35 a	9.45 b	9.40 b	9.00 b	8.60 c	9.33 b	8.30 c
Protein (%)	12.57 bc	9.70 e	15.27 a	12.14 cd	12.23 cd	11.20 d	11.59 cd	13.50 b
Fat (%)	1.62 c	1.21 d	2.63 b	2.54 b	2.41 b	1.11 d	1.22 d	2.91 a
Ash (%)	1.58 e	1.52 f	1.96 a	1.69 d	1.87 b	1.57 e	1.67 d	1.74 c
Crude fiber (%)	2.30 bc	2.34 b	2.08 c	2.86 a	2.22 bc	2.13 bc	2.37 b	2.15 bc
Nitrogen free extract % (by differences)	81.93 cd	85.23 a	78.06 f	80.77 de	81.27 d	83.99 ab	83.15 bc	79.70 e
Falling Number (sec.)	515 a	231 e	345 cd	363 b	317 d	348 cd	373 b	488 a

[1]Different wheats: AuW = Australian Standard White Wheat; FW = French Soft Red Wheat; CW = Canadian Red Spring Wheat; AmW = American Hard Red Winter Wheat; PW = Pakistani Hard Red Spring Wheat. EG-9 = Egyptian Soft Wheat Gemmeiza 9. ES-69 = Egyptian Soft Wheat Sakha 69; EDW = Egyptian Durum Wheat Bny Sweaf 1

[2]Means followed by the same letter in each row are not significantly different ($\alpha = 0.05$) by Duncan's multiple range test.

TABLE 3. Proximate analysis of flours produced from eight different wheats[1].

Component[2]	AuF	FF	CF	AmF	PF	EG-9F	ES-69F	EDF
Moisture (%)	13.41 d	13.80 bc	14.73 a	14.65 a	13.43 d	13.70 c	14.00 b	12.10 e
Protein (%)	11.60 b	8.30 d	13.70 a	11.84 b	12.04 b	9.86 c	10.46 c	12.10 b
Fat (%)	0.93 e	0.67 f	1.29 c	1.72 a	1.18 d	0.69 f	0.92 e	1.56 b
Ash (%)	0.53 e	0.56 de	0.62 c	0.62 c	0.75 b	0.59 cd	0.54 e	0.86 a
Crude fiber (%)	0.49 bcd	0.48 bcd	0.51 ab	0.45 d	0.50 bc	0.47 cd	0.50 bc	0.54 a
Nitrogen free extract (%) (by differences)	86.45 d	89.99 a	83.88 f	85.37 e	85.53 e	88.39 b	87.58 c	84.94 e
Falling Number (sec.)	527 a	296 d	384 c	363 c	521 a	381 c	384 c	494 b

[1]Different samples: AuF = Australian Standard White Wheat Flour; FF = French Soft Red Wheat Flour; CF = Canadian Red Spring Wheat Flour; AmF = American Hard Red Winter Wheat Flour; PF = Pakistani Hard Red Spring Wheat Flour; EG-9F = Egyptian Soft Wheat Gemmeiza 9 Flour; ES-69F = Egyptian Soft Wheat Sakha 69 Flour; EDF = Egyptian Durum Wheat Bny Sweaf 1 Flour

[2] Means followed by the same letter in each row are not significantly different ($\alpha = 0.05$) by Duncan's multiple range test.

TABLE 4. Wet & dry gluten contents of flours produced from eight different wheats. [1]

Gluten[2]	AuF	FF	CF	AmF	PF	EG-9F	ES-69F	EDF
Wet %	28.80 c	24.61 d	38.60 a	30.27 c	31.40 c	28.80 c	30.40 c	35.20 b
Dry %	10.25 ab	8.24 c	11.52 a	10.46 ab	10.26 ab	10.06 b	10.52 ab	10.93 ab
Hydration ratio %	180.98 d	198.67 cd	235.07 a	189.39 cd	206.04 bc	186.28 cd	188.97 cd	222.05 ab

[1]**Different samples:** **AuF** = Australian Standard White Wheat Flour; **FF** = French Soft Red Wheat Flour; **CF** = Canadian Red Spring Wheat Flour; **AmF** = American Hard Red Winter Wheat Flour; **PF** = Pakistani Hard Red Spring Wheat Flour; **EG-9F** = Egyptian Soft Wheat Gemmeiza 9 Flour; **ES-69F** = Egyptian Soft Wheat Sakha 69 Flour; **EDF** = Egyptian Durum Wheat Bny Sweaf 1 Flour

[2] Means followed by the same letter in each row are not significantly different ($\alpha = 0.05$) by Duncan's multiple range test.

The protein and wet gluten contents of semolina or flour suitable for spaghetti-making must be higher than 10 % and 23 % as cited by Manser (1981), while Matsuo *et al.* (1982) reported that semolina must have at least 11 % protein to produce pasta with good cooking quality. The Egyptian Standard Specification no. 286/1988 reported that semolina must have at least 12% protein content (on dry weight basis) for macaroni products (ES, 1988). Milatovie and Mondelli (1991) pointed out the necessity to take into account the content of wet gluten, which should never be less than 28 % (and at least 9 % as regards dry gluten) for pasta-making. Nevertheless, knowledge of the quantity of proteins in the semolina (or flour) or in the pasta is not enough to give with precision the quality yield of the cooked product. A type of semolina with a protein content of 12.0 - 12.5 % dose not always and necessarily give rise to pasta of very good cooking quality. In order to be able to foresee and understand the quality of pasta it is also necessary to know the rheological features of semolina or flour. From the previous results in Tables 3 and 4, it could be concluded that the Canadian, American, Pakistani and Egyptian durum flours are good for spaghetti- making because they have higher amount of protein contents and wet and dry gluten which are of greatest demand for spaghetti-making.

Rheological properties of the different samples

Table 5 shows the rheological properties of different flour samples under investigation. In considering the farinograph dough properties, Pakistani flour had the highest value for water absorption of 65.0 % compared with the other flour samples which had values of 62.0, 59.8, 56.2, 56.0, 55.6, 55.0, and 55.0 % for the respective samples: Canadian, Australian, Egyptian (Gemmeiza 9), American, Egyptian durum flour (Bany Sweaf 1), French and Egyptian (Sakha 69) flours. Semolina and flour, which are low in farinograph water absorption, are of greatest demand for pasta dough property that gives a homogenous dough mass for macaroni processing (Tawfik and Mansour, 1983). In considering the farinograph mixing properties for the different samples, it was found that the arrival time ranged from 1.0 to 3.5 min. The Canadian flour had the highest arrival time among all samples; and French, Pakistani and Egyptian flour (Sakha 69) had the lowest values. The dough development time (mixing time), ranged from 1.5 to 7.0 min and the Canadian flour had the highest value and the French flour had the lowest value. Usually, the decrease in mixing time is associated with weaker gluten (Dexter and Matsuo, 1978). It was found that American flour and Egyptian durum flour showed long periods of dough stability of 18.5 and 18.0 min, with low values of dough weakening of 25 and 20 B.U., respectively. On the other hand, French flour had the shortest period of dough stability 3.0 min, and the higher value of dough weakening 95 B.U. (the highest value for Sakha 69 was 110 B.U.). Milatovie and Mondelli (1991) demonstrated that a kind of flour (or semolina) presenting a weakening value higher than 90 B.U. cannot be used for pasta-making. If such a value is included between 60 and 90 B.U., the flour may be considered good. When the weakening value is lower than 60 B.U., the quality of the flour is undoubtedly very good. So, it appeared that the Canadian, American, Pakistani and Egyptian durum flours were stronger in their gluten than the other samples, and exhibited stronger mixing characteristics which are suitable for spaghetti-making. Mixing tolerance index ranged from 20 to 105 B.U. and the highest value was observed for French flour (105 B.U.). Irvine *et al.* (1961) showed that high tolerance indexes were usually associated with sample having very short mixing time and least period of dough stability. From the previous results, it can be concluded that the Canadian, American, Pakistani and Egyptian durum flours had the best characteristics of farinograph tests which are suitable for spaghetti-making (long dough development time, long stability, long time to break down; low mixing tolerance index, low degree of weakening). The Australian flour had the moderate characteristics of farinograph tests. These results are in agreement with those of Matsuo *et al.* (1972), who reported that farinograph characteristics were markedly affected by the increase in protein content, since this increase led to elevating the mixing tolerance index. In general, a correlation between general strength and protein is observed. With the aim of producing pasta, it is not enough to find the farinogram value with a farinograph. The most important values are actually those drawn from the extinsogram and amylogram.

The extensogram properties of the different flour samples are given also in Table 5. The data reveal that there are variations in the extensibility, resistance to extension and energy among the different samples. There was an inverse proportion between protein content and resistance to extension. Also, there are a relatively direct proportion between resistance to extension and energy. Milatovie and Mondelli, (1991) demonstrated that the flour or semolina that is fit to pasta-making should has the maximum resistance to extension "R" (should exceed 400 B.U.), while the strength of the flour, or dough energy, should by average be of about 120 square cm (namely, between 110 and 140 square cm). So, the samples which can be classified as good samples for pasta-making in considering extensograph properties are: Egyptian durum flours, American, Australian and Canadian. On the other hand, French, Egyptian Gemmeiza 9 and Egyptian Sakha 69 not suitable for pasta-making, although they had higher values in resistance to extension "R" because their results in dough energy were low (<110). For pasta-making the greater the strength (dough energy), the greater pasta elasticity is. Lastly, the comparison between protein content of different flour samples and their extensogram properties demonstrate that there is a positive relationship between them; also, there are a relatively positive relationship between resistance to extension "R" and energy, as reported by Milatovie and Mondelli (1991). Table 5 also showed the amylograph data of different wheat flour samples. It is clearly shown that Australian, Canadian, American and Egyptian durum flours gelatinized at higher temperature of 61.5°C, 63.0°C, 61.5°C and 63.0°C, respectively, whereas, that of French, Pakistani, Egyptian Sakha 69 and Gemmeiza 9 gelatinized at lower temperature. This means that the flour of the former samples resisted swelling and gelatinization more than the latter ones. The Australian, Pakistani and Egyptian durum flours reached their maximum viscosity's over 1500 B.U. at 91.5°C, 90.0°C and 94.5°C, respectively.

TABLE 5. Rheological properties of flour doughs from eight different wheats.[1]

Rheological parameters[2]		AuF	FF	CF	AmF	PF	EG-9F	ES-69F	EDF
Farinograph parameters :									
Water absorption	(%)	59.8	55.0	62.0	56.0	65.00	56.2	55.0	55.6
Arrival time	(min.)	1.5	1.0	3.5	1.5	1.0	1.5	1.0	2.0
Dough development time	(min.)	4.5	1.5	7.0	4.5	6.0	2.0	2.0	3.5
Dough stability	(min.)	9.0	3.0	11.0	18.5	12.0	7.5	3.5	18.0
Mixing tolerance index	(B.U.)	60	105	30	20	20	40	90	40
Time to breakdown	(min.)	9.5	3.5	16.0	19.0	14.5	8.0	5.0	—
Degree of weakening	(B.U.)	50	95	30	25	50	55	110	20
Extensograph parameters :*									
Extensibility "E"	(mm)	157.5 ab	117.5 bc	167 a	125 abc	155 abc	110 c	150 abc	125 abc
Resistance to extension "R"	(B.U.)	435 bc	510 b	410 c	640 a	370 d	470 bc	210 e	385 c
Proportional number	(R/E)	2.76 bc	4.3 a	2.46 bc	5.12 a	2.39 c	4.27 a	1.40 d	3.08 b
Energy	(Cm^2)	130.5 b	96.5 cd	120 bc	150 a	71.5 d	76 d	68.5 d	173 a
Peak height	(B.U.)	625 bc	685 b	585 bc	950 a	340 d	565 c	270 e	410 d
Amylograph parameters :									
Transition temp.	(°C)	61.5	60	63	61.5	60	58.5	60	63
Pasting temp.	(°C)	91.5	91.5	93	92.5	90	93	90	94.5
Peak viscosity	(B.U.)	2040	680	895	1460	2000	665	1040	1690
Viscosity at 95 °C	(B.U.)	2020	650	880	1400	1900	585	960	1685

[1]Different samples: AuF = Australian Standard White Wheat Flour; FF = French Soft Red Wheat Flour; CF = Canadian Red Spring Wheat Flour; AmF = American Hard Red Winter Wheat Flour; PF = Pakistani Hard Red Spring Wheat Flour; EG-9F = Egyptian Soft Wheat Gemmeiza 9 Flour; ES-69F = Egyptian Soft Wheat Sakha 69 Flour; EDF = Egyptian Durum Wheat Bny Sweaf 1 Flour

[2] Means followed by the same letter in each row are not significantly different ($\alpha = 0.05$) by Duncan's multiple range test.

Spaghetti cooking quality

Statistical analysis of cooking quality parameters of spaghetti made from different wheat flours is presented in Table 6. Results showed that there was a significant difference among all samples for various cooking parameters. Canadian sample had the highest volume of 100 g of uncooked samples (80 cm^3) followed by Australian, French and American (75 cm^3) and Pakistani, Gemmeiza 9, Sakha 69 and Bany Sweaf 1 (70 cm^3). This means that spaghetti made from Canadian flour resulted in a significant decrease in the specific gravity. With respect to the cooking time (min), it was found that the optimal cooking time for different samples under investigation ranged from 8.00 to 10.25 min. During pasta cooking, there was a competition between starch and protein for water. It is known that when less protein surrounded starch granules, they swelled and gelatinized faster (Grzybowski and Donnelly, 1977). Thus the greater amount of protein resulted in slower starch swelling and subsequently a longer time for gelatinization to occur (Bergman, *et al.,* 1994). Spaghetti made from flour samples that have great amount of protein such as, Canadian, American and Egyptian flours had the longer time of optimal cooking. The volume of 100 g-cooked pasta differed significantly among all samples after cooking. Increases in volume were seen for the Canadian flour spaghetti and Egyptian flour (Gemmeiza 9) spaghetti, French flour spaghetti recorded the lowest. The same trend was obtained for cooked weight. Hummel (1966) mentioned that good quality macaroni products should absorb at least twice their weight in water and swell to three or four times their original volume. The cooking loss data showed that there was a significant difference among all spaghetti samples. The cooking loss of different spaghetti samples ranged from 6.73 to 9.92 %. Means comparison of the cooking loss data (Table 6) showed that the highest cooking loss was observed for spaghetti made from Egyptian wheat (Sakha 69) flour (9.92%) and the lowest one for Egyptian durum (Bany Sweaf 1) flour (6.73 %). The variation in cooking loss among all samples may refer to the protein content of each sample. Wyland and D'Appolonia (1982) stated that spaghetti with high protein content was significantly lower in cooking loss than that with low protein. They pointed out that spaghetti with high protein allows less starch to leaching out, thus decreasing its cooking loss. The Egyptian Standard Specification no. 286/1988 demonstrated that cooking loss of macaroni that is made from semolina, must not exceed 8 %, while macaroni made from wheat flour other than durum must not exceed than 10 %. Generally, it was observed that the increase in weight appeared to correlate with that in volume. This was to be expected because the increase in weight in grams could be in the same time led to increase in volume. Matsuo *et al.* (1972) reported also that the volume increase was closely related to weight increase. Attia *et al.* (1990) and Dexter *et al.* (1983) mentioned that cooking loss was more strongly related to protein content than cooked weight. Samples with high percentage of protein content, gluten content and good rheological properties suitable for spaghetti-making were of good cooking quality. Therefore, Australian, Canadian, American and Egyptian durum flour spaghetti showed the best cooking quality.

Organoleptic evaluation

Cooked spaghetti samples were judged for the criteria mentioned in Table 7.

TABLE 6. Cooking quality attributes of spaghetti made from eight different wheat flours. [1]

Parameters[2]	AuS	FS	CS	AmS	PS	EG-9S	ES-69S	EDS
Volume of 100 g. uncooked spaghetti (cm^3)	75b	75b	80a	75b	70c	70c	70c	70c
Optimal cooking time (min)	9.1obc	8.00d	10.05ab	10.25a	9.50abc	10.00ab	8.00d	9.50abc
Volume of 100 g. cooked spaghetti (cm^3)	240.0d	235.0d	320.0a	237.5d	230.0d	277.5b	260.0bc	245.0cd
Volume increase (%)	320.0de	313.33e	400.00a	316.67de	328.57d	396.43a	371.43b	350.00c
Swelling Index (%)	220.00de	213.33e	300.00a	216.67de	228.57d	296.43a	271.43b	250.00c
Weight of 100 g. cooked spaghetti (g)	268.13b	259.81b	269.70b	264.15b	270.28b	303.10a	274.25b	269.50b
Cooking loss (%)	7.41de	9.56ab	7.61cde	8.20bcde	8.98abc	8.45abcd	9.92a	6.73e

[1]**Different samples:** **AuS** = Australian Standard White Wheat Flour Spaghetti; **FS** = French Soft Red Wheat Flour Spaghetti; **CS** = Canadian Red Spring Wheat Flour Spaghetti; **AmS** = American Hard Red Winter Wheat Flour Spaghetti; **PS** = Pakistani Hard Red Spring Wheat Flour Spaghetti; **EG-9S** = Egyptian Soft Wheat Gemmeiza 9 Flour Spaghetti. **ES-69S** = Egyptian Soft Wheat Sakha 69 Flour Spaghetti; **EDS** = Egyptian Durum Wheat Bny Sweaf 1 Flour Spaghetti

[2] Means followed by the same letter in each row are not significantly different ($\alpha = 0.05$) by Duncan's multiple range test.

TABLE 7. Means of organoleptic scores of spaghetti made from eight different wheat flours. [1]

Parameters[2]	AuS	FS	CS	AmS	PS	EG-9S	ES-69S	EDS
Appearance (4)	3.3ab	2.8b	3.5a	3.6a	3.3ab	2.8b	2.8b	3.7a
Color (4)	3.8a	3.0d	3.6abc	3.7ab	3.2bcd	3.0d	3.1cd	3.8a
Flavor (4)	3.2abc	2.8c	3.4ab	3.4ab	3.0bc	3.0bc	3.0bc	3.6a
Tenderness (5)	4.6a	3.2c	4.8a	4.8a	4.0b	3.8b	3.6bc	4.8a
Stickiness (3)	2.2abcd	1.6d	2.6ab	2.4abc	2.0bcd	1.8cd	2.2a	2.8a
Total score (20)	17.1b	13.4d	17.9ab	17.9ab	15.5c	14.4cd	14.7cd	18.7a

[1]Different samples: AuS =Australian Standard White Wheat Flour Spaghetti; FS= French Soft Red Wheat Flour Spaghetti; CS = Canadian Red Spring Wheat Flour Spaghetti; AmS = American Hard Red Winter Wheat Flour Spaghetti; PS = Pakistani Hard Red Spring Wheat Flour Spaghetti; EG-9S = Egyptian Soft Wheat Gemmeiza 9 Flour Spaghetti; ES-69S = Egyptian Soft Wheat Sakha 69 Flour Spaghetti; EDS = Egyptian Durum Wheat Bny Sweaf 1 Flour Spaghetti

[2] Means followed by the same letter in each row are not significantly different ($\alpha = 0.05$) by Duncan's multiple range test.

Sensory evaluation data of spaghetti were statistically analyzed. Taste panel members showed preference for spaghetti produced from Egyptian durum flour, Canadian flour, American flour and Australian flour over the different wheat flour samples. On contrary, spaghetti made from French flour received lower total scores over the different tested samples. Generally, it could be concluded that good palatable spaghetti with acceptable cooking quality could be produced from different wheat sources especially Egyptian durum, Canadian, American, and Australian wheat flours.

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تقييم بعض الأقماح المستوردة والمحلية لصناعة الأسباجتى

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تم فى هذا البحث دراسة الخصائص الطبيعية والكيماوية والريولوجية لخمسة أنواع من الأقماح المستوردة (الأسترالية ، الفرنسية ، الكندية ، الأمريكية ، الباكستانية) وثلاثة أنواع من الأقماح المحلية ، وتقييم جودة الأسباجتى المصنعة منهم . وأوضحت النتائج المتحصل عليها أن حبوب القمح اللين المحلى أعطت أعلى قيمة فى محتواها من العيوب الطبيعية .ولقد تراوح محصول الدقيق الناتج من كل عينات القمح المختبرة حوالى ٧٠% ماعدا قمح الديورم المحلى والذى أنخفض الى ٥ر٥٦% . وأوضحت نتائج المحتوى البروتينى وجـود مـدى واسـع من المحتوى البروتينى لأنـواع الدقيق المختلفة (٣ر٨: ٧ر١٣) ، وسجلت أعلى قيمة فى المحتوى البروتينى لدقيق القمح الكندى ، وأقـل قيمة لدقيق القمح الفرنسى . كذلك وجد أن المحتوى من الجلوتين الرطب والجاف يرتبط بالمحتوى من البروتين .وفيما يتعلق بنتائج التقييم الريولوجى ، أوضحت النتائج أن دقيق الديورم المصرى ،الأمريكى ، الكندى ، الأسترالى سجلوا أفضل النتائج الملائمة لصناعة الأسباجتى . وأشارت كذلك نتائج تقييم الجودة للأسباجتى المصنعة من دقيق الأقماح المختلفة أن الأسباجتى المصنعة من دقيق قمح الديورم المصرى ، الكندى ، الأمريكى ، الأسترالى كانت ممتازة .