Introduction

INTRODUCTION

Wheat is estimated to provide 20% of the total world food calories, and is the main food in about 45 countries (Kent,1983). Egypt produce about 25% of its consumption and import 75% from different countries. The Egyptian production of wheat was 1.9 million ton in 1986/1987 and in the same time 5.2 million ton was imported as wheat grains and 1.4 million ton as patent flour (Abd El-Khafar, 1988). Wheat which is cultivated or imported consist of a margin different varieties. Wheat and its milling products are used in making bread, biscuits, pastry, cakes and alimentary pastes. The present dissertation will concern with macaroni and high fiber bread processing.

The local sector depends mainly on the imported hard or soft wheat flour (72% extraction) for macaroni processing. Using hard or soft wheat flour for pasta production rather than durum semolina (which is almost 3 times than the price of wheat flour) does not give the final product with the acceptable characteristics of semolina pasta , whether from the final look of the product or cooking quality. On the other hand, the private sector import semolina and produce macaroni with acceptable yellow colour and superior cooking quality, but it price is three times than the local sector product. The consumer always demands a good macaroni quality with low price.

A try to produce pasta from stork's (*T. durum*) which was cultivated in upper Egypt, but its results were unsatisfactory due to the brown colour of the product. On the other hand, macaroni processed from local patent flour 72% extraction, (Australian wheat) yielded dough strings stretched and sometimes breaks during its drying beside its pale colour.

Therefore, the aim of this investigation is to evaluate the physical and chemical characteristics which affect the quality of pasta produced from stork's and local patent flour.

It will be very fruitful from the economical standpoint of view to solve the brown colour of pasta produced from Stork's or patent flour, and improving its cooking quality.

Also, in the local market, there are many types of high fiber bread (Low calories bread) which have high phytate content. So factors affecting phytate content were throughly studied in a trial to produce high fiber bread , characterized with minimum phytate phosphorous and moderate protein content.

According to Quisenberg and Reitz (1967) *T. aestivum* wheat is a hexaploid (2n = 42), its flour is suitable for breadmaking, while *T. durum* wheat is tetraploid (2n=28), which has particularly hard grain and is milled to provide semolina for making pasta products.

To facilitate the presentation of such massive amount of data in this dissertation, this review is divided into several heading including the following titles:

II.1. The physical and chemical characteristics of wheat kernels, flour and pasta.

2. Wheat conditioning.
3. Pasta brownness.
4. Pasta quality.
5. Low calories bread (High fiber bread).

II.1. The physical and chemical characteristics of wheat kernels, flour and pasta:

The physical and chemical properties of wheat kernels widely varies according to genetic and environmental factors.

Depending on the physical and chemical properties, Kent (1983) classified wheat according to the texture of the endosperm of the grain which is connected with the way of breaking down the grain in milling and the protein content. Also, the properties of the flour and its suitability for various purposes are related to this characteristics.

II.1.1. The physical characteristics of wheat kernels:

The physical properties of wheat includes the vitreous and mealy, hard and soft, strong and weak characters and grain size and shape.

II.1.1.1. Vitreous and mealy characters:

Vitreous kernels are translucent and appear bright against a strong light, whereas mealy kernels are opaque and appear dark under similar conditions.

The vitreous or mealy character is hereditary, but is also affected by environment.

Percival (1921) reported that T. durum is a specie with vitreous kernels, whereas T. aestivium is a mealy one. Although he concluded that the vitreous/mealy character may be modified by the cultural condition. Vitreousness can be induced by nitrogenous manuring and is positively correlated with high protein content, mealiness is positively correlated with high grain yielding capacity.

Bailey (1916) found that the specific gravity of vitreous grains is generally higher than that of mealy grains (1.422 for vitreous and 1.405 for mealy.)

Staudt and Ziegler (1973) reported that the vitreousness are heridity characteristic affected by the ecological cultural conditions. Also they added that hardness is a milling character affecting on milling yield and size of flour particles.

Dexter and Matsuo (1981) reported that protein content increased with increasing of vitreousness, while wheat ash, test weightand kernal weight were uneffected by starchness.

II.1.1.2. <u>Hard and soft characteristics</u>:

Hardness and softeness are milling characteristics relating to the way the endosperm breaksdown. According to Berg (1947), hardness is a milling characteristics that transmitted by breeding. He added that the endosperm of hard wheat may be flinty or mealy in appearance, but its break down is always typical of hard wheat.

Stenvert and Kingswood (1977), explained that hardness is related to the degree of adhesion between starch and protein and hardness depends upon degree of continuity of the protein matrix.

II.1.1.3. <u>Strong and weak character</u>:

Kent (1983) reported that wheat yielding flour which has the ability to produce bread of larg-loaf volume, good crumb texture and good keeping properties, generally have a high protein content are called "strong". The yielding flour from which only a small loaf with coarse open crumb texture can be made, and which are characterized by low protein content is called "weak". The flour of weak wheat is ideal for biscuits and cakes, unsuitable for breadmaking unless blended with strong flour. The maximum yield of flour obtained from wheat in milling is ultimately dependent upon the endosperm content and the latter is affected by the size and shape of the grain and by the thickness of the bran.

II.1.1.4. Grain size and shape:

Shellenberger (1961), found that the volumetric bran content is lower in large than in small grains, viz.14.1 % and 14.6% respectively, from samples of the same type of wheat, showing the economic importance of large kernel size. The bushel weight (bu.wt.) measurement (test wt.) estimate the weight of a fixed volume of grain and gives indication of kernel size and shape.

However, these measurements can be misleading, as soft mealy wheats often have high bushel weight. Moisture content also affects the same character.

Matsuo (1982) reported that there is a significant trend toward higher milling yield with increasing test weight. Also, he studied the quality factor in durum wheat and found that there is a positive relationship between test weight and 1000 kernel weight with milling yield.

II.1.1.5. Moisture content:

Refai (1965) cited that there is a relation between air relative humidity and flour moisture content, therefore at 65% relative humidity the flour moisture stand at 13.8%.

Abu-El Nasr and El Nahal (1968) reported that under 9% moisture content in kernels, the insect do not live or reproduce. While at 15% moisture, insects reproduction is very active. Therefore wheat grains must be stored at low humidity.

Anon (1976) reported that the rate of respiration of wheat grains depends mainly on its moisture content. Hard canadian wheat at 20°C up to about 19% moisture content - respiration was very slow. When the moisture increased above that figure, the respiration was greater . The criticial moisture content was about 16% for English wheat at 20°C. He added that for hard spring wheat the fiqures are to be 14.5% with lower figures for soft wheat. Also temperature affects the rate of respiration. It was found that a five hold increase in the rate of respiration of english wheat with 15% moisture raised the temperature from 21°C to 30°C.

Anon (1983) cited that semolina moisture content must not exceed 12% with protein not less than 13% on dry basis and ash content not more than 0.9%. The same auther (1984) cited that flour which is locally milled must have moisture content not exceeding 14%.

II.1.2. The chemical composition of wheat kernels, flour and pasta

The chemical composition of wheat kernels and flour is effective on the technology of wheat especially the quality factors, nutrition value and deterioration of the products. The main chemical constituents of wheat grains and flour are carbohydrates, proteins, lipids, vitamins and minerals.

II.1.2.1. The carbohydrates of wheat kernels and flour

II.1.2.1.1. The starch:

Starch is the major and important carbohydrate in all cereals. It is consisting about 74% of the dry matter of the entire wheat grain and about 81% of the endosperm of the wheat. Starch molecule consists of two main compounds , amylose (25-27%) and amylopectin.Starch plays an important role in the physical properteis and quality of baked products. Starch gelatinization and pasting are the most important properties related to backing and food technology industries. However very little information is available on the extent of starch gelatinization(Kent 1983).

Fraser and Holmes (1959) stated that the starch content of wheat and flour is, in general, inversely related to protein content. Therefore starch content is higher in flour from soft wheat than in those from hard wheat. They also added that the starch content ranges from 65 to 71 % in flour below 80% extraction at 14% moisture.

Watson and Johnson (1965) found that the succeptibility of starch to B-amylase after 30 min. of baking showed that starch had undergone maximum gelatinization at the temperature attained and with the moisture available in the bread.

Yasunaga et al.,(1968) found that the gelatinization of starch in bread was dependent on the location in the loaf; starch in the outer layers of crumb was gelatinized to a greater degree than that in the center . They concluded that the main factors controlling the extent of starch gelatinization were baking absorption, temperature and time. Medcalf and Gilles (1965) comparised the physichochemical properties of different HRS, HRW, durum and soft wheat starches. They concluded that the percent of amylose in the starches studied ranged from 23.4 to 27.6%, durum starches tended to be on the high end of the range. Starches from durum wheat generally had larger water binding capacities, greater rate of iodine absorption and slightly lower temperatures of initial pasting than those from other wheat classes. Their data suggested that solvents can penetrate durum starches more easily than other wheat starches, also starches from several spring wheat varieties had markedly different gelatinization characteristics.

According to Kent (1983) the level of damaged starch in the flour influences its ability to absorb water. The content of damaged starch in flour was estimated by methods which measure the quantity of maltose released from the starch by the action of amylase. Only the damaged granules are succeptible to amylase in the ungelatinized condition.

II.1.2.1.2. <u>The sugars of wheat kernels and flour</u>:

Koch <u>et</u> <u>al</u>.,(1951) stated that non reducing sugars in wheat flour were about 1.0%, where glucose, fructose , sucrose,mellibiose and raffinose contents were 0.01, 0.02, 1.0, 0.18 and 0.07% respectively.

El-Gindy (1982) reported that durum wheat have 1.6-3.9% sucros and 0.2-1.2% reducing sugars. He added that durum starch affected by amylases more than other wheat starch and this is due to its higher starch damaged. Starch damaged percentage of soft wheat flour, hard wheat flour and durum wheat flour are 1-2%, 3-4% and 6-8% respectively. Also he found that the total
in patent flour were 1.3%.

Kent (1983), reported that the percentage of reducing sugars in both T. aestivium and T. Durum were 0.1% and 0.12% while their total soluble sugars content were 1.0-1.67% and 1.19% respectively.

II.1.2.1.3. Effect of amylases on starch

Fleming et al.,(1961) cited that the thermostability of malted durum wheat alpha-amylase is 100% activity at 70°C, 60% activity at 75°C and 29.4% activity at 80°C while it was 98.8%, 56.2% and 25.7% respectively in white winter wheat.

Booth, (1973) reported that alpha-amylase activity is restricted to the aleurone and scutellum of mature wheats. Even at relatively high levels of alpha-amylase activity in the whole grains there is initially very little activity within the inner endosperm so that the level of alpha-amylase is reduced considerably on milling.

Simmonds et al.,(1973) found sufficient B-amylase in the water soluble fraction from starch granules isolated from hard wheat to account for the all of the β-amylase activity, indicating that this enzyme is spread throughout the endosperm. Staudt and Ziegler (1973) reported that β -amylase breaks down the amylopectin of starch to dextrins, while the remaining part of starch, amylose,is broken down in the middle. This action is very slow on undamaged starch geranules, a bit faster on damaged starch granules and very fast on gelatinized starch. They added that the Hagberg falling number method determines the α-amylase activity in a native substrate of the flour. The method is based upon rapid gelatinization of a flour suspension in a boiling water bath and subsequent measurement of the degradation of the starch paste by α-amylase.

Dick et al., (1980) cited that the falling number unit average were 181, 133, 166, 174, 170 and 247 sec.in north Dakota durum wheat counties and districts C.R.D. 1,2,3,4, 5 and 6 respectively. They reported that the standard average of falling number in years 1975,1976, 1977, 1978 and 1979 crops for North Dakota were 388, 469, 275, 436, and 404 sec. respectively.

Donnelly (1982) showed that U.S.A. durum wheat varieties wells, blend, crosby, wakooma, macoun and Edmorc having falling numbers565, 480, 559, 231, 313 and 574 sec. He added that the falling number of wakooma and macoun which are 231 , 213 sec. respectively may have some incipient sprouting. Kent (1983) reported that normal flour from sound wheat contains ample β-amylase, but generally only a small amount of alpha-amylas . The amount of α-amylase,however , increased considerably when wheat germinates. Indeed flour from wheat containing many sprouted grains may have too high α-amylase activity, with the result that during backing some of the starch is changed into dextrin-like substances. water holding capacity is reduced, the crumb is weakened and the dextrins make the crumb sticky.

Hall et al.,(1984) cited that starch can break down by two main ways, hydrolytic cleavage and phosphorylas is enzymes. Amylase catalize the hydrolysis of alternate α(1-4) glucosidic bonds to yield maltose units which in the presence of maltase yield glucose. B-amylase, however, has only a limited specificity which attack the α(1—4) glucanchains from the non-reducing end. Hence the linear molecule of amylose break completely to maltose, while amylopectin is only degraded as far as its outer branch points leaving limit dextrin. α-amylase, by contrast, will attack internal α(1—4) linkages within the core of molecule as well as the terminal chains. Hence α-amylase degrade amylopectin more or less compeletly, though small oligosaccharides bearing the α-(1—6) branch point will remain undigested. Phosphorylase like B-amylas attack the α(1—4) glucan chains from the non-reducing end to give α-D-glucose 1-phosphate, and,ultimately limit dextrins. Phosphorylase degrade amylopectin completely in the presence of high levels of inorganic phosphate and debranching enzyme. Also the same workers reported that α-amylase is produced in the aleurone layer and secreted into the endosperm.

II.1.2.2. The proteins of wheat and wheat products:

Protein is found in all the tissues of cereal grains, higher concentration occurring in the embryo, Scutellum and aleurone layer than in the starch indosperm, pericarp and testa. Within the endosperm, the concentration of protein increases from the center to the periphery. Kent (1966) reported that in hard winter wheat of 14.4% protein content, the outer most cellular layer of the starchy endosperm contained 45% of the protein while the remainder of the starchy endosperm contained an average 11% protein.

II.1.2.2.1. Protein content of wheat and wheat products:

Matsuo et al (1972) found that protein content is related to cooking quality for wheats of similar variety but differ in its protein content. The cooking quality improves with increasing protein content.

Walsh and Gilles (1974) stated that the protein content of durum wheat is not grading factor, a minimum of about 11% protein in the semolina is necessary to yield macaroni products that have good cooking quality.

Golik (1976) studied the protein content and wheat yield in spring and durum wheat cultivars in relation to fertilizers. He found an increase in both crude protein and wheat yield with NPK fertilization.

Mineev et al (1977) studied the protein content of wheat grown in rotations given fertilizers regulary. They found that the systematic application of high rates of NPK to crops in rotation in 5 agroclimatic regions of the USSR increased grain protein and gluten content in spring and winter wheat.

Kulp et al. (1980) reported that the protein content of HRW, HRS and soft wheat grains were 11.8%, 13.6% and 10.2% respectively, while their flour protein content were 10.6% 12.8% and 8.5% respectively.

Manser (1981) stated that in the production of macaroni products using durum or soft wheat the protein and gluten content must be higher than 10% and 23%respectively. Matsuo (1982) reported that Canada Semolina must have at least 11% protein to produce pasta of good quality. Anon (1983) cited that semoline flour must have protein content not less than 13% on dry basis.

McDermott and Pace (1960) observed an inverse correlation between the protein and lysine content in wheat grains and flour. Also, they added that the vitreous and mealy grains with 1.60% and 1.01% N content, had lysine content of 2.79 and 3.75 gm amino acid N/100 gm total N respectively. Stevens et al.,(1963) studied the amino acids composition of wheat grains and flour and observed that the high content of glutamic (as glutamine) and of proline and the low content of lysine in grain and flour are notable. Also, they stated that the biological value of the protein in germ and aleurone is higher than that of the endosperm proteins. The lysine content is 2-2.5 times as large in the protein of these tissues as it is in the endosperm.

II.1.2.2.2. Wheat protein fractions:

According to Osborne (1907) albumins and glubulins are reffered to the soluble protein fraction while prolamins and glutalins are referred to insoluble proteins. The four principal types of protein vary considerably in their amino acids composition.

Woychik et al. (1961) reported that the portion of the protein soluble in aqueous alcohol (prolamin) in wheat is called gliadine and its mol. wt. ranges between 42000 to 47000. Nielsen et al. (1962) considered that the portion insoluble in alcohl but soluble in dilute acids and alkalies (gluteline) is called glutenin and its mol. wt. is about 20,000 which are bonded together by disulphide bonds into macro units with mol. wt. going up into the millions. The gliadin and glutenin of wheat form with water and salts are called gluten.

Kent-Jones and Amos (1967) found that albumins and glubulins are cytoblasmic components while, glutenins and gliadins are storage protein.

Kent and Evers (1969) cited that the main source of quality difference was in the ratio of glutenin-gliadin. Dexter and Matsuo (1977) reported that protein content and gluten quality are of prime importance in determining spaghetti cooking quality. In their study on osborne solubility distribution of wheat proteins in two canadian durum wheats (T. Durum Dest.) which are representing a wide range of Spaghitti cooking quality and a hard red spring wheat (T. aestivum L.). Their results are tabulated in the following table:

Table (1): Osborne solubility distribution of semolina protein.

Source of Semolina	Albumins %	Glubulins %	Gliadins %	Soluble glutenins %	insoluble residue
T. Durum	9.4-12.1	4.9-6.2	41.4-42.6	12-12.6	24.1-25.9
T.aestivium HRS.	12.6	4.4	35.7	11.6	32.1

Simmonds, (1978) fractionate the protein of hard red spring (HRS) and durum wheat grains to its main fractions. Results are shown in the following table.

Table (2): Protein fractions of HRS and durum wheat.[1]

Source of protein	Protein range	Albumins %	Glubulins %	Prolamins %	Residue and glutelins %
HRS	10-15	5-10	5-10	40-50	30-40
Durum wheat	12-16	10-15	5-10	40-50	30-40

(1) on dry basis .

Dexter and Matsuo (1979b) showed that osborne solubility distribution of protein from ICW durum wheat composite semolina are 10.9% albumins, 7.6% glubulins, 39.0% gliadins, 11.5% soluble glutunins and 28.2% insoluble residue. Graveland et al., (1979) showed that the total protein in Dutch wheat varieties; Sicco and Tundra was 11% and 10.5 % while their total glutelin was 11% and 18% respectively. Variety sicco have a good breadmaking quality while, Tundra have a poor breadmaking quality. They added that Sicco contains more glutenins than Tunda, . viz 45% and 38% respectively of the total protein.

Doekes and Wennekes (1982) investigated the relation between total protein content of wheat flour and its composition. They concluded that albumin and glubulin have the same average amount i.e. 1.6 mg of N per gram of flour. Glutenin content of the flour samples was independent of the total protein content but differed among cultivars. Also,glutenin content proved to be related to both baking quality and grain hardness. The gliadin to glutenin ratio increased with loaf volume. They reported that the ratio of gliadin to glutenin in good, intermediate and poor backing characteristics was 2.3:3, 3.3:4.3 and 2.8:3.4 respectively.

Graveland et al.(1982) reported that the glutenin constitute the most significant protein fraction of the creation of a continously visco elastic protein net work in dough.

II.1.2.2.3. Gluten content of wheat protein:

Vakar (1961) stated that the composition of gluten dry matter are gliadin(43%) glutenin 39% other protein(4.4)% lipids(2.8%), sugars(2.1%)and starch(6.4%)with some cellulose and mineral matter. Also he added that the gluten complex has elasticity and flow properties of unique value for the baking of bread and other products. The elastic properties which are developed during mixing appear to involve sulphydryl groups, possibly their oxidation to disulphide bonds or the formation of new bonds.

Frey and Holliger (1972) observed that to obtain a compact gluten framework, the percentage of protein must be between 11-12% (on dry matter) in the raw material. Depending on gluten quality, the limits may be more or less this percentage. Furthermore, two low protein content results in an increase in breakage of the paste goods during process. Also they added that if the critical protein content is exceeded the influence of the gluten upon cooking quality is decidelly weakened. Also, gluten quality influences the formation of a compact protein framework.

Dexter and Matsuo (1978a) reported that durum wheat (T. Durum Dcsf.) is preffered over other classes of wheat for the production of pasta products due to its excellent rheological properties. Differences in pasta dough rheology and pasta cooking quality may be largely attributed to protein content and the nature of the proteins within the gluten complex. They added that gluten of midium strength appears to produce pasta of optimum cooking quality. In particular, a high proportion of glutenins among the gluten proteins appears to be a prerequisite for the production of superior pasta quality.

Dexter and Matsuo (1979a) showed that dough development depends upon the formation of a continuous network of protein sheets and fibrils. Then at the dough-water content of pasta goods, full gluten development does not occur.

Refai (1982) stated that a reasonably high level of protein or wet gluten content is desirable because in wheats of similar varieties the cooking quality is directly related to protein content.

Tawfik and Mansour (1983) reported the following results about protein and gluten content in flour samples and semolina.

Table (3): Protein and gluten content of flour and semolina samples.

Sample	Protein	Gluten %	
		Wet	dry
Semolina (Roma)	15.39	43.34	15.2
Flour stork's	16.93	48.08	15.1
East El-Delta	14.73	39.96	13.13
Banha	15.01	38.06	12.98

II.1.2.3. Lipids and pigments content of wheat and wheat products:

II.1.2.3.1. Fats and fatty acids content:

Refai (1965) reported that ether extract of wheat grains lipid was 1.2% and in flour about 0.8-2.0% according to flour type. He added that 50% of the wheat grains lipids located in bran,while 40% in the endosperm and 10% of it in the germ

Burkwall and Glass (1965) analyzed the fat content of hard red spring wheat (HRS), and found that the total lipid content of whole grains and flour were 2.33% and 1.55% respectively. Bound lipids and free lipids were 0.85% and 1.48% in whole grains,while in flour were 0.66% and 0.89% respectively. The total fatty acids of the free lipids were approximately twice than that of the bound lipids and ranged from 77 to 92% in the former and from 41% to 53% in the latter. In all fractions linoleic acid was predomenant followed by palmatic, oleic, linolenic and stearic acid in decreasing order. Also, straight-grade flour contained considerably more linoleic and palmatic and less oelic and linolenic than did the bran and the shorts.

Seckinger and Wolf (1967) reported that wheat flour milled from hard wheats normally has 1-2% lipids, of which 60% is free and 40% bound. These lipids occur almost entirely in the protein matrix of wheat where their concentration is around 10%. Free lipids were distributed throughout the protein matrix rather than in distinct bodies. Bound lipids appeared in small inclusion throughout the protein matrix and are assumed to be remnants of cytoplasmic structures occurring in endosperm cells at maturity.

Cramptom and Harris (1969) reported that the ethereal extract of wheat grains of HRS, HRW, soft, soft red winter and durum have 2.2%, 1.8%, 1.9%, 1.8% and 2.2% fat content respectively, while wheat endosperm farina fat content was 1.2%.

Arunga and Morrison (1971) reported that free fatty acids comprise about 5% of the lipids in new flour but can reach 70% of the total extremely old flour.

Staudt and Ziegler (1973) found that the whole grain and the endosperm have average 2.7% and 1.6% lipids content respectively. Flour fat contains roughly oleic (30%)linoleic (44%), linolenic (11%) Palmatic (14%) and Stearic (1%) Morrison et al.,(1975) found that crude fat content in whole wheat grain and endosperm were 2.1-3.8% and 0.75-2.2% respectively.

Clements (1977) stated that free flour lipids are usually extracted with hydrocarbons or diethyl ether and bound lipids with water-saturated n-Butanol. Non polar solvents generally eluted more lipids from soft wheat than from hard wheat flours, but polar solvents eluted about the same amounts from soft and hard wheat flours.

Morrison (1978) reported that lipids exist in the flour as amylose-complexed monoacyl lipids in starch granules. Starch lipids are effectively innert and non-starch lipids participation physical, chemical and biochemical processes in flour and dough.

El-Gindy (1982) reported that macaroni produced from semolina, patent flour and farina have 1.4%, 0.9% and 1.0% fat content respectively. He added that soft wheat, hard spring wheat, durum wheat and hard winter wheat have 1.39%, 2.2%, 1.1-2.4% and 1.8% fat content respectively.

Kent (1983) cited that wheat manitoba, hard red winter wheat and English wheat have 2.9%, 1.8% and 2.6% fat content respectively.

Pomeranz and Shellenberger (1961) reviewed that sound wheat is a poor source of lipolytic enzymes. However, when moisture content is raised, especially on germination, lipase activity increases. The lipase activity is located in the outer layers of wheat kernels. Highest esterase content was associated with the scutellum, and germ lipase activity was considerably less than the scutellum lipase activity. Also, they added that esterase content of endosperm was fairly high but much lower than in the scutellum. Bran contained a