



Butter: Chemical and Physical Properties and Health Effects

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Although there are plant-based butters on the market, i.e., almond butter, peanut butter etc., this article is about butter exclusively produced from animal milk, generally cow's milk. Butter is one of the oldest milk products dating back to the prehistoric times of animal husbandry. The records about making and consuming butter go back to 2,000 BC. Today, butter is a popular product enjoyed in many countries around the globe. About one-third of the world's milk production is utilized in butter production. Butter is a water-in-oil (W/O) emulsion, generally containing a minimum of 80 g milk fat/100 g and a maximum of 16 g moisture/100 g.

Standard of Identity

National legislations in many countries, including U.S., China and Japan, have similar specifications for labeling milkfat products. Butter was the only food defined by an Act of the U.S. Congress prior to the enactment of the Food, Drug and Cosmetic Act of 1938. The U.S. Department of Agriculture defines food butter as "the product made exclusively from pasteurized milk or cream, or both, with or without common salt, and with or without additional coloring matter, and containing not less than 80% by weight of milkfat." Codex Alimentarius has a similar standard for butter. According to the Codex Alimentarius 2018, butter is a fatty product made only from milk and/or products obtained from milk, containing a minimum of 80% milkfat, a maximum of 16% water and a maximum of 2% non-fat solids. Besides traditional butter (minimum 80% milk fat), other butter products such as reduced-fat or low-fat butter are available in stores. The Codex Alimentarius regulates those products as products exclusively obtained from milk with a milk fat content between 10% and 80%.

The USDA offers grading services for a wide range of styles of butter. Butter is evaluated by trained and licensed USDA graders following the U.S. Standards for the Grades of Butter. There are three grades of butter allowed for marketing. The details of the definitions, evaluation and grade rejection criteria can be found in the following document (https://www.ams.usda.gov/sites/default/files/media/Butter_Standard%5B1%5D.pdf).

- 1) U.S. Grade AA: The products, which are made from naturally low acid sweet cream, must have a fine and highly pleasing butter flavor. A slight feed and cooked flavor are allowed.
- 2) U.S. Grade A: The products in this grade possess a pleasing and desirable butter flavor. They may also have any of the following flavors to a slight degree: Acid, aged, bitter, coarse, flat, smothered, storage and feed flavor to a definite degree.

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- 3) U.S. Grade B: The products must have a fairly pleasing butter flavor. They may also possess any of the following flavors to a slight degree: Malty, musty, neutralizer, scorched, utensil, weed and whey. The following flavors are allowed to a definite degree: Acid, aged, bitter, smothered, storage, old cream and feed flavor to a pronounced degree. The USDA also requires that all U.S. grade butter shall be free of foreign materials and visible mold.

Whipped butter is the product made by uniformly incorporating air or inert gas into butter. There are two grades of whipped butter.

- 1) U.S. Grade AA: The product shall possess a fine and highly pleasing butter flavor. Whipped butter may also have a lactic culture flavor and may possess a slight feed or a definite cooked flavor.
- 2) U.S. Grade A: The product shall possess a pleasing and desirable butter flavor, may also have a lactic culture flavor, and possess to a slight degree the following flavors: acid, aged, bitter, coarse, flat, smothered and storage. A definite feed flavor is also allowed in the products graded as A.

Production

Butter is produced generally from cow's milk and/or cream by churning it until fat is separated from liquid (buttermilk) and it is in a semi-solid state. Then, the product is transferred to a storage container for pumping over to packaging machines. Butter was sold in 1-pound blocks until in 1906 when a restaurant requested that dairies divide butter into four 1/4-pound (110 g) sticks rather than one big chunk. At the time, Elgin Butter Company in Elgin, Illinois, was producing most of the butter in the Midwest and East coast. The Elgin Butter Cutter which was developed by the Elgin Butter Co. and was used to produce the standard shape for East Coast butter known as the Elgin sticks. In the 1960s, farms and dairies in California began producing short and stout butter sticks that are known as West Coast butter, or "stubbies." Today, in the U.S., butter is mostly sold in 1/2-or-1-pound packages. The product in the packages is split into quarter pound sticks. The wrapping on each stick has marks showing tablespoon measurements. There are 8 tablespoons in a stick. Butter is also packaged as continental chips (wrapped for individual consumption), in Hassia-style butter cups (individual butter portions), 25 kg packages and a variety of other styles.

Physical and Chemical Characteristics and Utilization

Butter is a high calorie product, about 102 kcal per tablespoon (1.2–2.5 g), because of its high fat content. The calorie content of whipped butter is lower than regular butter, 68 kcal per tablespoon, because of the incorporated gas (Table 1). The percent Daily Value (% DV) shows how much a nutrient in a serving of food contribute to a total daily diet. It can help to determine if a serving of food is high or low in a nutrient. As a general guide 5%DV or less of a nutrient per serving is considered low and 20%DV or more of a nutrient per serving is considered high. Regular and whipped butter have total fat %DV of 15 and 9, respectively. Saturated fatty acid %DV values for regular and whipped butter are 36 and 21, respectively.

The lipid fraction of butter mainly consists of triacylglycerols (98%) and small quantities of monoacylglycerols and diacylglycerols, glycolipids, ether lipids and free fatty acids. Phospholipids and sterols (see Fact sheet FAPC-196 Lipid Glossary) may also be present. Over 66% of the fatty acids in butter are saturated (Table 2). One tablespoon of regular and whipped butter have about 0.4 grams and 0.3 grams of polyunsaturated fatty acids, respectively. The %DV of cholesterol in regular and whipped butters is 10% and 7%, respectively. Butter does not contain significant amount of trans fat, less than 0.50 grams in 1 tablespoon (see fact sheet FAPC 133), but it contains substantial amounts of fat-soluble vitamins A and E and small amounts of calcium, phosphorus, vitamin K and D. Presence of carotene, vitamin A, and other fat-soluble pigments contribute to the color of butter.

Butter is mostly used as a spread and in pastry, cake, biscuit and confectionary, specifically chocolate, formulations. Consumer demand for any food product is determined by its price, perception, and presentation. Lipids (fats and oils) have a positive effect on sensory properties of many foods by enhancing their mouthfeel, color, texture and rheological properties (consistency, plasticity, texture, etc.). Butter has a unique texture and flavor among the other types of fats and oils commonly used in food formulations. Although the flavor and mouthfeel of butter are more favorable than any other edible fat, its physical and rheological properties, particularly its poor spreadability at refrigerated temperature, make it less attractive to some consumers. Yet, there are several mechanical and thermal techniques that are used to improve spreadability of butter. The most common method is the incorporation of air or nitrogen (the products sold as whipped butter). Butter is more expensive than similar fat products.

Health Effects

Although the 2015 Dietary Guidelines Advisory Committee recommended replacing animal fats, including butter, with non-hydrogenated vegetable oils with high unsaturated fatty acid and relatively low saturated fatty acid contents, the committee also determined that more research was needed to determine the effects of saturated fat from different food sources on cardiovascular risk, because fatty acid profiles

of fats in different foods vary significantly. Also, other food components may cause distinct lipid and metabolic effects. Scientists agree that the health effects of any food are influenced by a person's diet, genetics or risk factor profile. The Dietary Guidelines for Americans recommend that dietary cholesterol be consumed in as low amount as possible without compromising the nutritional quality of the diet.

Reference

Weber, Harnack, Johnson, Jasthi, Pettit, and Stevenson. Nutrient comparisons of margarine/margarine-like products, butter blend products and butter in the US marketplace in 2020 post-FDA ban on partially hydrogenated oils. *Public Health Nutrition*: 25(5), 1123–1130.

Table 1: Properties of butter

Property	Butter Salted	Butter Unsalted	Whipped Butter Salted	Whipped Butter Unsalted
Energy (kcal)	102	102	68	68
Total fat (g)	11.5	11.5	7.4	7.4
Total fat (%DV)	15	15	9	9
Saturated Fatty Acids (g)	7.3	7.2	4.3	4.3
Saturated Fatty Acid (%DV)	36	36	21	21
Monounsaturated Fatty Acid (g)	3.0	3.3	1.9	1.9
Polyunsaturated Fatty Acids (g)	0.4	0.4	0.3	0.3
Sodium (%DV)	4	0	2	0
Vitamin A (REA)(%DV)	11	11	7	7
Vitamin E (total a-tocopherol)(%DV)	2	2	1	1

Table 2: Fatty acid profile of butter

Fatty acid type	Name	Abbreviation	Amount (%)	Total (%)
Short and middle-chain saturated	Butyric	C4:0	3.4	14.2
	Caproic	C6:0	2.2	
	Caprylic	C8:0	1.1	
	Capric	C10:0	2.3	
	Lauric	C12:0	3.4	
	Behenic	C20:0	1.8	
	Long-chain saturated	Myristic	C14:0	
Palmitic		C16:0	33.0	
Stearic		C18:0	9.0	
Monosaturated	Myristoleic	C14:1	1.1	31.1
	Palmitoleic	C16:1	4.0	
	Oleic	C18:1	26.0	
Polysaturated	Linoleic	C18:2	2.3	2.3

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