MACARONI PRODUCTS. See PASTA SCIENCE AND TECHNOLOGY.
MACHINE VISION. See QUALITY CONTROL: MACHINE VISION SYSTEM.
MALNUTRITION. See CULTURAL NUTRITION; FOOD UTILIZATION; HISTORY OF FOODS; NUTRITION.

MALTED MILK

HISTORY

The technology for manufacturing malted milk is generally attributed to William Horlick (1). In 1870, following discussions with Chicago doctors, he became concerned about the high incidence of mortality from infantile diarrhea. Having been made aware of the need for a highly digestible weaning food, Horlick's interest was stimulated by a formulation for an infant food published by Justus von Liebig. This product, referred to as Liebig's Malt Soup, was prepared by mixing a malt–flour infusion with fluid milk. However, the product was perishable, which limited its use. A patent was issued in 1875 to James and William Horlick for a dry maltose–dextrin milk additive that became known as Horlick's Food (2).

Because milk pasteurization was virtually unknown, the Horlick brothers found that the beneficial results obtained by use of their dry additive were often destroyed because the fluid milk used was unsafe. After further experimentation with ways to combine milk with a mash made from barley malt–wheat flour, a patent was issued in 1883 to William Horlick (3). However, the selection and assembly of manufacturing equipment for preparation of the new product needed several additional years of experimentation. It was not until 1887 that malted milk was formally introduced to the medical profession with a registered trademark (4).

MANUFACTURE

Malted milk is significantly different from other forms of dried milk products because it contains large amounts of nondairy solids derived from barley and wheat flour. It is defined as the product resulting from combining fresh whole milk with the liquid separated from a mash of ground barley malt and wheat flour, with or without adding sodium chloride, sodium and potassium bicarbonate, so as to ensure complete enzymatic action of the malt extract, followed by drying. In the United States, a very few companies are responsible for the bulk of the malted milk powder manufactured and their methods are closely guarded.

A detailed description of the manufacturing procedure has been published, which considers the barley malt as the foundation of the process (5). It provides the amylases necessary to convert starch into sugars and it also provides proteolytic enzymes to break down proteins into peptides and amino acids. The malt is prepared from coarsely crushed barley, wetted with water at a ratio of 1 : 6 (w/w, barley to water) and steeped at 32.2°C (90°F) to solubilize the enzymes, a process taking about 30 min. Wheat flour is prepared in a separate kettle. It is generally mixed with about 1.3 times its weight of water and cooked for about 2 h at 95°C (200°F) to gelatinize the wheat starch. A mash is prepared by blending the malt and the gelatinized flour. Mashing refers to inversion and solubilization of all the starch by enzymatic action and partial proteolysis of the cereal proteins, greatly enhancing the digestibility of the products. The ratio of malt to flour is variable; the Horlick patent called for equal parts of ground barley malt and wheat flour, but general manufacturing practice is to use about 100–250 lb of barley malt with 100 lb of wheat flour.

Mash conversion is done by holding the mixture at 45°C (113°F) for 30 min to break down the cereal proteins; about 40% of the protein is solubilized during this stage. The temperature is gradually increased to 77°C (158°F) over a 30-min period and held for 2 h to convert the starch to maltose and dextrin. The liquid extract or wort is then separated from the barley husks and other insoluble materials by settlement, screening, centrifuging, filter pressing, or any combination thereof.

The wort contains about 11% cereal solids and has a pH of about 5.7. Bicarbonate is used to neutralize the acidity and sodium chloride (about 0.75 lb per 100 lb dry barley malt and wheat flour) is also added for flavor. Milk is blended with the wort in sufficient quantity to provide a minimum of 7.5% milk fat (6) in the finished product and to make the milk equivalent not less than 2.2 lb of fluid whole milk to 1 lb of dry malted milk. The typical malted milk flavor is produced by the interaction of the milk components with the soluble proteins, peptides, amino acids, sugars, and tannins in the wort.

Following blending, the mixture is forewarmed to 65.6°C (150°F) in a hot well and condensed under vacuum to 68–70% total solids. The concentrate may be spray or drum dried but these operations are difficult because of the high sugar content. However, much malted milk drying is done under vacuum on steam heated drums (7). Classically, drying is more readily accomplished in specially designed vacuum pans at temperatures below a maximum of 60°C (140°F). These pans are equipped with agitators and large doors to permit easy removal of the dried product. To obtain the desirable porous structure, at a certain stage in the drying process, air is mechanically worked into the semisolid mass, vacuum is suddenly increased, causing expansion of the entrained air bubbles and temperature drop, resulting in solidification of the material into a porous mass with a honeycomblike structure. The dried product is removed and ground to a granular powder. The moisture content should be less than 3.5% (6). Foam-spray drying, a one-step method of instantizing, has successfully been used to dry malted milk concentrates into free-flowing powders (8). As far as is known, this process has not been adopted commercially for malted milk powder manufacture.

Freshly dried malted milk is highly hygroscopic because of the sugars it contains. Therefore, it must be ground and packaged in low humidity chambers and the packaging must be impervious to moisture. Properly stored malted milk has very good keeping quality compared to other dry dairy products containing milk fat. This may be due to a film of gluten, sugars, and salts that protects the fat globules from contact with air (5). Flours from other cereals are not as effective in maintaining freshness. Oxidized and stale flavors are the common flavor defects that develop on prolonged storage.

COMPOSITION

A typical composition of malted milk powder may be as follows:

Ingredient	Percent
Dextrins	45–49
Lactose	20–23
Protein	13–15
Milk fat	7.5–8.5
Ash	3–4
Maltose	1–2
Moisture	2–3.5

Additives may include sugar, lecithin, cocoa, salt, or vanilla (8). Chocolate-flavored malted milk is made by processing cocoa, sucrose, and chocolate liquor with the other ingredients. Lecithin may be added to increase reconstitutability. A typical composition of the chocolate-flavored powder is (9) as follows:

Ingredient	Percent
Moisture	2.00
Protein	6.48
Total lipid	4.48
Total carbohydrate (includes added sugar)	84.89
Fiber	0.4
Ash	2.15

For use as a beverage, about 0.75 oz is blended into 1 c of milk. If whole milk is used, 1 c of the chocolate-flavored drink provides more than 300 mg of calcium (about one-third of the minimum daily requirement), 233 kcal, and 168 mg of sodium (9).

Although annual production is no longer tabulated by the U.S. Department of Agriculture, 23 million lb of malted milk were produced in 1966, the last year for which production figures are available (10,11). The product is sold primarily for use in flavoring dairy products and in confections.

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MALTS AND MALTING

The three most important ingredients used in the production of beer are malt, hops, and yeast (1–11). Malting involves controlled wetting (by steeping) and germination of seeds under conditions conducive to production of desirable physical and chemical changes associated with the germinative process while holding weight losses due to germination and respiration to a minimum. Malting develops the amylolytic enzymes that modify starch to fermentable carbohydrates, the source of alcohol in beer. Malt also contains a series of proteases and cytolytic enzymes. The products of proteolytic degradation (along with other components) act as flavor precursors and as nutrients for the yeast during fermentation. The malted grain is dried to halt growth and stop enzymatic activity and to develop a storable product of desired color and flavor. Drying is followed by removal of malt sprouts. The malting process is given in the form of a flow sheet in Figure 1 (12).

In the old system of malting, steeped barley was germinated on concrete floors in cool, moist rooms and turned by hand. Floor malting (20–60 ton capacity systems) was replaced by pneumatic-type malting (60–200 ton capacity) in which conditioned air was forced through the grain. Malting is performed in drums or compartments. In drum germination, the process is carried out in a rotating cylindrical drum of about 700 bushels capacity. The excellent control makes it possible to produce a fine malt at a rather prohibitive cost. Newer construction involves mainly compartments and greater mechanization to reduce labor and space costs and to obtain a more uniform product. It also