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Kalyani Gorrepati, S. Balasubramanian & Pitam Chandra

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REVIEW

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Abstract During the last few years the popularity for the plant based butters (nut and seed butters) has increased considerably. Earlier peanut butter was the only alternative to the dairy butter, but over the years development in the technologies and also the consumer awareness about the plant based butters, has led the development of myriad varieties of butters with different nuts and seeds, which are very good source of protein, fiber, essential fatty acids and other nutrients. These days' different varieties of plant based butters are available in the market viz., peanut butter, soy butter, almond butter, pistachio butter, cashew butter and sesame butter etc. The form of butter is one of the healthy way of integrating nuts and seeds in to our regular diet. Nut and seed butters are generally prepared by roasting, grinding and refrigerated to consume it when it is still fresh. During this process it is imperative to retain the nutritional properties of these nuts and seeds in order to reap the benefits of the fresh nuts and seeds in the form of butter as well. Proper care is needed to minimize the conversion of healthful components in to unhealthy components during processing and further storage. Roasting temperature, temperatures during grinding and storage are the vital factors to be considered in order to have healthy and nutritious plant based butters. In this article, different plant based butters and their processing methods have been described.

Keywords Butter · Plant · Nut · Seed · Peanut · Soy · Almond · Sesame · Cashew · Pistachio · Sunflower

K. Gorrepati (✉)
Directorate of Onion and Garlic Research,
Rajgurunagar 410 505 Pune, India
e-mail: kalyanigorrepati@gmail.com

S. Balasubramanian · P. Chandra
Central Institute of Agricultural Engineering, Bhopal 462 038, India

Introduction

The mounting health concerns regarding the consumption of dairy butter due to its fat content has raised an alarm to search for an alternative plant based butters viz., nut butters and seed butters. Nuts and seeds are nutrient dense foods and have been a regular constituent of mankind's diet since pre-agricultural times (Eaton and Konner 1985). Nuts and seeds are generally consumed as snack food in roasted form as they are of good taste, handy and easy to eat. But, recently with the advent of new technologies, myriad varieties of nut and seed based snacks and processed products have arrived in the market out of which the form of butter gained more popularity. So, in this article we have made an attempt to compile the different nut and seed butters and their preparation method. Even though the peanuts are generally considered as legumes for simplicity they are included as nuts in this article as they are widely identified as part of the nuts.

Dairy butter

Butter, the word derived from *bou-tyron* (cowcheese) in Greek and in usage about 2,000 years before Christ (www.webexhibits.org/). The dairy butter is a water-in-oil emulsion, i.e. >80 % fat with tiny water droplets, perhaps some solids-not-fat (SNF) and with/without salt (www.foodsci.uoguelph.ca/) (Table 1). However, animal foods such as butter are rich in saturated fat. Butter with and without salt contains 55±2 g/100 g of saturated fat and 222±2 mg/100 g cholesterol (Scherr and Ribeiro 2010). The fee fatty acid content of dairy butter and the fat crystalline network texture of butter is shown in Figs. 1 and 2.

Table 1 Composition of dairy butter

Composition	Per 100 g
Protein (g)	0.6
Carbohydrate (g)	0.6
Fat (g)	82.2
saturate	52.1
monounsaturate	20.9
polyunsaturate	2.8
trans fatty acid	2.9
Thaimin (mg)	Trace
Riboflavin (mg)	0.07
Niacin (mg)	Trace
Niacin from Tryptophan (mg)	0.1
Vitamin B_6 (mg)	Trace
Vitamin B_{12} (μg)	0.3
Folate (Ig)	Trace
Pantothenate (mg)	0.05
Biotin (μg)	0.2
Vitamin C (mg)	Trace
Retinol (μg)	958
Carotene (μg)	608
Vitamin D (μg)	0.9
Vitamin E (mg)	1.85
Sodium (mg)	606[a]
Potassium (mg)	27
Calcium (mg)	18
Magnesium (mg)	2
Phosphorus (mg)	23
Iron (mg)	Trace
Copper (mg)	0.01
Zinc (mg)	0.1
Chloride (mg)	994
Manganese (mg)	Trace
Selenium (μg)	Trace
Iodine (μg)	38
Energy (kcal)	744

[a] Unsalted butter contains 9 mg sodium per 100 g

Source: www.milk.co.uk/page.aspx?intPageID=383

Plant based butter/spread

Today, nuts and seeds continue to be enjoyed world-wide in a variety of ways, as recipe ingredients, spreads, snacks, and as a delicacy (King et al. 2008). Evidence suggests that nut consumption, including peanuts, protects against not only coronary heart disease (CHD) but also against diabetes and the CHD associated with diabetes, and other metabolic syndrome diseases, notably gallstone disease (Jenkins et al. 2008). Generally, nut/seed butters contain generous amounts of phytochemicals that may be protective against colon, prostate, and breast cancer (Mangels 2001). According to Jiang et al. (2002), the relative risk of developing diabetes was reduced 27 % in those who ate nuts five or more times per week compared with those who rarely or never ate nuts. Nutritional property of some of the nut/seed butter is presented in Table 2. Raw nuts have primarily 1 of the 2 unsaturated types (except coconut and palm kernels), thus leads healthful source of fatty acids for the production of lower cholesterol level foods (www.rejuvenative.com/). At present different plant based butters/spreads are available in the market. To name, peanut, almond, cashew, pumpkin seed, pistachio, soy, sunflower and sesame butter are few. The term plant based (Nut/Seed) butter refers to a product that contains at least 90 % nut/seed ingredients whereas, the spread refers to a spreadable product having at least 40 % nut ingredients which can be added in various forms, e.g. as nuts, a paste and/or a slurry (Wilkes 2012).

Different plant based butters

There are several types of plant based butters available in the market. Some are discussed as below.

Peanut butter

Peanut (*Arachis hypogaea*) butter is creamy, composed of peanut paste and stabilizer. It may also contain sweetener, salt, emulsifier and other ingredients. Peanut butter is prepared by roasting, blanching, grinding and tempering (Fig. 3). The formulation of a typical peanut butter is shown in Table 3. Good quality nuts and seed pods are sorted out and destoned before shelling. Shelled nuts are graded to ensure the sound or bold or even size nuts. Roasting is a dry heat treatment, carried out not so much for dehydration but for flavor, color and texture development (Alamprese et al. 2009). Roasting involves a number of physico-chemical changes including dehydration and chemical reactions. However, the development of flavour and aroma depends upon the temperature and time of roasting beside the type of nuts and techniques applied (Shakerardekani et al. 2011). Generally, for peanut butter, roasting is done at around 160 °C for 40–60 min depending upon the seed size and moisture contents (Pattee et al. 1982). Roasting reduces water contents to around 1 % followed by the release of oil from the cytoplasm of the cells which increases the shelf life of peanuts and helps in developing flavour for peanut butter (mofpi.nic.in). Ogunsanwo et al. (2005) reported that the peanut butter prepared by roasting at 160 °C for 30 min was found comparable with the commercial samples. Blanching of peanuts is done to remove the skin of the peanut. There are several blanching methods including dry, water, spin, and air impact. Dry blanching is used primarily in peanut butter production, as it removes the kernel hearts which affect peanut butter flavor (www.foodtechinfo.com/). After removing the outer skin during blanching, nuts are

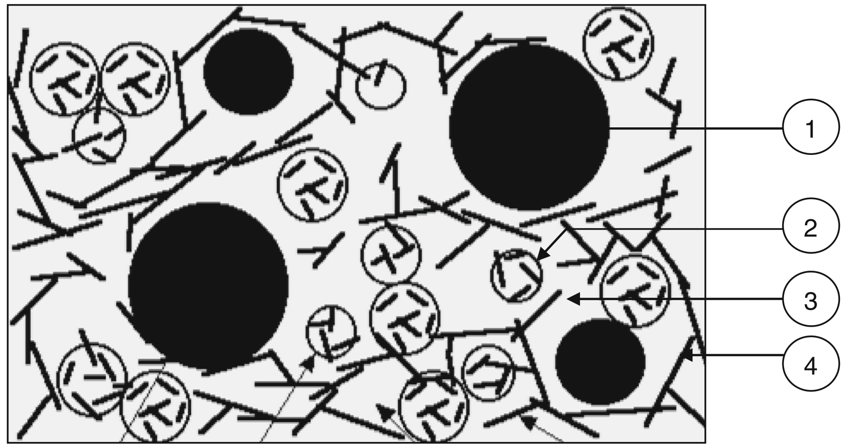

Fig. 1 Structure of dairy butter. 1. Moisture droplets containing SNF and salt, 2. Fat globules, partially crystalline, 3. Non-globular fat, continuous phase and 4. Fat crystals, semi-continuous networks. Source: www.foodsci.uoguelph.ca/dairyedu/butter.html

ground into paste. Peanut butter is usually made by two stage grinding operations. First grinding reduces the nuts to a medium size and the second milling uses a very high-speed grinder cum mixer that has a combination of cutting-shearing and attrition action and reduces to a fine (less than 0.025 cm) smooth texture (Industrial Extension Bureau). Due to this several passes the paste is subjected to excessively high temperature, an elaborative cooling methods need to be utilized to retain desired flavors in the nut butter. Patent by Connick (1997) states that accomplishing the grinding steps in the presence of solid carbon dioxide inhibits the dissolving, occlusion, and adsorption of free oxygen into the peanut butter and there by increases the shelf life as well as improves the flavour. Woodroof (1983) classified peanut butters into three types based on the texture viz., Smooth (even texure with no perceptible grainy peanut particles), Regular (definitely grainy texture with with perceptible peanut particles not more than 1/16 in. in diameter and Chunky (partially fine and partially grainy particles with substantial amounts larger than 1/16 in. in diameter). Crippen et al. (1989) reported that increased grind size (fine, medium and course), decreased the sensory smoothness, spreadability, adhesiveness and preference ratings. According to Dzurik et al. (1971) the high pressure homogenization after initial grinding produces a paste of smooth, glossy, melts more rapidly in the mouth than conventional peanut butter. During grinding, the ingredients like salt, sugar, stabilisers and emulsifiers are added. Addition of salt (< 1.2 %) increased the ease of swallowing, as well as consumer preference of texture. Before grinding of nut/seeds, carbohydrates, protein and other non-fat components will be in a continuous phase. Fat cells entrapped in non-fat components will be in a discontinuous phase. After grinding into

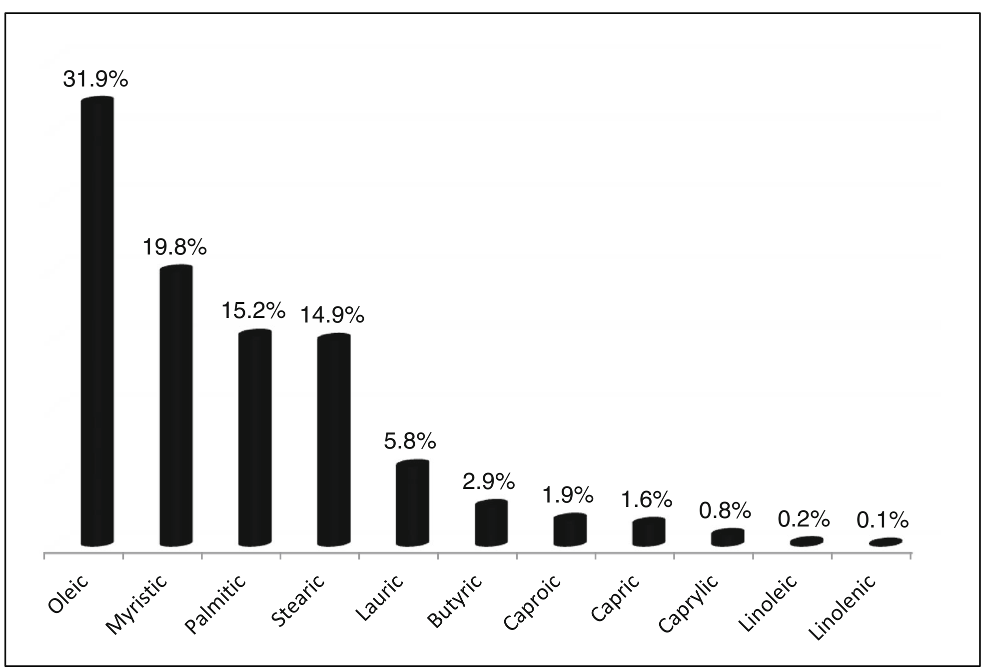

Fig. 2 Free fatty acids in dairy butter. Source: www.webexhibits.org/butter/compounds-fatty.html

Table 2 Nutritional property of nut and seed butter (1 Tbsp)

Product	Calorie	Protein (g)	Fat (g)	Calcium (mg)	Zinc (mg)
Almond butter	101	2.4	9.5	43	0.5
Cashew butter	93	2.8	8.0	7	0.8
Hazelnut butter	94	2.0	9.5	–	–
Sunflower butter	80	3.0	7.0	–	–
Sesame butter	89	2.6	8.0	64	0.7
Peanut butter					
natural	94	3.8	8.0	7	0.4
reduced fat	95	4.0	6.0	–	0.4
Soy butter					
sweetened	85	4.0	5.5	50	–
unsweetened	80	4.0	6.5	30	–
Soy-peanut butter sweetened	50	2.0	1.2	40	–

1Tbsp=14.19 g

Source: Mangels (2001)

paste, fat cells ruptured and become continuous and non-fat constituents form a discontinuous phase. Once the paste is formed, continuous phase (fat/ oil) will separate from the nonfat particles. Without stabilizers, paste settles at the bottom and forms a hard layer while the oil remains on top (Aryana et al. 2000). Thus, stabilizers in plant based butter prevent gravitational separation of less dense oil from solid particles during storage at ambient temperatures (Hinds et al. 1994). Galvez et al. (2006) reported that the peanut butter without stabilizer exhibited > 2 % oil separation after 12 weeks of storage. During conditioning to prevent oil separation, mixture is immediately chilled and the hydrogenated oil forms

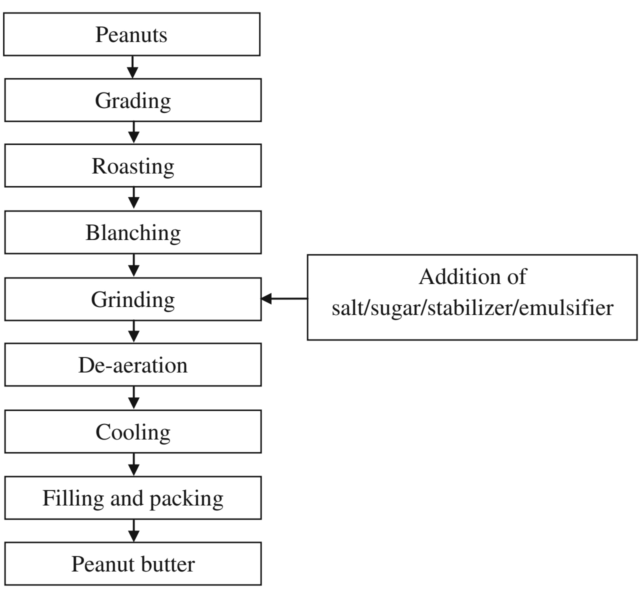

Fig. 3 A typical flow chart for peanut based butter preparation. Source: Global Agri systems Pvt. Ltd

Table 3 Formulation of a typical peanut butter

Component	Percentage
Peanut paste (~1 % moisture)	90
Hydrogenated vegetable oil	1–5
Sweetener	1–6
Salt	1–1.5
Emulsifier	0.5–1.5

Source: Akhtar et al. (2014)

finely divided and sufficient amount of hard fat crystals. The amount and nature of the crystals determines the stability of the product. The rate of cooling determines the size of the crystals (Francisco et al. 2006). Woodroof (1983) has discussed the important considerations on type and amount of stabilizer with respect to the desired consistency and mouth feel of peanut butter, oil content and particle size. The temperature of paste during the addition of stabilizer should be more than the melting point of stabilizer to produce a more homogenized product. Thus, the recommended temperature for blending of stabilizers is 60–74 °C. Totlani and Chinnan (2007) reported that the addition of 1–2 % stabilizer was found to be adequate for peanut butter stored for 3 months at 35 °C. Aryana et al. (2003) and Gills and Resurreccion (2000) reported that the use of blended hydrogenated rapeseed and cottonseed oils as stabilizer in peanut butter was superior to palm oil. Addition of emulsifier in the peanut butter negates stickiness so that it will not stick to the roof of the mouth. Suitable emulsifiers include lecithin and fatty mono- and diglycerides, for example, soybean mono- and diglycerides (Hunter and Eck 1989). Different emulsifiers affirmed as GRAS are shown in Table 4. Furthermore, for improved stability, the peanut butter should be packed at the proper temperature and it should be tempered for a minimum of 24 h before shipping. This tempering allows time for additional crystal growth and formation of a good crystalline network (Woodroof 1983; Francisco et al. 2006).

Woodroof (1983) observed that roasted peanut products with high moisture content developed an objectionable soggy nut flavor. Felland and Koehler (1997) found that peanut

Table 4 Some food emulsifiers affirmed as GRAS

Emulsifier	US FDA (21CFR)	EEC (E No.)
Diacetyl tartaric esters of monoglycerides (DATEM)	184.1101	E472e
Lecithin	184.1400	E322
Mono-and diglycerides	184.1505	E471
Monosodium phosphate derivatives of mono and diglycerides	184.1521	–

Source: Hasenhuett (2008)

butters with high product moisture develop more rancidity, off-flavors as compared to low moisture products. Abegaz (2003) studied the role of moisture in flavor changes of model peanut confections during storage. Peanut butter with added moisture resulted in a less intense 'roasted peanutty' character, also indicated by lower pyrazine concentrations. Oxidative related attributes such as 'rancid', 'painty', and 'cardboard' were higher in samples. Felland and Koehler (1997) reported that the peanut butter samples stored for 29 days at 4 °C, 25 °C and 50 °C showed that peanut butters with 0.56 a_w had lowest roasted aroma and flavor, with more off-odor and off-flavor than the 0.39 a_w and 0.29 a_w samples. Muego-Gnanasekharan and Resurreccion (1992) has reported that peanut butter can be stored for 1 year at 30 °C storage temperature. St. Angelo and Ory (1973) measured initial peroxide content of 9 commercial peanut butters and observed no 2 samples had the same initial peroxide content. They investigated the causes and prevention of fatty acid peroxidation in peanut butter with several additives viz., cupric acetate, boiled peroxidase, boiled peroxidase plus EDTA, boiled tyrosinase, and water. It was noticed that water either promote or retard oxidation. The metal salts cuppric acetate and ferric chloride showed an increase of 9.5 and 7.2, respectively. Tyrosinase and peroxidase resulted in increased rates of oxidation but neither enzyme were as effective a catalyst as the free copper which had the highest peroxidation. Lipoxygenase, the primary catalyst of enzymatic oxidation of unsaturated fatty acids also gave increased peroxidation but it was less than that caused by metal containing proteins. Young and Heinis (1989) noted that the addition of honey or corn syrup altered peanut butter flavors and viscosity. The rheological properties of two types of commercial peanut butter (unstabilized suspension consisting of solid peanut particles in peanut oil referred as '100 % peanuts' and the same suspension stabilized with vegetable oil and contains other ingredients such as salt and sugar in very small quantities referred as 'smooth') have been studied by Citerne et al. (2001). The mean volume particle diameter was found to be 6.6 μm with a narrow range of distribution. The samples behaved like plastic material and showed an apparent yield stresses of 24 Pa and 370 Pa, respectively. The stabilized suspension behaved more like a solid, the elastic modulus being larger than the loss modulus and almost independent of the frequency. The solid-like behavior is supposedly caused by strong repulsive forces induced by the stabilizing agent.

With the aim of increasing peanut butter consumption by providing peanut butter in the more convenient form of slices, Diaz (2000) made an attempt to prepare the peanut butter in the more convenient slice form, much like cheese, ready to be put on bread with shear thinning texture that could hold its shape, but become soft when eaten. The best formulation for peanut butter slices was given as: Peanut butter 95.30 %, Gellan Gum 2.4 %, paraffin wax 3.07 % and the process variables are: Temperature 61 °C, cooling rate 22 °C and storage temperature 4 °C. Adhikary (2001) studied the effect of various storage conditions on the physical properties of peanut butter slices for different packaging materials (Saran wrap, HB1-a high barrier material, DK11- a low barrier material, Cheese packaging material Print Pack having 3.0, 4.1075, 24.0 and 6.51 $g.m^{-2}.day^{-1}$ moisture permeability and 20.0, 0.5425, 6,920, and 160 $ml.m^{-2}.day^{-1}$ oxygen permeability respectively). Peanut butter slices exhibited good shelf-life properties of up to 6 months under refrigeration (4± 1 °C, <20%RH) for all packaging materials except DK11, which provides very low oxygen barrier. Lima et al. (2000) developed improved peanut flour for a reduced-fat peanut butter product. A commercial peanut flour (12 % fat) was mixed with water (30 % w/w), homogenized and drum-dried in a double drum dryer. Thin dried sheets were milled into flour which was no longer gritty and mixed with full fat (52.5 %) paste to obtain a 30 % fat reduction in the peanut butter product.

About 1.2 billion pounds of peanut butter are consumed annually in the United States. In 2008 to 2009, an outbreak involving *Salmonella* Typhimurium in peanut butter led to a recall of over 3,900 products by over 200 companies. More than 700 people became sick, 100 were hospitalized, and 9 people died from this outbreak (Grasso et al. 2010). Shachar and Yaron (2006) studied the heat tolerance of *Salmonella* enterica serovars Agona, Enteritidis, and Typhimurium in peanut butter and reported that the thermal treatments are inadequate to consistently destroy *Salmonella* in highly contaminated peanut butter and that the pasteurization process cannot be improved significantly by longer treatment or higher temperatures. Similar results were also reported by Ma et al. (2010), thermal treatments of peanut butter at 90 °C for less than 30 min were not sufficient to kill large populations (5 log CFU/g) of *Salmonella* in highly contaminated peanut butter. Grasso et al. (2010) examined the efficacy of high-pressure processing (HPP) to decrease *S.* Typhimurium American Type Culture Collection (ATCC) 53647 inoculated into peanut butter and model systems and reported that because of the protective effect of oil HPP may not help the microbial safety of water-in-oil food emulsions including peanut butter. Hvizdzak et al. (2010) studied the effectiveness of electron beam (E-beam) radiation (0 to 3.1 kGy) for the reduction of *Salmonella* serovars Tennessee (ATCC 10722) and Typhimurium (ATCC 14028) in creamy peanut butter. D_{10}-values showed that *Salmonella* Typhimurium was more resistant (0.82±0.02 and 0.73+ 0.01 kGy on TSA and XLD. respectively) than was *Salmonella* Tennessee (0.72±0.02 and 0.60±0.01 kGy on TSA and XLD, respectively) to E-beam radiation. E-beam irradiation is a promising food safety technique for the non-thermal pasteurization of peanut butter, however future studies should include sensory evaluation and consumer acceptance studies. No changes in total protein content, or total saturated and unsaturated fatty acid content of peanut butter were observed over a 14-day period at 22 °C when treated with E-beam irradiation (0, 3.0, 7.0, and 25 kGy) and no significant changes in spreadability were observed (El-Rawas et al. 2012). Ban and Kang (2014) studied the effect of gamma irradiation (60Co) treatment (0 to 3 kGy) on peanut butter product with different water activities (0.18, 0.39, and 0.65 a_w) inoculated with a 3-strain mixture of *Salmonella* Typhimurium. Water activity (a_w) of peanut butter product was likely the most critical factor affecting pathogen survival. When aw is reduced, radiolysis of water is reduced, thereby decreasing antimicrobial action. Lightness which was observed by using a colorimeter was slightly reduced on day 0. Acid values of peanut butter treated with Gamma irradiation were not significantly different from the control.

Soy butter

Soybeans (*Glycine max*) are excellent source of high-quality protein containing 40 g/100 g of high quality protein with all the essential amino acids needed for growth (Agrahar-Murugkar et al. 2013a). It contains many essential amino acids that our body does not have the ability to make. Soy bean and soy food provide a variety of health benefits including prevention of cardiovascular disease, cancer as well as menopausal treatment (Barret 2006). The popularity and acceptability of food products derived from soybeans is increasing due to their beneficial effects on nutrition and health (Pichel and Weiss 1967; Rinaldoni et al. 2012). Soy-butter is a relatively new product with limited commercial availability (Agrahar-Murugkar et al. 2013a) and it is a healthy alternative to peanut butter for consumers who are allergic to peanut butter (Glas 2006) and healthier too. Kellogg (1916) mentioned the process of soy butter making comprising of removal of skins from soy beans, roasting beans to a dark brown colour, then reducing the roasted beans to a fine powder, and then mixing the powder with an edible vegetable oil to make a paste. Baile (1927) mentioned an improved method for the preparation of soy butter as soaking of beans for 12 h, removing the skins and then boiling in any nut oil until beans attains good brown colour, making them into fine powder, addition of desired nut oil to yield a proper viscosity and then salting it. Pichel and Weiss (1967) described another improved method without 'grassy' or 'beany' flavour (Fig. 4). It has been described that the moisturising step should be controlled so as to avoid the weakening of the structure of the bean. Such control is assured by adding only enough moisture to remove 'grassy' or 'beany' flavour constituents, but not so much moisture that the beans are saturated with water. Glas (2006) reported that the addition of low calorie sweetener (sucralose) in homemade soy butter increased the force, decreased water activity and the overall quality is comparable with soy butter made with sugar.

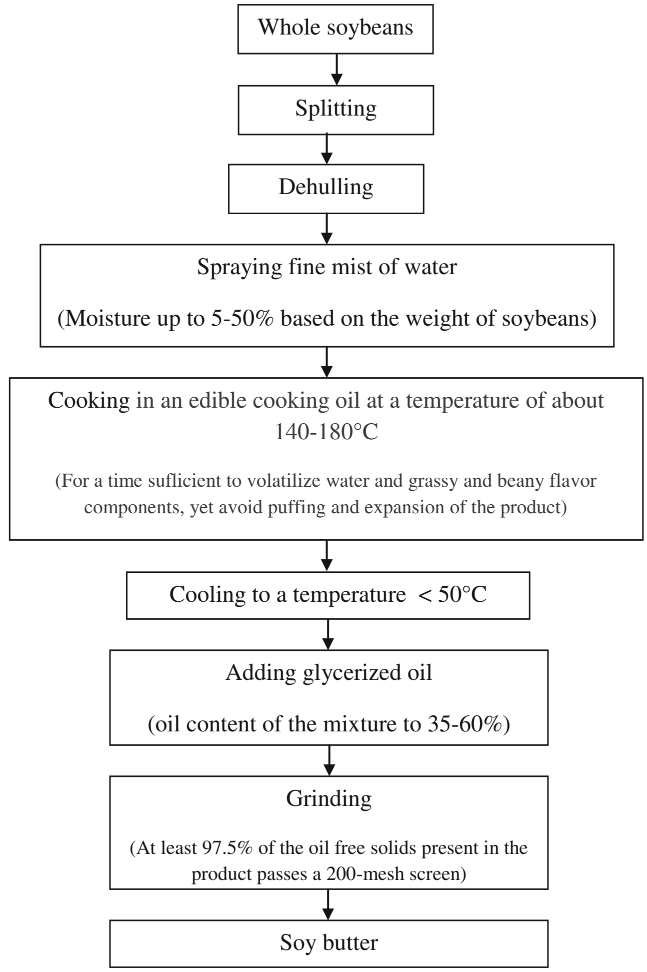

Fig. 4 Soy butter preparation without 'grassy' or 'beany' flavour. Source: Pichel and Weiss (1967)

Agrahar-Murugkar et al. (2013b) optimised roasting condition for preapartion of soy butter as 160 °C Temperature and 90 min time. Agrahar-Murugkar et al. (2013a) prepared soy butter using sprouted and unsprouted soybeans. Soy-butters behaved like visco-elastic shear thinning material with presence of hysteresis. Butter from sprouted beans showed decreased particle size, apparent viscosity and flow behavior index and increased consistency coefficient compared to butter from unsprouted beans. Agrahar-Murugkar et al. (2014) optimized conditions for soy butter making from sprouted soybeans. Roasting temperature of 127 °C for 37 min was the best condition for preparation of butter from sprouted soybeans and this butter contained 38.0±1.5 g/100 g of protein and 34.1±1.82 g/100 g fat on dry matter basis.

In 1998 July, The SoyNut Butter Co., a marketing company of Barrington, Illinois, introduced I.M. Healthy SoyNut Butter in Chunky, Creamy, or 100% Organic. They produce soy butter with the brand name "I.M. Healthy SoyNut Butter" and offer it in different choices like Creamy, Chunky, honey-sweetened and unsweetened flavors and now there is a Chocolate SoyNut Butter with 60% less sugar and 50% more protein. It is the "Mawoogah" alternative to the leading chocolate hazelnut spreads. In 2007 October, Hilton Soy Foods of Staffa, Ontario, Canada launched FreeNut Butter (Soynut Butter). Hilton Soy Foods is a Canadian company. It is the leading manufacturer specializing in high quality and unique peanutty tasting, yet peanut-free, School Safe SoyButter that "tastes, looks and spreads just like Peanut Butter". They produce soy butter in two variants i.e. wow butter creamy and wow butter crunchy.

Pistachio butter

Pistachio nut (*Pistacia vera*) is one of the most delicious and nutritious nut. The non-split pistachio is used in the production of pistachio oil, pistachio butter, pistachio chocolate and pistachio halva (Shakerardekani et al. 2011). Pistachio butter, a semi-solid paste, is made from ground and roasted pistachio kernels with adding some proper flavorants and sweeteners and is a semi-solid substance that behaves as non-Newtonian pseudoplastic with yield stress (Taghizadeh and Razavi 2009). For pistachio butter production, recommended range of roasting temperature and time for whole-kernel has been reported as 130–140 °C for 30–40 min (Shakerardekani et al. 2011). It is necessary to use proper amount of emulsifying and anti-oxidation agents in its formulation as it contains high amount of unsaturated oil in such a product (Shaker 2005). Ardakani et al. (2009) investigated the effect of two emulsifiers (lecithin and mono-di glycerides) in three levels (0.0, 1.0 and 2.0 %) on the oil leakage and the effect of antioxidant (BHT) in three levels (0.00, 0.01 and 0.02 %) on the on the peroxide values of pistachio butter. Samples containing lecithin and mono-diglycerides had the least leakage of oil after 4 months stored at 20 °C. Adding BHT antioxidant had a significant effect on peroxide value and shelf life of pistachio butter. The best formulation for production of pistachio butter was 72.99–82.99 % roasted pistachio kernels, 15–25 % sugar, 1 % lecithin, 1 % mono di glyceride and 0.01 % BHT. Roasting of the pistachios at 110 °C for 15 min was the best condition as determined by taste panelists. Taghizadeh and Razavi (2009) assessed the effect of different levels of emulsifier i. e. Lecithin and Mono-diglyceride (Without any emulsifier, 0.5, 1, 1.5 and 2 %) at different temperatures. The approximate composition (w/w%) of studied pistachio butter samples was grounded and roasted pistachio kernels 84 %, sweeteners such as sugar 10 %, moisture content 3 %, salt 1–2 %, and emulsifying agents 0–2 %. Pistachio butter containing 1 % of Mono-diglyceride mixture and lecithin was the most consistent, coherent and uniform. To respond to the consumers' demand of the low- calorie version of full fat pistachio butter, Emadzadeh et al. (2011) has formulated low- calorie pistachio butter (Fig. 5) and the viscous flow properties of low- calorie pistachio butter was studied. The effects of 3 fat replacers (Balangu seed gum, Reihan seed gum, xanthan) and 2 sweeteners (isomalt and sucrose) on the rheological parameters of different models (Power law, Casson, Bingham and Herschel- Bulkley models) were investigated. All the samples showed a shear thinning behavior. Emadzadeh et al. (2012) studied the effect of 3 fat replacers (Xanthan gum (0.06–0.1 wt.%), Reihan seed gum (0.01–0.023 wt.%), and Balangu seed gum (0.01–0.04 wt.%)), and 2 sweeteners (sucrose and isomalt) on time-dependent rheological properties of low-calorie pistachio butter. The steady shear behavior of all samples was shear thinning. In most cases, increasing the sweetener level led to a significant decrease in consistency coefficients. However, the effect on the flow behavior index was not significant. The effect of gum concentration on the rheological parameters was not significant, except for formulas prepared using Balangu seed gum. All formulas studied were stable on shelf. Emadzadeh et al. (2013) studied the changes in viscoelastic and textural characteristics that occur due to different types of fat replacers and sweeteners. The magnitudes of dynamic moduli increased in

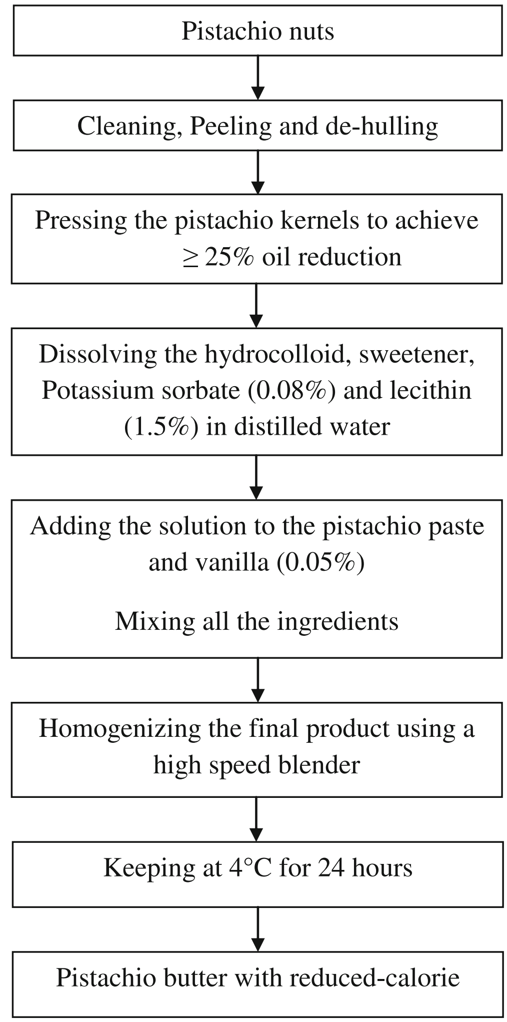

Fig. 5 Prepartion of reduced-calorie pistachio butter. Source: Emadzadeh et al. (2011)

the frequency sweep test with loss tan values <1. The elastic structure of all samples changed to viscous behavior with increasing temperature (5–65 °C), regardless of the type of fat replacers and sweeteners' level. The temperature sweep test on heating and cooling samples resulted in higher viscoelastic properties and more solid-like behavior. Shakerardekani et al. (2013) developed Pistachio spreads using pistachio paste as the main component, icing sugar, soy protein isolate (SPI), and red palm oil (RPO), at different ratios and reported that the work of shear for an acceptable spread as 0 to 11 kg. Presence of RPO had a direct effect on the viscoelastic behavior of the pistachio spreads.

Cashew butter

Cashew (*Anacardium occidentale*) plays an important role among tropical nuts, as an edible nut and is a principal industrialized product too (Chandrasekara and Shahidi 2011). Nagaraja (2003) prepared sweetened and flavoured spread from cashew kernel baby bits (CKBB). Among the sweetened spreads prepared with different flavours, cardamom spread was the most preferred. Defatting of CKBB did not affect the organoleptic acceptability of the spread. Lima et al. (2012) prepared cashew butter by roasting nuts immersed in vegetable oil at 140 °C for 3–4 min. Kernels (89.9 g/100 g), were ground with the other ingredients (refined cane sugar (8.0 g/100 g), soybean lecithin (2.0 g/100 g) and sodium chloride salt (0.1 g/100 g)) for 5 min in a food processor with the use of a stainless steel cutter. Different grades of kernals (Butts (B), kernels which are broken crosswise and are less than 7/8, but not less than 3/8 of a whole kernel, and whose cotyledons are still naturally attached; Splits (S), one half of a cashew kernel that has been split lengthwise, provided that no more than 1/8 of this cotyledon has been broken off; Pieces (P), pieces passing through sieve number 22 (8.00 mm opening) and retained on sieve number 4 (4.75 mm opening); Small pieces (SP), pieces passing through sieve number 4 (4.75 mm opening) and retained on sieve number 7 (2.80 mm opening); Special small pieces (SSP), pieces passing through sieve number 7 (2.80 mm opening) and retained on sieve number 8 (2.36 mm opening); Granules (G), pieces passing through sieve number 8 (2.36 mm opening) and retained on sieve number 10 (1.70 mm opening)) were tested for best quality butter and reported that the butter made from B (butts), S (splits) and P (pieces) kernel grades were of better quality.

Almond butter

Almond (*Prunus dulcis)* butter has significantly more fibre, calcium, and potassium than sunflower seed or peanut butter (Thomas and Gebhardt 2010). Spiller et al. (2003) compared the lipid-altering effect of roasted salted almonds and roasted almond butter with that of raw almonds, as part of a plant-based diet (Table 5). High-density lipoprotein-cholesterol (HDL) did not significantly change with raw or roasted almonds but slightly increased with almond butter. HDL cholesterol is the good cholesterol that cruises the bloodstream and high levels HDL reduces the risk for heart disease.

Sunflower butter

Sunflower (*Helianthus annuus)* seed butter has more monounsaturated fat, magnesium, phosphorus, zinc, copper, iron, manganese, and vitamin E, Selenium and less saturated fat than peanut butter (Thomas and Gebhardt 2010). However, sunflower have fibrous outer layer and associated moisture retention upon improper roasting. Nutritive properties of sunflower butter are equivalent to those of peanut butter and roasting conditions had a significant effect on nutritional and sensory quality, color, and spreadability of sunflower butter. Redness values represented by positive *a* values were 1.6, 2.9, 3.3, and 2.9 for sunflower butters made with raw kernels, conventionally roasted, microwave roasted, and from a health food store respectively (Dreher et al. 1983). Acceptable color ranges for sunflower butter to be darker than most commercially prepared peanut butters (Falk and Holm 1981; Lima and Guraya 2005). The sunflower butter prepared by added 7 % sugar, 1.1 % salt, 1.8 % stabilizer, and a low roast level has been reported as best determined by sensory data (Lima and Guraya 2005). The effect of roast level and stabilizer on sunflower butter property is shown in Table 6.

Sesame butter

Sesame (*Sesamum indicum*) butter called as *tahina, tehineh, tahin* is produced by milling of mechanically dehulled roasted

Table 5 Composition of raw and processed almods per 100 g edible portion

	Raw Almonds	Roasted Almonds	Almond Butter
Water (g)	4.2	1.3	2.1
Protein (g)	25.3	25.4	24.6
Total lipid (g)	49.5	52.5	55.7
MUFA (g)	30.7	32.1	32.7
PUFA (g)	10.6	11.4	13.8
SFA (g)	3.5	3.7	3.9
Carbohydrate (g)	17.9	18.5	14.5
Dietary fiber (g)	13.9	11.8	10.5
Vitamin E (mg ATE)	25.3	25.5	23.6
Phytosterols (mg)	113.6	125.8	145.1
Sodium (mg)	<10	209	<10

ATE Alpha Tocopherol equivalants, Source: Spiller et al. (2003)

Table 6 Effect of different stabilizers and roasting on sunflower butter property

	Stabilizer (%)	Roast level	Penetrometer depth (mm)	Hardness (N)	Oil separation (%)	Colour		
						L	a	b
Dritex-C	1.8	3	17.6	2,989	2.2	39.9	10.8	34.6
	1.6	3	20.3	1,343	3.6	39.9	10.7	34.3
PST	1.8	3	17.6	2,444	2.0	39.9	10.6	34.3
	1.6	3	18.5	1,779	3.3	39.9	10.5	34.0
Dritex-C	1.8	4	21.0	2,007	3.1	38.8	11.1	34.6
	1.8	2	21.7	1,464	3.6	42.7	9.1	33.8
	1.8	1	20.7	1,891	2.7	43.1	8.8	33.4

Dritex-C (hydrogenated cottonseed and rapeseed oils); PST (hydrogenated palm oil); Roast levels: 1: low, 2: medium-low, 3: medium-high, 4: high

Source: Lima and Guraya (2005)

sesame (Kahyaoglu and Kaya 2006; Ciftci et al. 2008). Kahyaoglu and Kaya (2006) studied the effect of heating time (120 min) and temperatures (120, 150, and 180 °C) on moisture content, color and texture of sesame seeds using conventional method optimized the processing of roasting at 155–170 °C for 40–60 min for the production of sesame paste.

Besides color, texture is another important control parameter for roasting. A faster moisture loss is occurred as roasting temperature increased. During roasting, sesame seeds become more crumble and brittle, which are typical characteristics of roasted products. EI-Adawy and Mansour (2005) reported that the tahina prepared by hot air roasting (130 °C for 1 h) and

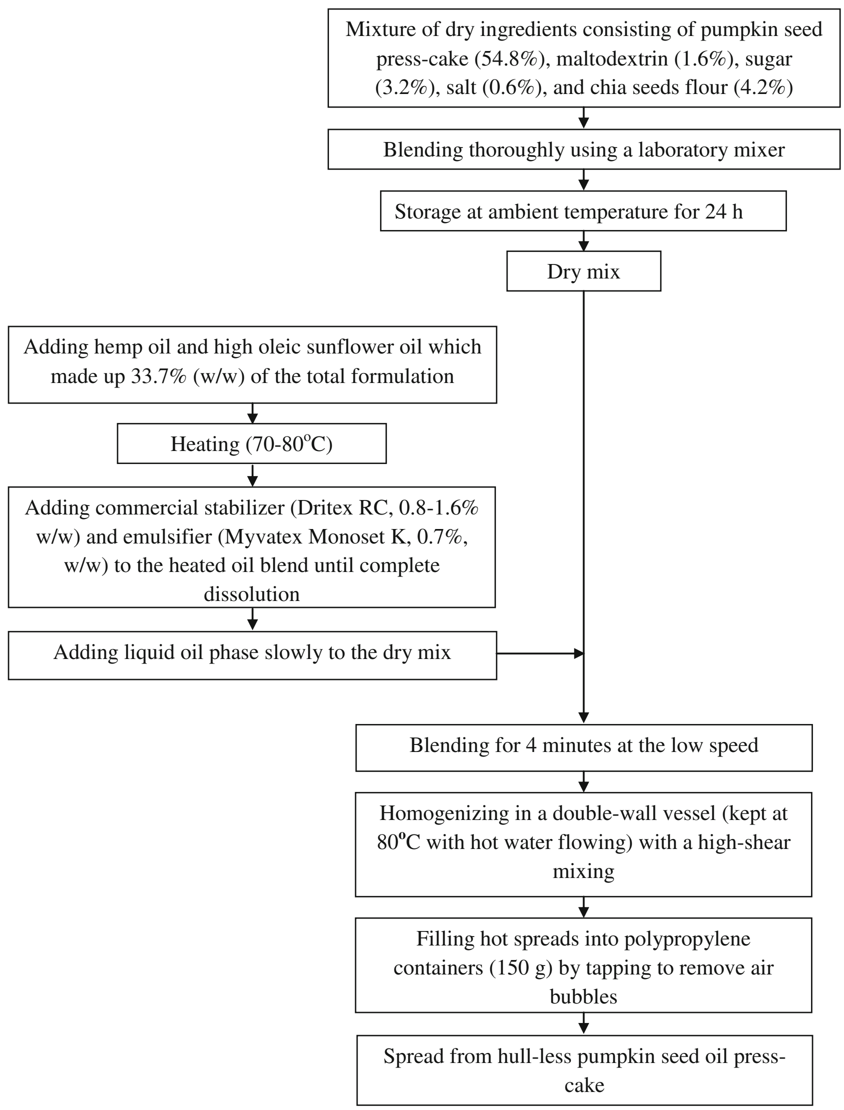

Fig. 6 Preparation of spread from hull-less pumpkin seed oil press-cake. Source: Radocaj et al. (2011)

vacuum roasting (100 °C for 1 h) had higher panel scores than the steam roasted (100 °C for 3 h) and hot plate roasted (130 °C for 1 h) for the tested sensory properties. Although sesame paste is shelf stable with respect to chemical deteriorative reactions, but its colloidal instability is a main problem during storage (Isa 2001). Both particle size and storage temperature had significant effect on the sesame paste stability. Higher particle sized (mean particle size 129.11 μm) sesame paste lost the stability at a higher rate than the smaller ones (mean particle size 14.23 μm). As the storage temperature was increased (20 to 40 °C), the colloidal stability of samples decreased due to the low viscosities of oil at high temperature (Ciftci et al. 2008).

Pumpkin seed butter

Pumpkin (*Cucurbita maxima*) seeds, commonly known as 'pepitas', are flat, encased in yellow-white husk (Amin and Thakur 2013; Abdel-Rahman 2006). Pumpkin seeds are nutritionally very good. They are rich source of proteins, fatty acids and minerals (Magnesium, Copper and Zinc). Pumpkin seeds are rich not only in proteins but also a rich source of antioxidants vitamins such as carotenoids and tocopherols and minerals, and low in fats and calories (Amin and Thakur 2013). The nutritional value of pumpkin seeds is based on high protein content (25–51 %) (Abdel-Rahman 2006). Pumpkin seeds could be utilized successfully as a good sources of edible protein (320 g/kg) and oil (450 g/kg) for human consumption, as well as animal food; at the same time, it minimizes waste pollution (El-Soukkary 2001). Pumpkin seeds are popular snack that are found hulled/semi-hulled (Amin and Thakur 2013). Recently the pumpkin seed butter has gained more popularity due to its high nutritional properties. Radocaj et al. (2011) optimized spread formulation from hull-less pumpkin seed oil press-cake. Hull-less pumpkin seed press-cake, a by-product of the pumpkin oil pressing process, was used to formulate a fat-based spread which resembled commercial peanut butter, both in the appearance and in texture. Method followed for reparation of spread is shown in Fig. 6. The components content was optimized for the minimum values of hardness and ad-hesiveness, with a target for maximum values of cohesiveness, with a stability of the spreads similar to peanut butter. Samples with 1.0 % stabilizer/40 % hemp oil content and 1.2 % stabi-lizer/20 % hemp oil content were closest to the instrumental texture of the peanut butter sample.

Butter with combination of nuts

Whisner (2006) studied the effect of soy bean addition (<50 %) in peanut butter to make a healthier nut spread and found that the firmness increased with the increase of soy bean addition. Mazaheri-Tehrani et al. (2009) studied the physicochemical and sensory properties of peanut spreads fortified with soy flour. Adhesiveness increased, cohesiveness decreased with incorporation of soy flour in peanut spreads.

Conclusion

Different nut and seed butters or spreads are prepared by roasting the nut and seed, grinding, mixing with sugar, salt, stabilizers and emulsifiers. Optimum roasting conditions are necessary for getting the nut and seed butters with better flavour. Degree of grinding and process followed for grinding effects the smoothness and mouth feel of the butter. Optimization of different quantities of sugar, salt, stabilizers and emulsifiers is needed for getting improved tasty, stabilized butter without any oil separation during storage. As consumer's preference is increasing for low fat butters, there is need to optimize the processes for producing low fat nut and seed based butters or spreads.

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