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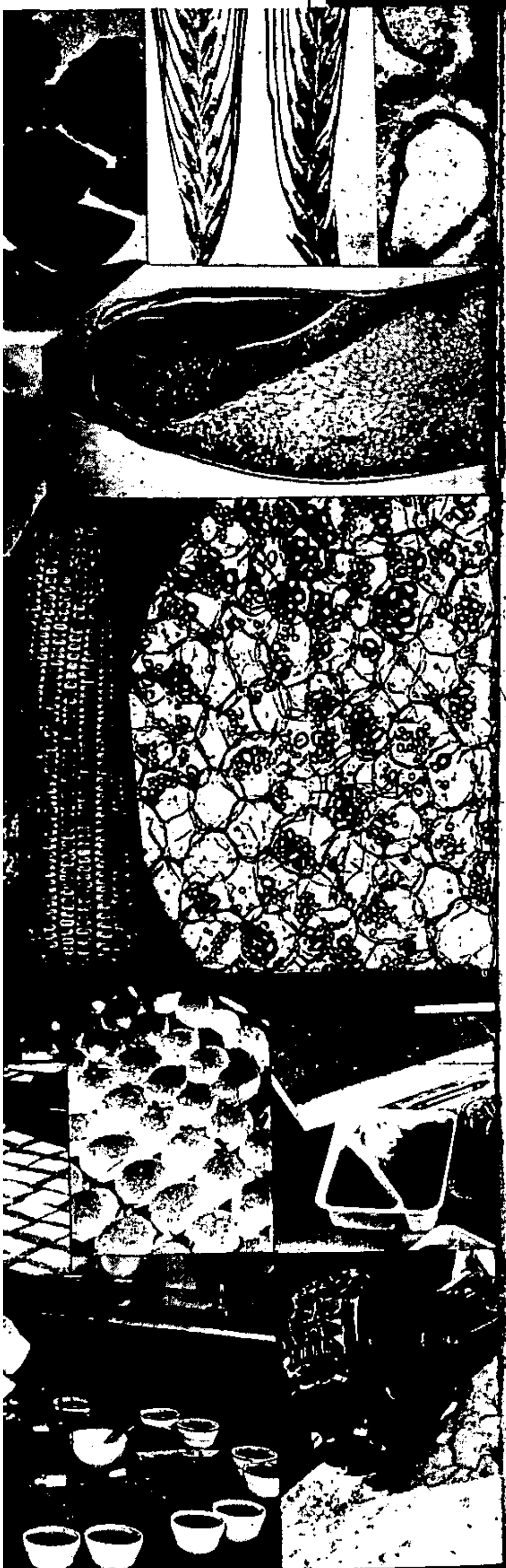

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Preface

There has been a need for a textbook
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S. VICTOR VAECK, Central Laboratory of Ministry of Economic Affairs, Brussels, Belgium

DOROTHY VAN EGMOND, School Foodservice Division, Prince George's County Public Schools, Maryland

MATTHEW K. VELDHUIS, Deceased. Formerly, Laboratory Chief, Citrus and Subtropical Products Laboratory, Southeastern Marketing and Nutritional Research Division, Agricultural Research Service, U.S. Department of Agriculture, Winter Haven, Florida 33880

H.S. VILLARS, Food Ingredients, Inc., 1411 Peterson Ave., Park Ridge, Illinois 60068

D.E. WALSH, Department of Cereal Chemistry and Technology, North Dakota State University, Fargo, North Dakota 58102

M.E. WATERS, Acting Laboratory Director, Fishery Products Technology Laboratory, U.S. Department of the Interior, P.O. Box 1207, Pascagoula, Mississippi 39567

BETTY M. WATTS, Professor Emeritus, University of Florida, Tallahassee, Florida 32306

BYRON H. WEBB (retired). Formerly, Chief, Dairy Products Laboratory, U.S. Department of Agriculture, Washington, D.C. 20250

HARRY W. WEISER, Deceased. Former Professor of Microbiology, Ohio State University, Columbus, Ohio.

R.L. WHISTLER, Department of Biochemistry, Purdue University, Lafayette, Indiana 47907

JONATHAN W. WHITE, JR., Chief, Plant Products Laboratory, Eastern Regional Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, 600 E. Mermaid Lane, Philadelphia, Pennsylvania 19118

A. WOHL, Technical Sales Manager, Spices and Botanical Products, Ltd., 450 Lebau Blvd., Montreal, Canada

W.J. WOLF, Northern Regional Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, 1815 N. University St., Peoria, Illinois 61604

EVERETT R. WOLFORD, Fruit and Vegetable Products Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Puyallup, Washington 93871

JASPER G. WOODROOF, Professor Emeritus of Food Science, University of Georgia, Experiment, Georgia 30212

HAROLD YOUNG, Kraft Foods Division, Kraftco Corp., 500 Peshtigo Court, Chicago, Illinois 60690

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Pasta

Sec. 2

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Pasta Technology

MACARONI PRODUCTS

D. E. Walsh and K. A. Gilles

According to legend, the famous Italian explorer, Marco Polo, upon his return from China, first introduced pasta products to the royal courts of Italy in the 13th Century. As you can imagine, food storage was a major problem for the sailing vessels of the 13th Century. A major consideration was to carry enough food aboard ship for voyages of several months. To do this, a food was required which could be stored without deterioration for long periods of time. Macaroni products, if kept dry, could be stored without refrigeration for several years, or longer, with little noticeable deterioration in either nutritional or aesthetic quality. Therefore, such products would be useful on voyages. Macaroni products have survived the test of time and remain one of the popular foods of modern day society.

Although macaroni products had their origin in antiquity, only since the beginning of the 20th Century have efficient equipment and high quality ingredients for macaroni been available. Prior to the industrial revolution, most macaroni products were homemade, or produced by hand in small shops where the products could be made and sold in small quantities. The mechanization of the macaroni processing industry began in about 1850 when the first mechanical presses (which were not hand powered) were invented. The machine consisted of a mixer, a dough kneading device, and a large, mechanical piston and cylinder for forcing the paste through the die. While there are still a few of the machines in operation, they have been replaced largely by continuous, high capacity extruders of the type shown in Fig. 15.1. The continuous press works on the auger extrusion principle in which the kneading and extrusion are done in a single operation. For efficient production modern presses require uniform raw ingredients so that the continuous equipment may be operated with few adjustments.

Raw Materials for Pasta Products

Three main milled products of durum wheat (semolina, durum granulars, and durum flour) are preferred for use in pasta products. To a lesser extent, farina and flour from common wheat are used also.

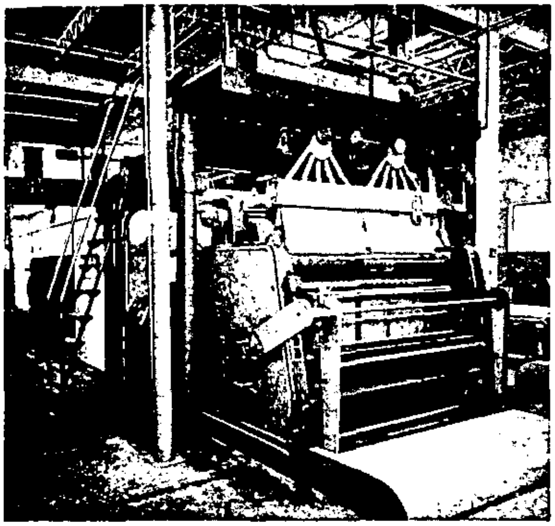


FIG. 15.1. MODERN CONTINUOUS PRESS FOR LONG SPAGHETTI PRODUCTION

Courtesy of Braibanti, Milan, Italy

Semolina.—Semolina is the raw material of choice for macaroni products. Semolina is a granular product which is milled from the endosperm of amber durum wheat and contains less than 3% flour. Most U.S. macaroni manufacturers prefer semolina which has a uniform fine particle size rather than a coarse ground semolina. With a fine granulation, less trouble is encountered in mixing the semolina and water to form a uniform dough for extrusion. If the semolina is not uniform, but consists of fine as well as coarse particles, the fine particles will tend to absorb water faster than the larger particles. Consequently, the coarse particles remain relatively dry throughout mixing operations and tend to result in white specks in the macaroni. Macaroni made from good quality durum semolina is characterized by a bright clear yellow color. A pale or gray color results if the product is made from other ingredients, such as common wheat flour.

Durum Granular and Flour.—Durum granular is another milled product of durum wheat which, like semolina, is used in macaroni making. While semolina contains less than 3% flour, durum granular may contain as much as 20% flour. Durum flour, which has a particle size less than 140 μ, is generally used in noodles, but also may be used for macaroni. Generally, macaroni made from durum flour has good color, but is less resistant to overcooking than products made from semolina or durum granular.

Water.—Water used for macaroni products should be pure, have no off-flavors, and should be suitable for drinking. Since macaroni is processed below pasteurization temperatures, the bacterial count of the water is directly related to the bacterial count of the finished product. Consequently, only pure water of low total plate count should be used.

Eggs.—The final ingredient of major importance is eggs. In the United States, egg noodles and egg spaghetti must contain at least 5½% egg solids by weight in the finished product. The eggs improve the nutritional quality and richness of the product. Moreover, noodles which do not contain eggs must be specially labeled as "plain noodles" to distinguish them from the egg-containing products.

Eggs may be added either as fresh eggs, frozen eggs, dry eggs, egg yolks, or dried egg solids. A major problem with the use and incorporation of eggs into macaroni products is bacterial contamination. Because eggs provide an excellent medium for bacterial growth, special care and precautions must be taken in storage and handling of eggs and egg products. Only pasteurized egg products which have low bacterial count should be used. Good quality liquid whole egg or egg yolks generally contain a total plate count of less than 5000 bacteria per gram. Moreover, the eggs must show negative Salmonella and should contain less than 10 mold spores, and less than 10 yeast spores and coliforms per gram of egg.

Artificial coloring material is not used in macaroni products. However, eggs may be added to improve the color. Chickens which lay the special high yellow eggs are fed a high carotene diet which enhances the color and adds to the cost of the eggs.

Optional Ingredients.—In addition to semolina, eggs, and water, other minor ingredients may be added to macaroni products. These optional ingredients are listed later in the chapter under the Standards of Identity for macaroni products. When optional ingredients are included, they must be declared on the package label.

Types of Macaroni Products

One of the reasons for the popularity of macaroni products is the great number of possible shapes and sizes available and numerous methods of preparing macaroni foods. Although most macaroni products consist only of semolina and water, the products can be formed into various shapes which provide an interesting and pleasant variation of the food. Some of the popular shapes of macaroni and their names are shown in Fig. 15.2. In the United States, the most popular macaroni products are spaghetti, elbow macaroni, and noodles. Grouped by types and consumption, spaghetti is listed as the most popular pasta product with approximately 40.5% of the total consumption; macaroni is second and accounts for 32.5% of the total while noodles represent 27% of the U.S. total.

Consumption (1977)

The per capita consumption of macaroni products naturally varies throughout the world. Italy, as expected, leads world consumption with 87 lb per person per year. France has a yearly average of 13 lb per person; the United States has a per capita consumption of 7½ lb per person, while England shows a per capita consumption of 3 lb. In addition, Spain, the South American countries, Japan, and North African countries also consume significant amounts of macaroni products.

Economic Importance

In the United States, the macaroni industry has shown a steady growth over the past 20 yrs in the total volume as well as in per capita sales. This is unique, since the per capita consumption of wheat products in general has declined in the United States during the same period. At present, annual total sales for the industry are approximately 500 million dollars.

Courtesy of Wheat Flour Institute, Chicago, Ill.

FIG. 15.2. POPULAR MACARONI SHAPES

Reading top left to bottom right: noodle bows, long spaghetti, elbow spaghetti, medium noodles, alphabets, shell macaroni, spaghetti or thin spaghetti, fine noodles, elbow macaroni, broad noodles, small macaroni shells, jumbo macaroni shells.

WHEAT AND MILLING

Wheat

A primary factor which sets the economic value of durum wheat is the grade. In the United States, there are 21 possible grades for durum wheat. In determining durum wheat grade, physical factors such as test weight, kernel vitreousness, amount of damaged kernels, and extraneous material are used. Each of the factors has a significant effect on the quality as well as the selling price of the durum wheat.

In order to understand durum wheat quality, it is necessary to be familiar with the terms used to describe durum wheat and durum wheat grades. According to the Official Grain Standards of the United States, durum wheat is divided into the following three subclasses: "Hard Amber Durum Wheat" which must contain 75% or more hard vitreous kernels, "Amber Durum Wheat" which must contain more than 60% but less than 75% hard vitreous kernels, "Durum Wheat" which contains less than 60% hard vitreous kernels. Within the three subclasses for durum wheat, there are also numerical grades which are assigned according to Table 15.1. In addition, the classification of "heavy" also may be assigned to the

TABLE 15.1

GRADES AND GRADE REQUIREMENTS FOR DURUM WHEAT

		Maximum Limits of						
		Defects					Wheat of Other Classes	
U.S. Grade	Minimum Test Weight Per Bushel (Lb)	Heat Damaged Kernels (%)	Damaged Kernels (Total) (%)	Foreign Material (%)	Shrunken and Broken Kernels (%)	Defects (Total) (%)	Contrasting Classes (%)	Wheat of Other Classes (Total) (%)
1	60.0	0.1	2.0	0.5	3.0	3.0	1.0	3.0
2	58.0	0.2	4.0	1.0	5.0	5.0	2.0	5.0
3	56.0	0.5	7.0	2.0	8.0	8.0	3.0	10.0
4	54.0	1.0	10.0	3.0	12.0	12.0	10.0	10.0
5	51.0	3.0	15.0	5.0	20.0	20.0	10.0	10.0
Sample grade[1]								

Source: U.S. Dept. Agr.

[1] Sample grade shall be wheat which does not meet the requirements for any of the grades from No. 1 to No. 5, inclusive; or which contains stones; or which is musty, or sour, or heating; or which has any commercially objectionable foreign odor except of smut or garlic; or which contains a quantity of smut so great that any one or more of the grade requirements cannot be applied accurately; or which is otherwise of distinctly low quality.

grade to indicate that the wheat has a test weight greater than 62 lb per bu. Accordingly, the highest possible grade for durum wheat in the United States is U.S. No. 1 Heavy Hard Amber Durum. It is commonly assumed that high grade wheat will result in high quality macaroni products. However, it should be recognized that the grade does not take into account macaroni processing criteria. Consequently, the grade gives only a rough indication of the quality in terms of macaroni-making criteria.

There are, however, a few generalizations which can be drawn to relate durum wheat grade to quality. For example, top grade durum wheat has a high test weight, contains more than 75% vitreous kernels, and is relatively free of damaged or broken kernels. Durum millers prefer high grades of durum wheat because vitreous kernels give a high yield of semolina when milled. For the upper grades, there will be less wheat lost due to removal of broken and damaged kernels during the cleaning operation. Furthermore, the upper grades are more valuable to the miller because there are more pounds of wheat per bushel than for the lower grades.

Protein content of durum wheat is not a grading factor, and there is no protein premium paid in the United States for high protein durum. However, protein is important from a nutritional standpoint. Furthermore, a minimum of about 11% protein in the semolina is necessary to make macaroni products which have good cooking quality.

Durum wheat grade and quality are influenced by the environment under which the durum is grown. In the United States, the conditions in North Dakota are best suited for the production of good quality durum wheat. Other areas of the world suitable for durum wheat production are North Africa, Russia, Italy, France, Canada, and Argentina.

Wheat diseases often limit the production of quality durum wheat to certain climatic regions. Blight, black point, ergot, and various fungus infections can occur where the growing season is cool and wet. With fungus damage, portions or all of the durum kernel turn black. Black kernels are similar in size and density to normal wheat and, therefore, difficult to remove with conventional wheat cleaning equipment. When inadequately-cleaned, fungus-damaged wheat is milled, the black kernels are ground into black particles which appear as unsightly specks in the semolina and ultimately in the finished product.

A topic of special interest with regard to wheat condition is sprout damage. In the United States, since most of the durum wheat is grown in a fairly small area of North Dakota, sprouting can occur in a large percentage of the total crop in the event of heavy rainfall during the harvest season. Because of sprouting in 1965 and 1968, it was difficult for millers to obtain top grade durum. In many cases, sprouted durum was milled into semolina in order to meet the demands of the pasta processing industry. Although the sprouted durum wheat was used in large quantities by the pasta processors, there was little agreement as to what effect the sprouting had on the quality of the finished product. In recent studies sprouted durum wheat was tested at a number of levels of germination to determine the effect of field sprouting on durum wheat. The results of the experiment showed that sprouting caused a significant drop in the wheat grade and vitreous kernel content, protein content, test weight, and the number of damaged kernels. On the other hand, semolina milling yield and the speck count were not significantly altered by the sprouting. The results also indicated that spaghetti color, cooked weight, cooking loss, and cooked firmness were not influenced significantly by sprouting.

Durum Wheat Milling Process

Durum wheat usually is milled into either semolina, durum granular, or fl(Milling of durum patent flour is similar to conventional flour milling. Semoi milling is unique in that the objective of the operation is to prepare granular m dlings with a minimum of flour production.

Semolina Storage

Unlike bread wheat flour which improves in quality with age, storage of dur milled products is detrimental to quality. The natural pigments of durum whe responsible for the characteristic yellow color of macaroni products, are destro by oxidation during the storage. Consequently, durum semolina or flour should shipped to the macaroni manufacturers as soon as possible after milling. To mi mize loss of color, even brief storage is best done under cool, dry conditions.

Insects are another problem associated with storing semolina. Since semolina granular, it cannot be passed through an entoleter to destroy insect eggs. As a sult, if semolina is held for long periods at temperatures above 10°C, there is a p sibility of infestation due to hatching of insect eggs during storage.

Standards of Identity of Milled Products

Durum semolina, durum granular, and durum flour are the three general class of durum wheat products used for making macaroni and other pasta products. S molina is defined as the purified middlings of durum wheat which has been groun so that all of the product shall pass through a No. 20 U.S. sieve and not more tha 3% shall pass through a No. 100 U.S. sieve. Durum granular is defined as the pur fied middlings of durum wheat which shall pass through a No. 20 U.S. sieve an not more than 20% shall pass through a No. 100 U.S. sieve. Durum flour is the pur fied endosperm of durum which is ground fine enough to pass through a No. 1C U.S. sieve. Thus, it is possible to mill durum patent flour, semolina, or granular and have a wide range of possible combinations of milled products which can b used to make macaroni products.

MACARONI PRODUCTION

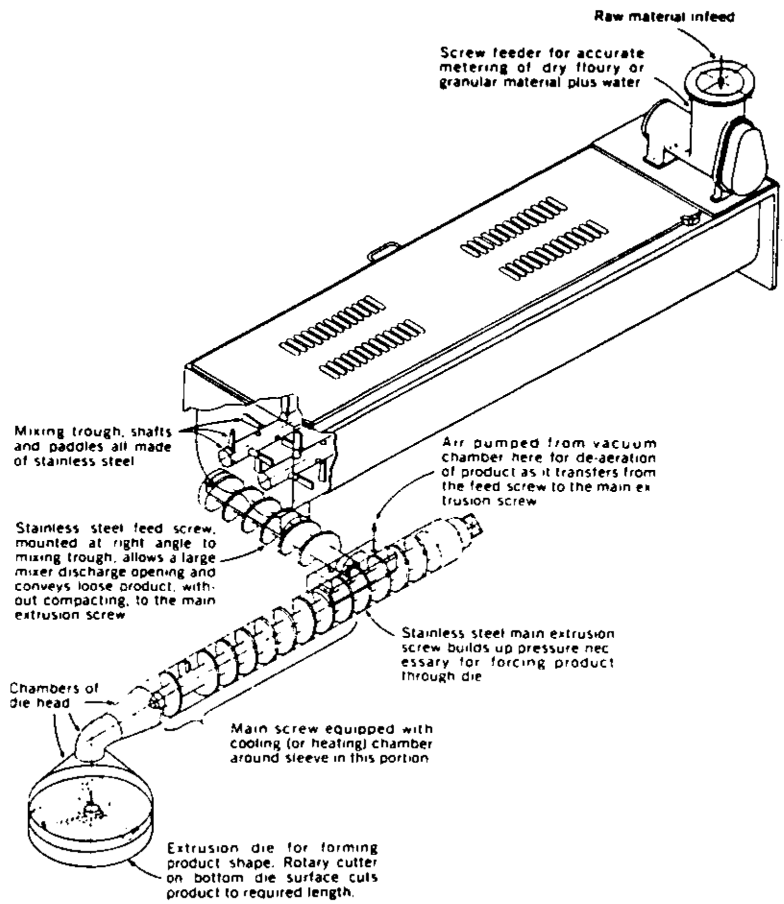
In commercial practice, macaroni products are formed by extrusion on large, au tomatic machines which perform several processing operations.

Mixing

In the mixing operation, water is added to the semolina or flour so that the mois ture content of the dough (pasta) is approximately 31%. To obtain a uniform mix ture, water and semolina are usually mixed in a special twin shaft mixing chamber.

The shafts of the mixer turn in opposition so that the pasta is simultaneousl pulled in two different directions to limit the amount of balling that can occur.

Modern presses are equipped with a vacuum chamber to remove air bubbles fron the pasta prior to extruding. A vacuum is applied to the pasta either by enclosin the entire mixer in the vacuum chamber or by drawing a vacuum on the pasta just prior to extrusion. An example of the latter design is shown in Fig. 15.3. With this



Courtesy of Buhler Corp., Minneapolis, Minn.

FIG. 15.3. DIAGRAM SHOWING THE PROCESSING ELEMENTS OF SINGLE-AUGER EXTRUDER

type of press, air is removed as the pasta is transferred to the final extrusion auger. If air is not removed, small bubbles will form and give the finished product a white, chalky appearance. Furthermore, air bubbles can diminish the mechanical strength of the dried product.

Extruding

The extrusion auger is the heart of the macaroni press. The auger not only forces the dough through the die, but it also kneads the dough into a homogeneous mass, controls the rate of production and influences the quality of the product. Recent research shows that the auger speed as well as the dough temperature affect the color and the cooking quality of the finished macaroni product.

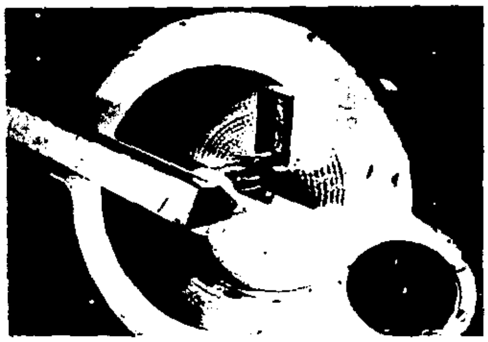
Construction and dimension of the extrusion augers vary among equipment manufacturers. However, most modern presses are equipped with sharp edged augers which have a uniform pitch over their entire length rather than an increasi. pitch. The auger fits into an extrusion barrel which is grooved. The grooves he the dough move forward and reduce friction between the auger and the inside the barrel. Actually, when the press is in operation, there is little wear on the ba rel and the auger because the auger floats inside the barrel on a cushion of doug. The auger is in contact with the barrel only when the cylinder is empty; therefor equipment manufacturers caution that excessive wear will take place on the cyli. der walls and auger if the press is run empty.

During the extrusion process, a considerable amount of heat is generated. Extr· der barrels should be equipped with a water cooling jacket to dissipate heat ar hold a constant extrusion temperature. For best results, the pasta temperatu: should be held near 51°C during the extrusion process. If the dough becomes too h (above 74°C), the cooking quality of the finished product will be damaged.

Figure 15.4 shows a short goods macaroni die with a rotating knife which sweer the surface of the die to cut the product. Because variations in the flow rate acros the die will cause variation in the lenths of the product, the flow rate of the doug through the die is quite important. In spaghetti making, if dough does not flow un. formly through the die, there will be a variation in length of the spaghetti. Whe. cut to lengths, some spaghetti may be too short to package and must be either dis carded or reprocessed. Since waste and reprocessing of material add to the uni production cost of the product, an even flow rate of pasta through the die is ver· important. To control the extrusion pattern, rotation rate of the auger and the tem perature and physical condition of the dough are quite important. Usually these ar· adjusted by trial and error—to get an even flow rate across the die is considere part of the art of macaroni making.

The inside surface of the die influences the product appearance and the extru sion rate. Until recently, most macaroni dies were made of bronze. A good bronze die which had uniform extrusion characteristics resulted in a fairly good produc with acceptable color. However, bronze dies were relatively soft and tended to wear on the die increased, the size and shape of the macaroni products changed accord- ingly. In order to maintain the proper dimensions, it was necessary periodically tc repair or replace dies. Recently, dies have been introduced where the extruding surface of the die is fitted with Teflon inserts to extend the life of the dies and im- prove the quality of the product.

Macaroni products extruded through Teflon are very smooth and tend to have a much better appearance than similar products extruded through a bronze die. This



Courtesy of Buhler Corp., Minneapolis, Minn.

FIG. 15.4. SHORT GOODS MACARONI DIE EQUIPPED WITH ROTATING KNIFE

improved appearance is due to the waxy smooth surface imparted by low friction Teflon dies.

Drying

Drying is without doubt the most difficult and critical step to control in the processing of macaroni products. The objective of the drying is to lower the moisture content of the product from 31 to 12-13% so that the macaroni will be hard, retain its shape, and will store without spoiling. To accomplish this, any number of dryer designs are used. However, the problems in selecting a dryer and setting the proper temperatures and relative humidity increments are similar regardless of the design of the dryer. If dried too slowly, macaroni products will tend to spoil or become moldy during the drying. On the other hand, if they are dried too rapidly, moisture gradients will occur which cause the products to crack or check. Checking can occur either during the drying period or as long as several weeks after the product has left the dryer. In the latter case, the product may check even after the product has been packaged and sold.

Space in this chapter does not allow for a complete description of drying theory. However, some of the factors which influence drying and an example of a drying cycle are presented. Drying of macaroni depends on the hygroscopic equilibrium moisture content (M_1), the free moisture (M_2) and the shape and size of the product to be dried. M_1 is the moisture content of the product at equilibrium with the atmosphere at a specified relative humidity. M_2 is the difference between equilibrium moisture and the actual moisture content (M_3) of the product ($M_2 = M_3 - M_1$). Charts and formulas are available to compute drying rates for macaroni products.

Most macaroni drying operations use a preliminary dryer to quickly dry the product surface immediately after extruding. Predrying case-hardens the surface so that the pieces of macaroni will not stick together. The interior of the product remains soft and plastic during this operation. The final dryer is used to remove the bulk of the moisture from the interior of the product. Since the surface of macaroni products dries more rapidly than the inside, a moisture gradient develops across the surface to the interior of the product. As the product dries, the interior shrinks more rapidly than the outer crust. Shrinkage sets up strains inside the product. If the strain becomes greater than the mechanical strength of the macaroni, cracks and checks will develop below the surface of the macaroni product. Cracks give the product a poor appearance and a very low mechanical strength. Cracked products are usually so fragile that they will crumble during the packaging and shipment.

It is essential that products be dried with a drying cycle which is tailored to meet the requirements of each product. The following is an example of the drying cycle which has been successfully used for long spaghetti. The predryer exposes the product to air at 65°C for 1 hr at 65% relative humidity and lowers the product moisture content from 31 to 25%. At this point, the macaroni is still quite pliable so that rapid predrying does not set up stresses which would result in cracking. The product then enters the final dryer, which is usually a continuous dryer having several zones or chambers in which the relative humidity can be varied, with the temperature held constant at 54°C. The first stage of the final dryer holds the product for 1½ hr at 95% RH. This is called the "sweating" or rest period where the product is equilibrated with high humidity air. In the second zone of the dryer, the product is exposed to a relative humidity of 83% for 4 hr after which the moisture content of the product is about 18%. Additional moisture is removed in the third zone of the dryer, where the product is held for 6 hr at a relative humidity of 70%. Finally, the product is removed from the dryer and cooled to room temperature and cut to the proper length for packaging. If the drying cycle is successful, the product will be quite hard and flexible so that it can bend to a considerable degree before breaking. If the product has not been dried properly, it will be rather soft and tend to crumble quite easily. The true test of drying is to find the product free of checks a week after the product has left the dryer.

For best results, automatic controllers are used to hold the relative humidity of the dryer at precise settings. Relative humidity under processing conditions is often difficult to control and at times even the best controllers give erroneous readings. It is often necessary to return to the wet bulb depression method to determine the actual relative humidity in the dryer. The cost, in any case, of measuring the relative humidity at regular intervals and installing reliable automatic controllers can be recovered if uniform drying conditions are achieved and product losses due to improper drying are minimized.

Packaging

There are literally thousands of different sizes, shapes, and types of packages in which macaroni products may be sold. However, they all perform a similar function, that is, to keep the product free from contamination, to protect the product from damage during shipment and storage, and to display the product favorably.

The principal packaging material for noodles is the cellophane bag. The cellophane bag provides moisture-proof protection for the product and is used easily on automatic machines. Macaroni products are packed often in low density polyethylene bags, which have the disadvantage of being difficult to stack on grocery shelves.

Many macaroni manufacturers prefer packaging their products in boxes, although bags are considerably less expensive. Boxes are easy to stack and provide good protection for the fragile macaroni products. There is also an opportunity to print more readable advertising on boxes than on bags.

Whether bags or boxes are used, selecting, ordering, and specifications for packaging materials is one aspect of the macaroni manufacturing business which bears considerable thought. In all cases, it is necessary for the macaroni manufacturer to specify the type of material used in his packaging, the specific information, size, and construction of the packaging material. Every operation, from the design to the delivery of packaging material, must be tailored to fit the product as well as the available packaging equipment.

Consequently, packaging must be ordered far in advance of when it is needed.

STANDARDS OF IDENTITY

The following are excerpts for definitions and standards under the Federal Food, Drug and Cosmetic Act, Part 16.1, Macaroni and Noodle Products:

(a) Macaroni products are the class of food each of which is prepared by drying formed units of dough made from semolina, durum flour, farina, flour, or any combinations of two or more of these with water and with or without one or more of the optional ingredients specified in subparagraphs (1) to (6) inclusive, of this paragraph.

(1) Egg white, frozen egg white, dried egg white, or any two or all of these in such quantity that the solids thereof is not less than 0.5 percent and not more than 2.0 percent of the weight of the finished food.

(2) Disodium phosphate, in a quantity not less than 0.5 percent and not more than 1.0 percent of the weight of the finished food.

(3) Onions, celery, garlic, bay leaf, or any two or more of these in a quantity which seasons food.

(4) Salt, in a quantity which seasons the food.

(5) Gum gluten in such quantity that the protein content of the finished food is not more than 13 percent by weight. The finished macaroni product contains not less than 87 percent of total solids as determined by the method prescribed in "Official and Tentative Methods of Analysis of the Association of Official Agricultural Chemists," Fifth Edition, 1940, page 235, (Ed. note, 9th Edition, 1960, p. 175, sec. 13:112) Under "Vacuum Oven Method—Official."

(6) Concentrated glyceryl monostearate (containing not less than 90 percent monoester) in a quantity not exceeding 2 percent by weight of the finished food.

(b) Macaroni is the macaroni product the units of which are tube shaped and more than 0.11 inches but not more than 0.27 inches in diameter.

(c) Spaghetti is the macaroni product the units of which are tube shaped or cord shaped (not tubular) and more than 0.06 but not more than 0.11 inch in diameter.

(d) Vermicelli is the macaroni product the units of which are cord shaped (not tubular) and not more than 0.06 inches in diameter.

(e) The name of each food for which a definition and standard of identity is prescribed by this section is "macaroni product" or alternately, the name is "Macaroni," "spaghetti," or "Vermicelli" as the case may be when the units of the food are the shapes and sizes specified in paragraph (b) (c) or (d), respectively, of this section.

(f) (1) When disodium phosphate is used, the label shall bear the statement "Disodium phosphate added for quick cooking."

(2) When any ingredients specified in paragraph (a) (3) of this section is used, the label shall bear the statement "Seasoned with __________." The blank being filled in with the common name of the ingredient; or in the case of bay leaves, the statements "spiced" or "spice added" or "spiced with bay leaves."

(3) When the ingredient specified in paragraph (a) (6) of this section is used, the label shall bear the statement "glyceryl monostearate added" or the statement "with added glyceryl monostearate."

(4) Wherever the name of the food appears on the label so conspicuously as

to be easily seen under customary conditions of purchase, the words · statements prescribed in this section, showing the optional ingredien· used, shall immediately and conspicuously precede or follow, or in pa; precede and in part follow, such name, without intervening writte; printed or graphic matter.

Enrichment

Macaroni products may be enriched by adding vitamins and minerals according : the levels specified in paragraph 16.9 of the FDA Definitions and Standards f(Macaroni Products. To be labeled as "Enriched Macaroni" each pound of produc must contain not less than 4 mg and not more than 5 mg of thiamin, not less tha. 1.7 mg and not more than 2.2 mg riboflavin, not less than 27 mg and not more tha. 34 mg niacin or niacinamide, and not less than 13 mg and not more than 16.5 mg c iron (Fe). As optional enrichment, Vitamin D may be added at levels of not less tha. 250 USP units and not more than 1000 USP units per pound. Calcium also may b· added as an optional ingredient so that a pound of product contains not less tha: 500 mg and not more than 625 mg of calcium.

Composition

Table 15.2 shows the composition of macaroni and noodle products with value: given for the cooked as well as dry products. Information in the table was adopte(from USDA Handbook No. 8. The data are expressed for 100 gm of macaroni prod ucts which are prepared according to the definition of standards for macaroni an(noodle products without optional ingredients. In the case of cooked macaroni o: noodles, a considerable variation from the data is possible, since the degree of swell· ing influences the analysis.

QUALITY

Since a detailed description of tests for quality of macaroni ingredients and products is beyond the scope of this chapter, only the more common tests are presented. A more complete description of quality tests is described in AACC Approved Methods, American Association of Cereal Chemists.

Wheat Products

Physical Properties.—*Granulation Test.*—Granulation of semolina can be measured with a series of stacked sieves on a rotary shaker (Rotap). The following example shows granulation data for a typical U.S. commercial semolina.

U.S. Sieve No.	Sieve Opening (Mm)	Total Semolina (%)
On 20	0.86	0.0
On 40	0.38	28.8
On 60	0.23	51.6
On 80	0.18	14.6
On 100	0.14	3.3
Through 100		1.7

TABLE 15 2

COMPOSITION OF MACARONI AND NOODLES

Food[1]	Energy, Cal/100 Gm	Major Constituents[2]					Minerals, Mg/100 Gm						Vitamins/100 Gm			
		Proteins (%)	Carbo-hydrates (%)	Crude Fiber (%)	Fat (%)	Mois-ture (%)	Na	K	Ca	Mg	P	Fe	Thiamin (Mg)	Ribo-flavin (Mg)	Niacin (Mg)	A (IU)
Macaroni, enriched dry	368	12.5	74.0	0.3	1.2	12.0	2.0	197	27	48	161	2.9	0.88	0.37	6.0	0
Macaroni, enriched cooked	107	3.4	23.0	0.1	0.4	73.1	0.7	60	8	18	50	0.9	0.14	0.08	1.1	0
Macaroni, not enriched dry	386	12.5	74.0	0.3	1.2	12.0	2.0	197	27	48	161	1.3	0.09	0.06	1.7	0
Macaroni, not enriched cooked	107	3.4	23.0	0.1	0.4	73.1	0.7	60	8	18	50	0.4	0.01	0.01	0.3	0
Egg noodles, enriched dry	388	15.5	67.8	0.3	4.4	12.0	6.0	133	33	48	183	2.8	0.89	0.39	6.1	220
Egg noodles, enriched cooked	125	4.1	23.3	0.1	1.5	71.0	2.0	44	10	14	59	0.9	0.14	0.08	1.2	70

[1] All products as defined by FDA Definitions and Standards, no optional ingredients included.
[2] All data reported on an "as is" basis.

Semolina Speck Test.—Since black specks and bran particles can detract from th appearance of macaroni products, the speck test is a simple but valuable test o semolina quality. To test, a well-blended sample of semolina is poured on a flat sur face. A 4 × 5 in. glass plate with a 1-in.-sq window is placed at random on the semolina surface and the visible specks (bran or black particles) within the window ar counted. The determination is replicated 3 times, and the average is expressed a specks per 10 sq in. Values of 10-20 specks per 10 sq in. are considered normal fo good quality semolina.

Moisture Test.—The moisture test is used to determine the performance of mac aroni drying operations as well as to check incoming ingredients. The test is per formed by drying 10 gm of ground macaroni, semolina, or flour for 1 hr in an ai oven at 130°C. The weight loss by drying is expressed as moisture on a percentag basis. To store macaroni, semolina, or flour, the moisture content of the materia should be less than 13.5%.

Chemical Tests.—*Sprout Damage.*—Sprout-damaged wheat, semolina, or flou can be detected with a simple test called the Falling Number test. Flour may b tested directly. However, semolina must be ground to flour and sifted through No. 70 U.S. sieve for the test. In the method, 7.0 gm of flour (15% moisture basis are mixed and gelatinized in a test tube which is fitted with a special metal plunger The time in seconds required for the plunger to fall through the gelatinized flou is the "falling number." Falling numbers below 300 are an indication that the semo lina or flour has been milled from sprouted wheat.

Macaroni Products

Appearance.—Color and appearance of macaroni products are usually judge visually. However, since this depends on personal bias, the visual test is subject t human error, and color values are difficult to compare among different laboratories

Recently, a method was developed for accurate measurement of spaghetti colo with a reflectance colorimeter. In the method, the color of spaghetti is expressed i terms of lightness, L%, and yellowness, b% values—high values indicate good co or. Good agreement between photoelectric readings and visual judgement of th color was reported.

Composition Quality.—The quality of macaroni products is related to the qualit of the wheat used in the milling process. Generally, products milled from durur are preferred for pasta. Substitution of lower cost common wheat for durum ma occur, particularly when the price differential between these wheat classes b comes excessive. The detection of admixtures of common and durum wheats, whi easily accomplished by visual observation of wheat kernels, is relatively difficu after milling.

The chemical composition of the major components, starch and protein, is sim lar. However, significant differences are able to be detected in the lipids. Fractior ation of the lipids extracted from semolina, granular or flour, by means of thi layer chromatography (TLC) shows that sitosterol palmitate is present in comm wheat but absent in durum wheat. This TLC technique is useful for quality contr purposes as it is more rapid than either the crystallization technique or the infr red procedure.

Cooking Quality.—The quality of cooked macaroni products depends upon several factors: how the product holds up to cooking, how much water is absorbed, the loss of solids to the cooking water, and especially the final firmness. Water absorbed during cooking can be measured easily by weighing the product before and after cooking. The weight increase is due to water absorption. Cooking loss is usually measured by evaporating the cooking water to dryness. The residue after drying is weighed and reported as a percentage based on the weight of the uncooked product.

Firmness of cooked macaroni products is usually measured with the "bite test" where a judge or panel of judges tastes and scores the product for firmness. However, the "bite test" depends on human judgement and personal preference of the judges who perform the test. Consequently, errors are inherent in the "bite test."

Recently, an instrument method was developed to objectively measure the firmness of cooked spaghetti. In the method, an Instron Universal Test Instrument was fitted with a blunt plexiglass tooth, so that a single strand of cooked spaghetti could be sheared. The overall work required to shear the spaghetti is used as a measure of cooked spaghetti firmness. The test data showed a high positive correlation with the taste panel results ($r = 0.812$). In addition, the instrumental method appeared more convenient and reproducible than the "bite test."

Nutritional Quality

Macaroni products are a good source of many essential nutrients (Table 15.2). However, like any single food source, macaroni does not supply all of the nutrients for a complete human diet.

The proteins of macaroni contain all 8 essential amino acids; thus, 1½ lb of macaroni of 12% protein content *could* supply the required daily amounts of protein for a normal man. However, the protein of macaroni lacks the proper balance of amino acids and is particularly low in lysine. To improve the amino acid balance, optional ingredients like egg solids, milk, dry yeast, and soy proteins which are rich in lysine may be added to macaroni products. Since there are strict rules regulating labeling and enrichment of foods, the FDA must be consulted before any new protein-enriched product is marketed.

When assessing nutritional quality, the combined value of other foods which are consumed with macaroni products should be considered. Most often, when macaroni products are eaten, a cheese or meat sauce is added. The protein in the sauce usually balances the macaroni protein so that the combined nutritional quality of the food is very high.

SUMMARY

Macaroni products have survived the test of time and remain one of the popular foods of modern day society. Macaroni technology presently is applied to a wide variety of deep-fat fried snacks.

In the next chapter, we will study fat and oil technology itself.