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The evolution, processing, varieties and health benefits of yogurt

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Abstract- Yogurt or yoghurt is one of the most popular fermented dairy products worldwide which has great consumer acceptability due to its health benefits other than its basic nutrition. In general, yogurt is considered as a nutrition-dense food due to its nutrient profile and is a rich source of calcium that provides significant amounts of calcium in bio-available form. In addition, it provides milk proteins with a higher biological value and provides almost all the essential amino acids necessary to maintain good health.Yogurt is considered as a probiotic carrier food that can deliver significant amounts of probiotic bacteria into the body which can claim specific health benefits once ingested. These are usually marketed as bio-yogurts. Moreover, yogurt is reported to claim improved lactose tolerance, immune enhancement and prevention of gastrointestinal disorders. Because of these known health benefits of yogurt,consumer demand for yogurt and yogurt related products has been increased and became the fastest growing dairy category in the global market. Yogurts are now being manufactured in a numerous styles and varieties with different fat contents, flavors and textures suitable for different meal occasions and plates as a snack, dessert, sweet or savory food.

Index Terms- bio-yogurt; health benefits; probiotics; yogurt

I. INTRODUCTION

Yogurt is one of the most popular fermented dairy products which has a wide acceptance worldwide whereas its nutritional and health benefits are well known for centuries. The origin of yogurt is dated back to the 6000 B.C. when the Neolitic people in the Central Asia transformed from a status of a food gatherer to a food producer where they began the practice of milking their animals. It is generally accepted that the fermented milk products including yogurt have been discovered accidentally when they used to store milk in sheep-skin bags and has been evolved over centuries into commercial yogurt making which paved the pavement for different commercially available varieties with a range of flavors, forms and textures [1, 2]. According to the Code of Federal Regulations of the United States Food & Drug Administration (FDA), yogurt can be defined as a food produced by culturing one or more of the optional dairy ingredients namely, cream, milk, partially skimmed milk, and skim milk, used alone or in combination with a characteristic bacterial culture that contains lactic acid producing bacteria, *Lactobacillus bulgaricus* and *Streptococcus thermophilus* [3].Yogurt should contain at least 3.25% of milk fat and 8.25% of Milk Solids Non Fat (MSNF) with a titratable acidity of not less than 0.9 percent, expressed as lactic acid [3]. The composition requirement for milk fat and MSNF is applied to the yogurt prior to the addition of bulky flavoring ingredients according to the USDA specifications for yogurt [4]. Traditionally yogurt is made of cow, water buffalo, goat and sheep milk. However, milk from mare and camel is also used in yogurt making in some of the regions in the world.

According to the available literature, it can be suggested that the health benefits associated with yogurt consumption is well known for centuries [5, 6, 7].Yogurt is considered as healthy food due to its high digestibility and bioavailability of nutrients and also can be recommended to the people with lactose intolerance, gastrointestinal disorders such as inflammatory bowel disease and irritable bowel disease, and aids in immune function and weight control [8, 9]. Because of these health benefits associated with yogurt consumption, there is an increasing trend for yogurt and is the fastest growing dairy category in the market in particular, standard yogurt and yogurt drinks [10]. Moreover, yogurt represented $51 billion in global spending in 2011, whereas Switzerland and Saudi Arabia were among the leading per head yogurt consumers globally that accounts for 28.8 and 22.1 kg of yogurt per head per year in 2008 [11]. The history of yogurt, manufacturing process, varieties and types of yogurts available in the market, and its associated health benefits are reviewed in this article.

II. HISTORY OF THE YOGURT MAKING

Milk fermentation is one of the oldest methods practiced by the human beings to preserve milk with an extended shelf life. The exact origination of milk fermentation is not clear; however, it seems that it is dated back to the dawn of the civilization. It has been reported that the early civilizations such as the Samarians, Babylonians, Pharoes and Indians were well advanced in agricultural and animal husbandry practices [5]. This can be supported by the findings of Copley et al., 2003 in which the dairy fat residues were found in pottery fragments from Neolitic Bronze-age and Iron-age settlements, which suggests that the practice of dairying had existed in Britain approximately 6500 years ago [12]. However, it is questionable that the milk fermentation was practiced during this period. Therefore, the origination of the fermented milk products including yogurt

remains unsolved. It has been reported that the Anatolian goatherds conserve their milk by thickening as they used to dry it in the sun and transport in animal stomachs[6]. It is generally accepted among the historians that the fermentation of milk is discovered accidentally by the Neolithic people of Central Asia when they stored milk in primitive methods such as in sheep-skin bags in warm climates [7].With reference to yogurt, it can be suggested that it has been evolved in Turkey as the term "yoghurt" has been derived from a Turkish verb, "jugurt" that means "to be curdled or coagulated" [5, 7]. The earliest writings about yogurt can be found from those of Pliny who lived in the first century A. D. and wrote about ancient barbarous nations that knew how to thicken the milk into a substance with an agreeable acidity. According to the literature, the founder of the Mongol empire, Genghis Khan and his armies was lived on yogurt and spreading of this news among the people had made theyogurt consumption to spread throughout the East [7].

Moreover, according to the Persian tradition, Abraham owed his fecundity and longevity to the regular ingestion of yogurt, and the emperor Francis I of France was said to be cured of severe diarrheaby consuming yogurt made of goat milk leading to introduce the health benefits of yogurt into the western world in 1542 [5, 6].The first industrialized production of yogurt was taken place in 1919, in Barcelona, Spain at a company named Danone[7]. Yogurt was firstly introduced to the USA in the early 20th century in the form of tablets especially designed for those with digestive intolerance [6]. However, it became popular in the North America when Dannon, a small-scale yogurt factory started manufacture of yogurt in New York in 1940. Even though, yogurt has been evolved for centuries, it was subjected to a significant and dynamic evolution process in the 20th Century to originate a vast array of products.For instance, fruit yogurts, yogurts with fruit on bottom and blended yogurts were introduced in 1937, 1947 and 1963 respectively[6, 7]. It seems that the evolution process of yogurt has taken place in different regions of the world once it had been originated in the Central Asia. This might be the reason of having different types of yogurts and yogurt-like products in different names which are summarized in the Table 1.

Table 1 Yogurt and yogurt-like products originated in different regions of the world

Region	Country/island or region of origin	Traditional name of the yogurt or yogurt-like product
Europe	Turkey	Jugurt/eyra/ayran
	Balkans	Kisselmleka/naja/yaourt
	Balkan mountains	Urgotnic
	Greece	Yiaourti
	Italy	Cieddu
	Sicily	Mezzoradu
	Sardinia	Gioddu
	Hungary	Tarho/taho
	Finland	Viili
	Scandinavia	Filmjolk/fillbunke/filbunk/surmelk/taettem
	Iceland	Skyr
	Yugoslavia	Gruzoviz
	Portugal	Iogurte
Eurasia	Russia	Donskaya/varenetes/kurugna/ryzhenka/guslyanka
	Turkestan	Busa
	Transcaucasia (South Caucasian state was once extended across the modern-day countries of Armenia, Azerbaijan, and Georgia)	Katyk
	Armenia	Mazun/matzoon,matsun, matsoni, madzoon
Middle East and Asia	Lebanon and some Arab countries	Leban/laban
	Egypt and Sudan	Zabady/zabade
	Iran and Afghanistan	Mast/dough/doogh
	Iraq	Roba/rob
	India	Dahi/dadhi/dahee
	Mongolia	Tarag
	Nepal	Shosim/sho/thara

Note: Adapted and modified from Tamime and Robinson, 1999 [5]

III. GENERAL MANUFACTURING PROCEDURE OF YOGURT

Manufacturing of yogurt is an ancient technique, which dates back to thousands of years, and the knowledge has transferred generation to generation. However, during the last few decades, it became more rational due to improvement of various fields such as microbiology, biochemistry and food engineering. Today it is a complex activity combined with art and science[5]. The generalized process of yogurt making is comprised of modifying the original composition of milk, pasteurizing the yogurt mix, fermentation at thermophilic temperatures (40-45 ºC), cooling and addition of fruits and flavors. The production steps in manufacture of stirred- and set yogurt are illustrated in the Figure 1.

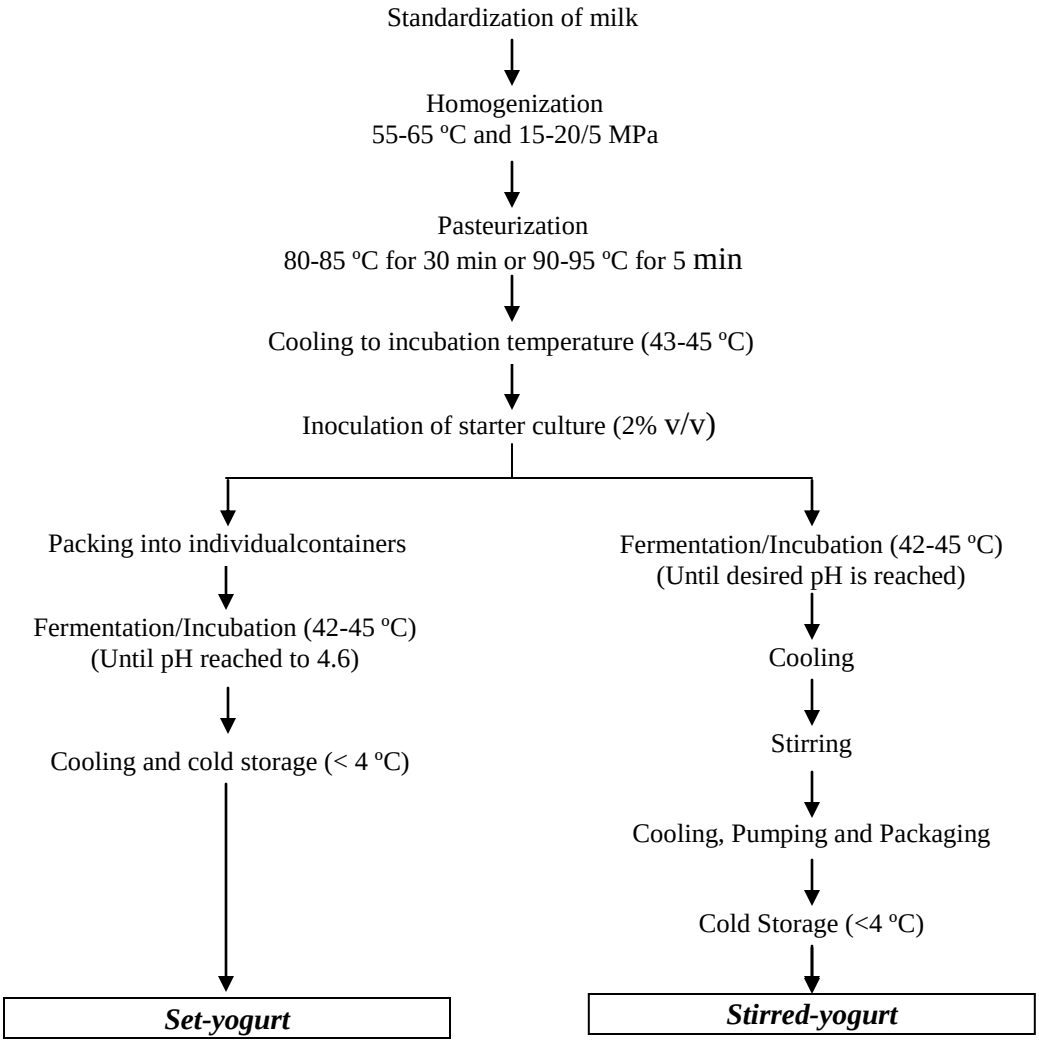

Figure 1: Manufacturing process of set- and stirred-yogurt (Adapted from Lee and Lucey, 2010) [13]

Ingredients for yogurt manufacture

Yogurt is made with a variety of ingredients including milk, sweeteners, stabilizers, fruits, flavors, and bacterial cultures. Milk is the main ingredient used in yogurt manufacturing. The type of milk to be used depends on the variety or type of the yogurt that will be prepared. For instance, whole milk is used for full fat/regular yogurt, partially skimmed milk is used for low fat yogurt and skimmed milk is used for nonfat yogurt. Cream/butter fat is used to adjust the fat content whereas skim milk powder, whey protein concentrate are used to elevate the total solid content of the yogurt mix. Stabilizers are usually added to the mix in order to increase the body and texture leading to an increase in firmness, prevents whey separation/syneresis, and aids in uniform distribution of ingredients. In addition, sweeteners are added to increase the flavor and consumer appeal.

Milk Standardization

Milk solid content of yogurt seems to be varied from 14-15% in commercial yogurt products and the minimum milk solids non fat content varies from 8.2-8.6% according to the standards and

regulations of many countries [5].According the Codex Alimentarius Commissionyogurt should have a minimum protein content of 2.7% and a maximum fat content of 15% [14]. In order to achieve this, the FAO/WHO standards specifies that milk should be standardized with the minimum SNF and milk fat content of 8.2% and 3% respectively for yogurt manufacture. The average composition of bovine milk comprised of 4.5% lactose, 3.3% protein, 3.5% of fat and 0.7% mineral matter. Therefore, it is obvious that the composition of yogurt is varied according to the variety, and yogurt mixture should therefore standardize accordingly in such a way that produce an end product with not less than 2.7% of protein and less than 15% of milk fat with a titratable acidity not less than 0.3% expressed as percentage of lactic acid[14]. Stabilizers such as pectin and gelatin are added to the yogurt mix in order to attain the characteristic properties of yogurt namely, texture, mouth feel, appearance, viscosity and to inhibit the whey separation [5, 13]. However, both over-stabilization and under-stabilizationmay causequality defects as the over-stabilization results a"jello-like" springy body of yogurt, whereas the under-stabilization causes "runny body" or whey separation [13].

Homogenization

Homogenization treatment reduces the diameter of fat globules to less than 1µm and ensures uniform distribution throughout the food matrix, thus considered as an important processing step especially for yogurt with high fat content. Consequently, it results no distinct creamy layer on surface of the yogurt and improves consistency of the yogurt [15]. Homogenization is accomplished by using a homogenizer or viscolizer where the milk is forced through small openings at a high pressure in which the fat globules are broken up due to the shearing forces [16]. Typically, milk is homogenized using pressures of 10-20 and 5 MPa in first and second stages, respectively for over 10-17 min [13]. More recently, ultra-high pressure homogenization has been introduced to the commercial yogurt manufacture leading to an increase in yogurt firmness and water holding capacity comparatively to that of the conventional homogenization process [17, 18].

Heat Treatment

It is generally considered that the heat treatment of milk is an essential step in yogurt manufacturing process that greatly influences the microstructure and physical properties of yogurt. Heat treatment has a number of beneficial effects as it will destroy the microorganisms present in milk or yogurt mixture which can potentially interfere with the controlled fermentation process, will denature the whey proteins that will give the final product a better body and texture, and will release the compounds in milk that stimulate growth of the starter culture microorganisms. In addition, it will help some ingredients to achieve the required state to form gels and protein lattice, that affects the final texture and viscosity of the product while aids in removing dissolved oxygen in the milk and thereby assists the starter culture growth as they are sensitive to oxygen [13, 16]. Heat treatment is a continuous- or batch-process involves heating of milk to relatively high temperature and hold in there for pre-determined time period. The time-temperature combinations for the batch heat treatments that are commonly employed in the commercial yogurt making include 85 º for 30 min and 90-95 ºC for 5 min [5].Alternative time-temperature combinations available for the milk pasteurization are summarized in the Table 2. Despite the time-temperature combination used, it is a must to fulfill the minimum requirement to destroy the most heat resistant pathogen currently recognized in milk, *Coxiella burnetii* that cause Q-fever in humans [16]. Heat treatment of milk is important to destroy unnecessary pathogenic organisms and enzymes present in milk.

Table 2 Time-temperature combinations for milk pasteurization

Type of Pasteurization	Process	Temperature (ºC)	Holding time
Low Temperature Long Time (LTLT)	Batch	62.8	30 min
High Temperature Short Time (HTST)	Continuous	71.7	15 s
Higher Heat Shorter Time (HHST)	Continuous	88.3	1 s
Ultra-pasteurization	Continuous	137.8	2 s
Ultra High Temperature (UHT)	Aseptic	135-150	4-15 s

Source: Food and Drug Administration, 2011 [19]

Inoculation and Fermentation

After the heat treatment, the yogurt mixture is cooled to 43-46 ºC prior to the addition of yogurt starter culture bacteria at a concentration of about 2 % (v/v). This temperature range is optimal for the thermophilic microorganisms used in the yogurt starter culture [16]. The typical standard yogurt culture consists of *S. thermophilus* and *L. delbrueckii* subsp. *bulgaricus* in 1:1 ratio. Inoculation of starter cultures usually takes place in a sealed hygienic stainless steel vessel. However, the place of fermentation is different to each other in set-and stirred yogurt manufacture. It is usually occurred in individual containers and in large hygienic stainless steel vats in set- and stirred yogurt manufacturing processes, respectively. Incubation temperature is maintained and monitored at optimal level throughout the fermentation process for few hours (2.5-3 h) until the pH and acidity reached their desired levels prior to discontinue the fermentation process by rapid cooling. During the fermentation process, due to the metabolic activity of the lactic acid bacteria used, lactose converts into lactic acid which coagulates milk proteins along with the production of certain volatile compounds that gives its characteristic flavor and aroma.

Cooling

When yogurt has reached the desired pH (4.5-4.6), it will then often blast chilled to refrigerated temperatures (<10 ºC) in order to stop the fermentation process and thereby stops further acid development [5]. In the manufacture of set-yogurt, yogurts are directly transferred to a cold store or blast chilled in cooling tunnels. On the other hand, in the manufacture of stirred-yogurt, cooling is first performed by agitating the coagulum in the

jacketed fermentation vat in order to produce smoothened product before filling to containers [13]. According to the USDA Specifications, after the final steps in manufacturing and/or packaging, the yogurt should be cooled and maintained at temperatures less than 7.2 ºC [4].

IV. NUTRITIONAL PROFILE OF YOGURT

Yogurt is a highly nutritious and easily digestible dairy product which is a rich source of more than ten essential nutrients in particular, certain minerals and vitamins. The nutritional composition of yogurt can be varied according to the strains of starter culture used in the fermentation, type of milk used (whole , semi or skimmed milk), species that milk is obtained (bovine, goat, sheep), type of milk solids, solid non-fat, sweeteners and fruits added before fermentation as well as the length of the fermentation process (Table 3).

Table 3 Nutritional composition of different varieties of yogurt (per 100 g)

Component	*Whole milk yogurt*	*Low fat yogurt*	*Non fat yogurt*	*Greek-style yogurt*	*Drinking yogurt*
Energy (kcal)	79	56	54	133	62
Protein (g)	5.7	4.8	5.4	5.7	3.1
Carbohydrate (g)	7.8	7.4	8.2	4.8	13.1
Fat (g)	3.0	1.0	0.2	10.2	Trace
Thiamin (mg)	0.06	0.12	0.04	0.12	0.03
Riboflavin (mg)	0.27	0.22	0.29	0.13	0.16
Niacin (mg)	0.2	0.1	0.1	0.1	0.1
Vitamin B6 (mg)	0.10	0.01	0.07	0.01	0.05
Vitamin B12 (mg)	0.2	0.3	0.2	0.2	0.2
Folate (µg)	18	18	8	6	12
Carotene (µg)	21	Trace	Trace	Trace	Trace
Vitamin D	0	0.1	Trace	0.1	Trace
Potassium (mg)	280	228	247	184	130
Calcium (mg)	200	162	160	126	100
Phosphorus (mg)	170	143	151	138	81

Source: The Dairy Council, 2013[20]

However, the general composition of yogurt is more or less similar to that of milk. Therefore, yogurt is a rich source of milk proteins, carbohydrate, minerals such as calcium and phosphorous, and vitamins such as riboflavin (B2), thiamin (B1), cobalamin (B12), folate (B9), niacin (B3) and vitamin A. Milk proteins available in yogurt is in high quality due to its high biological value and provide almost all essential amino acids necessary to maintain good health [9]. In addition, milk proteins available in yogurt contain higher content of proline- and glycine-contain amino acids than that in whole milk while performing additional body functions such as enhancing calcium absorption and boosting the immune system [9]. Lactose is the main carbohydrate found in yogurt as in other dairy products. Lactose content in raw milk is about 4.6%. However, the original lactose content in milk is lowered by 20-30% during the fermentation process as the lactose coverts into its simple forms of glucose and galactose due to the metabolic activity of lactic acid bacteria. Fat content of yogurt is highly dependable on the fat content of the original yogurt mixture. According to the USDA specifications for yogurt, low-fat yogurt and non-fat yogurt, fat content varies from 0.5-3.25% [4]. However, the fat content of yogurt is highly subjective as some products; for instance Greek style yogurt contains a high fat content as high as 10%. Unlike milk,processes that are employed in yogurt manufacturing such as homogenization and fermentation result in breakdown of some amount of fat into easily digestible and absorbable fatty acids [9]. Vitamins and minerals found in milk and dairy products are in bio-available form where they are available for absorption and use by body. Yogurt as of other dairy products is an exceptional source of several B vitamins in particular, riboflavin and thiamin. It is reported that a 150g serving of whole milk plain yogurt and low-fat plain yogurt will provide 31% and 30% of an adult's daily riboflavin requirement respectively whereas the same amount of serving of each type of yogurts will provide 23% and 45% of an adult's daily thiamin requirement [9]. However, vitamin B12 and B6 are found in significantly lower concentrations than that in milk as *Streptococcus thermophilus* uses these B vitamins for its metabolism. Folic acid/folate content of yogurt can be varied depending on the composition of lactic acid bacteria used as some of the LAB species such as *S. thermophilus* and Bifidobacteria synthesize certain vitamins including folate by their own [9].

V. VARIETIES AND TYPES OF YOGURT

Yogurt can be categorized into two different groups namely, standard culture yogurt and bio- or probiotic yogurt. Standard yogurt refers to those made with *L. bulgaricus* and *S. thermophilus*. These bacteria said to be not actually inhabit gut; however able to stimulate the friendly microflora already present in the gut helping to maintain the general intestinal health [21]. On the other hand, bio yogurts are manufactured by culturing beneficial microorganisms that claim to have numerous health benefits once ingested, typically the probiotic strains of Bifidobacteria and *L. acidophilus*. Unlike standard yogurt cultures, these probiotic strains are said to claim more specific health benefits and represent the types of friendly microflora present in the gut [21]. This type of yogurts are more popular and have a milder, creamier flavor and less acidic. Further, bio-yogurts are claimed to aid in digestion and promote good health; however, these probiotic strains should remain live at adequate numbers to claim any health effect [22]. Because of this reason, a term called "Live and Active Cultures" has been introduced recently which refers to the living microorganisms including standard yogurt cultures and probiotic cultures present in the yogurt at the time of manufacture. In order to identify the yogurt products with adequate amounts of beneficial live microorganisms, the National Yogurt Association recently

introduced the *Live and Active Cultures Seal*. Therefore, according to the National Yogurt Association's guidelines, the refrigerated products should contain at least 100 million live cultures per gram and the frozen products should contain at least 10 million live cultures per gram at the time of manufacture in order to obtain the *live and active culture seal*[23]. Apart from this classification, the yogurt products available in the market are in a wide variety of flavors, textures and forms that suits a vast array of palates and meal occasions. These can be consumed either as a snack, dessert or a part of a meal. Different varieties of yogurt that can be categorized according to the physical and chemical nature, added flavors and post incubational processes are discussed in this section.

a) Based on the chemical composition of the product

Based on the fat content of yogurt, it can be categorized into three major varieties namely, regular yogurt, low-fat yogurt and non-fat yogurt. Regular yogurt is produced from the full fat milk which should contain at least 3.25% of milk fat [3]. On the other hand, low-fat yogurt and non-fat yogurt are produced from low fat milk or partially-skim milk, and skim milk respectively. The fat content along with pH and titratable acidity of these three varieties of yogurt are shown in the Table 4.

Table 4 The composition of regular-, low-fat- and non-fat yogurt

Parameter	Regular Yogurt	Low-fat Yogurt	Non-fat Yogurt
Fat (%)	≥3.25	0.5-2.0	≤0.5
Solid Non Fat (%)	≥8.25	≥8.25	≥8.25
Titratable Acidity (%)	≥0.9	≥0.9	≥0.9
pH	≤4.5	≤4.5	≤4.5

Adapted from FDA and Australia New Zealand Food Standard Code Recommendations [3, 24, 25, 26]

b) Based on the physical nature of the product

The physical nature of yogurt can be solid, semi-solid or fluid. Yogurts that are solid in nature (jelly-like texture) are called as set yogurt that is incubated and cooled in the final packaging. Whereas yogurts which are in semi-solid state and fluid nature called as stirred yogurt and fluid/drinking yogurt, respectively. Stirred yogurts are produced by incubating the mix in a tank followed by breaking by stirring prior to cooling and packaging [16]. The manufacturing processes of the set and stirred yogurt are illustrated in the Figure 1.Drinking yogurts usually go through a homogenization process in order to reduce the particle size that assured hydrocolloidal distribution and stabilization of the protein suspension.

c) Based on the flavor of the product

Addition of flavors would enhance the consumer appeal while produce a variety of products. Flavors can either be added immediately before homogenization or after the homogenization.Yogurts can be categorized into plain-, fruit- and flavored yogurt based on the particular flavor of the yogurt.

Plain/Natural Yogurt

This is the simplest and the least adulterated form of the yogurt made by lactic acid bacterial fermentation of pasteurized milk in order to produce its characteristic texture and flavor. In other words, it can be defined as the plain and unsweetened fermented milk product containing no added color or any other additives [22]. Therefore, it is closer to the nutritional value of milk which it is made of, and provides all of the benefits associated with fermentation while supplying fewer amounts of calories. Moreover, plain yogurt gives the pure yogurt taste and contains the richest calcium content among the yogurt products [21, 27].

Flavored Yogurt

Yogurts are available in a vast array of flavors including fruit (apple, apricot, black cherry, black currant, blue berry, lemon, mandarin, raspberry, strawberry, peach), cereal, vegetables, chocolate, vanilla, caramel, ginger, etc [28]. In general, flavors are added to yogurt during production stage and theaddition of flavors not only results a wide array of tastes, but also increases sweetness of the product [27].

d) Yogurt related products

After the basic incubation process in the yogurt manufacturing, depends on the manufacturing processes employed such as mixing with other mixtures, heat treatment and drying, may results a range of yogurt products namely, pasteurized yogurt, UHT yogurt, dried yogurt, etc.

Pasteurized and UHT Yogurt

These types of yogurts are produced after the fermentation by subjecting to heat treatment with different time-temperature combinations [22]. Although these types of yogurt products are produced by the manufacturers in order to prolong the shelf life and/or to decrease the natural tartness of yogurt, the heat treatment may destroy considerable numbers of live and active cultures present, which would be a disadvantage when considering the health benefits of yogurt consumption.

Frozen Yogurt

The Pennsylvania Code defines frozen yogurt as a food which is prepared by freezing while stirring a pasteurized mix consisting of the ingredients permitted for ice cream and should contain not less than 3.25% milkfat, not less than 8.25% milk solids non fat and has a titratable acidity of at least 0.3% expressed as lactic acid[29]. Whereas the low fat version resembles more than 0.5% but less than 2% of milk fat with same amount of milk solid nonfat [30]. In order to obtain the National Yogurt Association's *Live and Active Cultures seal*, frozen yogurt must be a product produced by fermenting pasteurized milk using traditional yogurt cultures until the proper acidity is reached followed by mixing with pasteurized ice cream mix including cream, sugar, stabilizers, etc according to the pre-determined recipes of the manufactures which can then be blended with fruits and then

frozen [2].

Dried Yogurt/Yogurt Powder

Yogurt powder is produced by fermenting non-fat milk using standard yogurt cultures until attain the desirable pH followed by a step of drying, most probably by freeze-drying. In addition, blended yogurt powder is manufactured by blending cultured non-fat milk, cultured whey, cultured whey protein concentrate, cultured dairy solids, nonfat dry milk and lactic acid which are similar to the flavor and functionality to that of the traditional yogurt powder [31]. Yogurt powders add a unique dairy flavor to food applications including beverages, confections and dips. The main intension of manufacturing yogurt powder is to store the product in a stable and readily utilizable state, and it can be utilized to replace fresh yogurt for beverage and dip, and in confectionary industry as a coating material for coating of dried fruit, nuts, pretzels, cereal and other snack items [31, 32]. Composition of the commercial yogurt powder is shown in the Table 5. Color of the yogurt powder ranges from off-white to pale yellow whereas the pH and titratable acidity can be varied from 4.7-5.1 and 5.8-7.4, respectively [31].

Table 5 Composition of the Commercial Yogurt Powder

Component	Percentage (%)
Moisture	3.0-5.0
Fat	1.2-2.0
Protein	33.0-36.0
Lactose	50.0-51.5
Ash	7.0-8.0

Source: Krasaekoopt and Bhatia, 2012 [32]

Herbal Yogurt

Many traditional preparations with various combinations of herbs have been used for over 1500 years to treat upper respiratory ailments, and reduce their incidence and severity[33]. In recent years, there is an increasing trend towards the production of herbal yogurts by incorporating natural food additives and health promoting substances. Addition of neem (*Azadirachta indica*) into yogurt has shown increased acidification, total phenolic compounds, antioxidant activity and inhibition of enzymes related to diabetes and hypertension [34]. Bio yogurts prepared from cow milk and camel milk with *Cinnamomum verum* reported to inhibit enzymes such as α-amylase and α-glucosidase related to diabetes whereas the higher counts of Lactobacilli was observed in the herbal yogurts prepared with camel milk than that of the plain yogurt [35, 36].Herbal yogurts prepared with *Anethum graveolence*, *Mentha piperita and Ocimum basilicum* showed higher ACE inhibitory activities, α-amylase and α-glycosidase activities than that of the plain-yogurt which suggested that these herbal yogurts may be beneficial to treat hypertension and diabetes mellitus [37]. In addition, inclusion of *Alliumsativum* and *C. verum* has enhanced Lactobacilli counts more in camel-milk yogurts than in cow-milk yogurts except during refrigerated storage and do not affect to organoleptic properties of yoghurt [36].Barrantes, et al. (1996) showed the possibility of preparing yogurts rich in poly- and mono-unsaturated fatty acids which were manufactured from reconstituted skimmed milk powder using vegetable oils (olive, groundnut, sunflower or maize) to replace the milk fat [38].

e) Types of yogurt

Yogurts can be divided into a number of types based on the fact that how they are made. Only some of the most popular types of yogurt available in the market are described in this section.

Balkan-style Yogurt

Balkan-style yogurt is also known as set-style yogurt which has a characteristic thick texture and made in small and individual batches after poured the warm cultured mix into containers following by incubation without any stirring for over 12 hours or more until the desired thickness and creaminess is attained [1, 39]. This type of yogurt is used in making Balkan meat-based recipes, as a substitute for sour cream, as salad dressing or topping for Mediterranean dishes such as moussaka, spanakopita, pita sandwiches with slices of meat or chicken. In addition, It can also be consumed as a regular yogurt, sweetened with chopped fruits, sugar or honey or served with granola for breakfast [39].

Greek-style Yogurt

This is also known as Mediterranean-style yogurt made of either from partially condensed milk or by staining whey from plain yogurt to make it thicker and creamier. Due to its thick texture, it tends to hold up better upon heat than regular yogurt and thus utilizes as a main ingredient in making thick dips such as tzatziki [1, 39]. Although it isa deliciousproduct, it claimed to have a high amount of fat including high content of saturated fat. However, it is likely to be a rich source of vitamin A as a 150g of serving will provide one fifth of the Recommended Daily Allowance of vitamin A [21]. Greek-style yogurts are available, in full fat and low fat versions, many cooks and bakers used to make their own strained yogurts with the intension to utilize in their cuisines in fresh form [39].

European-style Yogurt/Stirred Curd Yogurt

European-style yogurt is a type of stirred yogurt with a characteristic creamy and smooth texture and is made by incubating the yogurt mixture in a large vat instead of individual cups, followed by cooling and then stirring in order to obtain a creamy texture most often with added fruits (blueberries, strawberries, mango, and peach) and flavors [39]. Yogurts of this style are slightly thinner than that of the Balkan-style and set yoghurt and can be incorporated into cold beverages and desserts.

French-style Yogurt

This style of yogurt is also known as custard-style yogurt made by direct culturing in the pot according to a French culture and process which characterized with a pudding-like texture [21, 39]. Sometimes French-style yogurts are flavored with fruit pieces which stirred into the mixture, most commonly with strawberries and blueberries or a mixture of both [21]. It is said to be an ideal source of iron, protein and vitamin A [39].

Fruit Yogurt

There are two kinds of fruit yogurts: one has the fruits set at the bottom of the packaging (sundae-style yogurt) while the other has the fruit uniformly distributed within the yogurt itself (Swiss-style yogurt) [39]. Fruit pieces or pulp are added at production stage that produces variety of tastes while increasing consumer appeal and sweetness [27].

VI. HEATH BENEFITS OF YOGURT

Yogurt is considered as a nutrient dense food that contains essential nutrients such as protein, vitamins and minerals necessary for growth. Consumption of dairy products such as yogurt helps to improve the overall quality of the diet while increasing the chances of achieving nutritional recommendations such as Recommended Dietary Allowances of each nutrient in daily basis. For instance, milk products including yogurt is a rich source of calcium in bio-available form which is reported to provide 41% of the recommended daily requirement of Calcium for a 5-year old through a serving of 50 g of yogurt [9]. It seems that the health benefits of fermented dairy products including yogurt are well-known for centuries as their health benefits are even mentioned in the Bible and the ancient books of Hinduism [8, 9]. Other than its rich nutritional profile, yogurt is claimed to have many health benefits.

Lactose is the main carbohydrate found in milk which is a disaccharide composes of one molecule of glucose and galactose. Lactose is broken down to its simple sugars due to the action of the enzyme, lactase inside the gut. Inadequacy of secretion or interferences to the digestion process of lactase may pass undigested lactose into the large intestine which will then be fermented by colonic microflora that results gastrointestinal symptoms such as flatulence, diarrhea and abdominal pain. This phenomenon is called as the lactose intolerance. It has been reported that the lactose intolerance is associated with low calcium intake and bone mineral density most probably unnecessary exclusion of milk and dairy products from the diet [9, 40]. Therefore, it can be concluded that yogurt is effective for the individuals with lactose intolerance to attain all the benefits of milk products without causing discomforts associated with hypolactasia.

It is generally accepted that the optimum balance in the intestinal microflora is associated with good nutrition and health. Further, Lactobacilli and Bifidobacteria are known to be the primary microbial strains associated with this balance [9, 41]. Available research findings suggest that maintaining favorable microbial profile through regular consumption of bio-yogurt results numerous therapeutic benefits [9]. In 1908, the Russian scientist, Metchnikoff suggested that the prolonged life of the Bulgarians was associated with the regular consumption of fermented milk products with lactic acid bacteria [42]. Yogurt acts as a probiotic carrier food that is considered as an easy food to incorporate probiotics which results high probiotic viability. Bio-yogurt is considered to be an ideal source for the delivery of viable probiotic strains, *L. acidophilus* and *Bifidobacterium bifidum* which are the most common probiotics used in the dairy industry. However, in order to attain the probiotic effect, it is reported the need of consuming adequate amounts of viable probiotic cells regularly which is known as the therapeutic minimum. Therefore, the consumption should be more than 100 g of bio-yogurt containing more than 10^6 cfu·mL^{-1} viable cells [8]. Consumption of probiotics seems to be helpful to maintain good health, restore body vigor and combat intestinal disorders through the therapeutic and beneficial effects associated with them. Probiotics reported to have the therapeutic effects such as prevention of urogenital infections, alleviation of constipation, protection against diarrhea, prevention of infantic diarrhea, prevention of hypercholesterolemia, protection against colon/bladder cancer and prevention of osteoporosis. On the other hand, probiotics claimed to have other beneficial effects such as maintenance of normal intestinal flora, enhancement of the immune system, reduction of the lactose-intolerance and serum cholesterol levels, and enhance anticarcinogenic activity [8, 9, 43].

Some have recommended fermented milk products to cure gastrointestinal disorders; for instance, Tissier has recommended the administration of Bifidobacteria to cure infantic diarrhea [42]. Moreover, yogurt is reported to be beneficial for the treatment of Inflammatory Bowel Disease (IBD) that includes gastrointestinal disorders such as Crohn's disease, ulcerative colitis and pouchitis. The VSL#3 (a mixture of four strains of lactobacilli including *L. casei*, *L. plantarum*, *L. acidophilus* and *L. delbrueckii* ssp. *bulgaricus*, three strains of bifidobacteria including *B. longum*, *B. breve* and *B. infantis* and one strain of *S. thermophilus*) found to be effective in maintaining remission in patients with chronic relapsing pouchitis [44] and for the prophylaxis of pouchitis in patients who had ileo-pouch anal anastomosis for ulcerative colitis [9, 45]. On the other hand, Ishikawa et al. (2002) reported that the supplementation of Bifidobacteria fermented milk for 1 year was successful in maintaining remission and clamed beneficial preventive effects on the relapse of ulcerative colitis [46]. In adiition, *Saccharomyces boulardii*, non pathogenic yeast, VSL#3 and E-coli Nissle 1917 were found to be effective against Crohn's disease [47, 48].

Yogurt consumption is also reported to be effective in cytokine production, T-cell function and natural killer-cell activity, and thereby result an overall immunological enhancement [9].

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