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Preparation and Evaluation of Sunflower Butter as a Fat Substitute

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ABSTRACT

The study aimed to develop and evaluate sunflower butter as a minimally allergenic alternative to traditional plant-based butters and as a potential fat substitute in pâté bread. Sunflower butter, prepared from sunflower seeds, was analyzed for its chemical composition, antioxidant activity, oxidative stability, microbiological safety, and sensory characteristics. The results highlighted its rich nutritional profile, including high protein (22.5g/100g), dietary fiber (9.6g/100g), and vitamin E content (22.1IU/100g). It also demonstrated significant antioxidant activity, with a phenolic content of 735mg/100g and high oxidative stability during storage at 4°C. Microbiological analysis confirmed its safety, showing no growth of *E. coli*, molds, or yeasts over three months. When incorporated into pâté bread as a fat substitute, sunflower butter improved sensory attributes, including taste, texture, and overall acceptability. These findings suggest sunflower butter as a nutritious, health-beneficial, and allergen-friendly alternative, with potential applications in food industries.

1. Introduction

Seed butter is a spreadable product created by milling seeds into a paste. Plant-based butters are popular vegan alternatives to traditional dairy butter. However, common options such as soy, peanut, and tree nut butters are major allergens, limiting their use in foods for individuals with allergies (Boyce et al., 2010). This highlights the need for minimally allergenic alternatives like sunflower butter, which can cater to those unable to consume allergenic products while also meeting the growing demand for vegan protein sources (Radnitz et al., 2015). Sunflower butter offers additional benefits beyond being vegan and minimally allergenic. It has a lower calorie content of 80 kcal per tablespoon, compared to other plant-based butters, which range from 80 to 106 kcal per tablespoon. Moreover, it provides a protein content of 3.0g per tablespoon, surpassed only by peanut butter (3.8g per tablespoon) and soy butter (4.0g per tablespoon) (Gorrepati et al., 2015). Nutrition scientists are increasingly recognizing the importance of consuming adequate amounts of complex plant foods, such as seeds, nuts, and whole grains, on a regular basis. Sunflower seeds, in particular, are a highly nutritious and versatile food that can be easily incorporated into various diets (Holliday and Phillips 2001). These seeds are considered one of nature's most potent nutritional powerhouses, providing an abundance of protein, fiber, selenium, copper, zinc, iron, folate, phytochemicals, and beneficial unsaturated fats. Consuming just one ounce of sunflower seeds daily can significantly enhance the nutritional quality of a diet (Maier et al., 2009). In addition, specific minerals found in sunflower seeds, such as selenium, have been shown to reduce the risk of certain cancers. Sunflower butter, derived from these seeds, offers even greater nutritional benefits. It contains more than twice the amount of phosphorus, selenium, copper, and iron compared to peanut butter (USDA, 2017). As a result, sunflower butter serves as an excellent allergen-friendly alternative to dairy-based and other plant-based butters. However, sunflower seeds have a low lysine content and a high level of insoluble fiber, which can reduce their digestible energy (Silva et al., 2002). Despite this, they are rich in phytochemicals such as tocopherols, choline, betaine, lignans, phenolic acids and arginine.

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These compounds contribute to sunflower seeds being classified as a functional food, as they provide health benefits beyond basic nutrition. Due to their antioxidant properties, sunflower seeds can help prevent various illnesses, including cancer, obesity, arterial hypertension, and hypercholesterolemia (Skrypetz 2003). Sunflower seeds are also an excellent source of essential vitamins and minerals, including thiamine, folic acid, vitamin B6, and vitamin E. They are high in fat, with over 90% of the fat content being polyunsaturated fatty acids, primarily linoleic acid (omega-6). Vitamin E, the body's primary lipid-soluble antioxidant, is abundant in sunflower seeds. Its anti-inflammatory properties help protect against inflammatory disorders such as rheumatoid arthritis, cancer, diabetes, and osteoarthritis, which are often triggered by free radical damage. Consuming just a quarter cup of sunflower seeds can provide approximately 90% of the recommended daily intake of vitamin E. Studies have also shown that vitamin E can reduce the risk of colon, bladder, and prostate cancers (Warsner et al., 2003). Oxidative rancidity in high-fat products is commonly assessed using lipid oxidation measurements. The peroxide value (PV) measures the peroxides and hydroperoxides formed during the early stages of oxidation and has been widely used to evaluate oilseed products, including peanut butter, shea butter, and sunflower kernels. The thiobarbituric acid reactive substances (TBARS) assay, on the other hand, evaluates rancidity caused by secondary oxidation compounds in high-fat food systems by measuring aldehydes formed as hydroperoxides degrade. Together, these two methods provide a reliable indication of the oxidative stability of high-fat food products (El-Rawas et al., 2012). The shelf life of seed butter can be affected by factors such as microbial contamination, lipid oxidation, and texture changes. Microbial contamination may involve fungi, bacteria, or both, potentially leading to spoilage or posing safety risks. Additionally, the high lipid content of seeds makes them prone to rancidity if stored in conditions that promote oxidation, particularly in the absence of antioxidants like vitamin E (Aryana et al., 2003). The objectives of this study were to (1) develop a nonallergenic butter alternative using sunflower seeds, which are widely available in Egypt. (2) evaluate the use of sunflower butter as a fat substitute to improve the overall quality of pâté bread. (3) assess the nutritional and sensory qualities of sunflower butter. (4) investigate the impact of sunflower seeds' vitamin E content on the shelf life (oxidative stability) of sunflower butter without compromising the quality of the final product.

2. Material and Method

Materials

Sunflower seeds were obtained from the Crops Research Institute, Agricultural Research Center, Ministry of Agriculture, Giza, Egypt. Wheat flour, salt, yeast, honey, and olive oil were purchased from the local market in Cairo, Egypt. Chemicals, reagents, and solvents used for proximate analysis were sourced from El-Gomhoria Pharmaceutical Company, Cairo, Egypt.

Methods

Preparation for sunflower Butter

Sunflower seeds were prepared using a modified version of the method described by Pepra-Ameyaw et al. (2022). The sunflower seeds were ground into a fine powder and then crushed into a paste.

Honey (10g) and salt (2g) were thoroughly mixed into the paste.

Preparation of pate bread

Pâté bread was formulated using sunflower butter as a fat substitute. The bread-making process followed the method of Alvarez-Jubete et al. (2010), with some modifications. The sunflower butter was prepared by mixing sunflower seed powder with salt, honey, and olive oil. For the preparation of pâté bread, the dry ingredients (1.5g yeast and 1g salt per 100g wheat flour) were blended to ensure uniform distribution. The sunflower butter was then incorporated, and the mixture was manually kneaded for 15 minutes to form a homogeneous dough. The dough was left to ferment at 25±2°C for 30 minutes in a mold (20×10×6cm). After fermentation, the dough was baked in a locally manufactured mechanical gas oven at 250°C for 15 minutes. The baked loaves were allowed to cool before being stored for further analysis.

Chemical Composition

Moisture, total protein, total fat, ash, and total carbohydrate (calculated by difference) were analyzed following the methods described by AOAC (2012) and AOAC (2015).

Mineral Composition

The mineral content, including magnesium, calcium, zinc, iron, and selenium, was determined using an atomic absorption spectrophotometer (PUG 100 X Series, PerkinElmer, Model 110013). The analysis followed the methods outlined by AOAC (2015).

Vitamin Determination

The vitamin content, including vitamin E, niacin, and vitamin B6, was analyzed using the procedures described by AOAC (2015).

Determination of Total Dietary Fiber (TDF)

Total dietary fiber (TDF) was measured according to the methods described by AOAC (2012) and Prosky et al. (1992).

Determination of Fatty Acid Profile

The fatty acid profile was determined using gas-liquid chromatography (GLC) as outlined by AOCS (1985).

Determination of Antioxidant Activity in Sunflower Butter

Total Phenolic Content (TPC)

The total phenolic content of sunflower butter was determined using the method described by Singleton and Rossi (1965).

Total Flavonoid Content

The total flavonoid content was measured following the method described by Brand-Williams et al. (1995).

DPPH Radical Scavenging Activity

The DPPH (2,2-Diphenyl-1-picrylhydrazyl) radical scavenging activity was evaluated according to the method of Katalinic et al. (2006).

Oxidative Stability Test

Peroxide Value (PV)

The peroxide value was determined using the method outlined by Jeyakumari et al. (2018).

Thiobarbituric Acid (TBA) Assay

The TBA assay was used to quantify rancidity caused by secondary oxidation compounds in high-lipid food systems. This method measures aldehydes, such as malondialdehyde (MDA), formed as unstable hydroperoxides break down. MDA reacts with thiobarbituric acid (TBA) and trichloroacetic acid (TCA) to form a pinkish-red complex. The absorbance of this chromogen was measured at 531 nm using a spectrophotometer, following the method described by Sinnhuber and Yu (1977).

Microbiological Analysis

Enumeration of Coliforms

Coliform counts were determined using MacConkey broth as described by WHO (1963) and El-Hadedy and El-Nour (2012).

Yeast and Mold Count

Yeast and mold counts (CFU/g) were assessed using the method described by Copetti **et al**. (2009).

Sensory Evaluation

Sensory evaluation was conducted to assess various product characteristics, including color, odor, chewability, taste, texture, and overall acceptability. The evaluation was performed by 15 trained staff members from the Agricultural Research Center (Cairo, Egypt) using a score sheet. Each characteristic was rated on a 10-point scale, where 1 represented "very poor" and 10 represented "very good." The evaluation method followed the guidelines described by Penfield and Campbell (1990).

3. Results and Discussion

Table 1 shows that sunflower seed butter has a low moisture content, ranging from 2.9 g/100g. The moisture content of sunflower seed butter is below 10%, which is within the limit described by Grompone (2005) to avoid enzymatic reactions.

Sunflower seed butter is an excellent source of protein, containing 22.56 g/100g, while its fat, carbohydrate, total fiber, and ash contents are 50.24g, 20.58g, 9.67g, and 3.72g per 100g, respectively.

In comparison, peanut butter has a higher moisture content (4.32g/100g) and a lower total fiber content (5.2g/100g) than sunflower seed butter. The protein, ash, fat, and carbohydrate contents of peanut butter are 21.9g, 4.2g, 49.1g, and 20.4g per 100g, respectively. According to Maier et al. (2009), sunflower seeds are rich in protein, fiber, selenium, copper, zinc, iron, folate, and phytochemicals, along with healthy unsaturated fats. Consuming one ounce of sunflower seeds daily can enhance the nutritional value of the diet. These findings are consistent with those of Silva et al. (2002), who reported that sunflower seeds are a valuable ingredient in feed production due to their high protein content. However, sunflower seeds also contain a high level of insoluble fiber, which can reduce digestible energy. Sunflower seeds, rich in fiber, contribute to overall health by reducing cholesterol, stabilizing blood sugar, and preventing constipation.

Table 1. Chemical composition (g/100g) of sunflower butter compared with peanut butter

Component	Sunflower butter, Conc., (g/100g)	Peanut butter, Conc., (g/100g)
Moisture	2.9	4.3
Protein	22.5	21.9
Ash	3.7	4.2
Fat	50.2	49.1
Total dietary fiber	9.6	5.2
Total carbohydrate	20.5	20.4

Minerals and Vitamins components of sunflower butter

Table 2 shows that sunflower seed butter is an excellent source of vitamin E (α-tocopherol), providing 22.1IU, and niacin (6.5mg/100g). These results are consistent with Warsner et al. (2003), who reported that a quarter cup of sunflower seeds can provide about 90% of the daily recommended intake of vitamin E. Sunflower seed butter is also a good source of vitamin B6 (0.56mg/100g), which has been shown to alleviate symptoms of depression (Bazzano, 2009). Sunflower seed butter is an excellent source of magnesium (300mg/100g) and selenium (100mg/100g). Sunflower seeds are a good source of selenium, an essential trace mineral for human health. Several studies, including prospective studies, intervention trials, and animal model research, suggest that selenium intake is inversely correlated with cancer incidence. Additionally, sunflower seeds are a significant source of zinc (4.53mg/100g), which plays a key role in immune health and helps fight infections (Oliver, 2000). However, sunflower seed butter is relatively low in calcium (64.22mg/100g) and iron (4.23 mg/100g). The iron content of one ounce of sunflower seeds accounts for approximately 10% of the daily value. Iron is essential for transporting oxygen to the lungs, blood, and cells, and a deficiency can lead to anemia, fatigue, and increased susceptibility to infections (Wintergerst et al., 2007). These findings align with those of Holliday and Phillips (2001), who highlighted sunflower seeds as one of the best complete foods, easy to incorporate into diets and a great nutritional source.

Table 2. Vitamin and Minerals Component of sunflower butter

Component	Conc.	
Vitamin E IU	*22.1	IU
Niacin	*6.5	mg/100g
B6	0.56 (-)	mg/100g
Magnesium	*300	mg/100g
Calcium	64.2	mg/100g
Zinc	4.53 (-)	mg/100g
Selenium	*100	mg/100g
Iron	4.2	mg/100g

(*) mean that an excellent source, (-) mean that a good source

Data presented in Table 3 show that sunflower butter contains a total fat content of 50.2g/100g, with 8.5g of saturated fat, 26.3g of polyunsaturated fat, and 15.2g of monounsaturated fat per 100g. Sunflower seeds and oil contain unsaturated fats that may help protect the heart, including monounsaturated oleic acid and polyunsaturated linoleic acid. Studies suggest that diets higher in unsaturated fats are better for health than low-fat diets, as they lower LDL (low-density lipoprotein), commonly known as "bad" cholesterol, and triglycerides, while maintaining higher levels of HDL (high-density lipoprotein), also known as "good" cholesterol, thereby improving the lipid profile (Oliver, 2000). These results are consistent with those of Warsner et al. (2003), who found that fat is the primary source of calories in sunflower seeds. One ounce of deshelled sunflower seeds contains approximately 163 calories and 14g of fat. As a good source of both monounsaturated and polyunsaturated fatty acids, sunflower seeds help remove plaque that can form in blood vessels due to low-density lipoproteins. This can reduce the risk of strokes and heart attacks, significantly improving cardiovascular health. Additionally, sunflower seeds contain linoleic acid (LA), a pro-health fatty acid, which has been shown to prevent many types of infectious diseases and cancer due to its powerful antioxidant properties.

Table 3. Total fat content (g/100g) of sunflower butter

Component	Conc. (g/100g)
Total fat	50.2
Saturated fat	8.5
Polysaturated fat	26.3
Monosaturated fat	15.2
Free Fatty Acid (as oleic), %	1% max

Antioxidant Activity of Sunflower Butter

Table 4 shows the antioxidant capacity of sunflower butter. Specifically, the phenolic content and flavonoid content were 735 mg/100g and 305.80 mg/100g, respectively. The antioxidant activity of sunflower butter was higher at concentrations of 0.05% (26.32), 0.1% (61.05), and 0.2% (86.32). Table 4 also presents the correlation coefficient between antioxidant compounds and antioxidant activity in sunflower butter. Both total polyphenols (TP) and total flavonoids showed a linear correlation with DPPH. These results indicate that total phenolic content (TPC) and total flavonoids significantly contribute to the antioxidant activity of sunflower butter. The overall results revealed that DPPH values ranged from 26.32 to 86.32, suggesting that sunflower butter may play a role in the positive management of oxidative stress-related ailments such as cancer, cardiovascular diseases, and lipid peroxidation in vivo. The antioxidant activity of natural compounds has been shown to be involved in terminating free radical reactions. The DPPH radical scavenging activity is particularly used to evaluate the hydroxyl chain-breaking activity of lipid (and protein) peroxidation (Aparadh et al., 2012).

Table. 4 Antioxidant activity, Total phenols, total flavonoids and (% DPPH) of sunflower butter

Item	Total phenols (mg gallic acid equivalent /100 g)	Total Flavonoids (mg rutin equivalent /100 g)	% DPPH Radical-Scavenging Activity		
			0.05%	0.1%	0.2%
Sunflower butter	735	305.80	26.32	61.05	86.32

Sensory Evaluation

Sensory evaluation is a crucial factor in determining the quality of food. It helps assess whether trained panelists find various product samples (sunflower butter and pâté bread) acceptable. The sensory quality attributes of sunflower butter (color, odor, degree of chewing, taste, texture, and overall acceptability) were compared with those of peanut butter, as shown in Table 5. The tabulated data demonstrated significant differences ($p < 0.05$) in the color, odor, degree of chewing, taste, texture, and overall acceptability of sunflower butter compared to peanut butter. Sunflower butter received significantly higher scores ($p < 0.05$) for color, odor, degree of chewing, taste, texture, and overall acceptability. The sensory quality attributes of pâté bread (color, odor, degree of chewing, taste, texture, and overall acceptability) supplemented with sunflower butter as a fat substitute were compared with control pâté bread (without sunflower butter), as shown in Table 6. The data indicated significant differences ($p < 0.05$) in the color, odor, degree of chewing, taste, texture, and overall acceptability of pâté bread with sunflower butter compared to the control. Regarding overall acceptability, the pâté bread with sunflower butter as a fat substitute scored significantly higher ($p < 0.05$) with a score of 9.222 compared to the control sample, which scored 8.444. The pâté bread with sunflower butter as a fat substitute also received significantly higher scores ($p < 0.05$) for color, odor, degree of chewing, and taste. When sunflower butter was added to wheat flour as a fat replacement, the chewiness and cohesiveness of the flour gel significantly increased compared to the control. Despite being a healthful and hypoallergenic plant-based spread, sunflower butter can positively impact the flavor and mouth feel of baked goods (Lima and Guraya, 2005).

Table 5. Sensory evaluation of sunflower butter compared with peanut butter

Treatments	Color	Odor	Degree of chawing	Taste	Texture	Overall acceptability
Peanut butter	9.279±0.442[b]	8.222±0.972[b]	8.556±0.527[b]	9.500±0.500[a]	9.402±0.491[a]	9.000±0.472[b]
sunflower butter	9.946±0.163[a]	9.222±0.667[a]	9.222±0.667[a]	9.500±0.503[a]	9.402±0.701[a]	9.444±0.527[a]
L.S.D.	0.5547	0.7202	0.6647	0.5368	0.6215	0.4158

Table 6. Sensory evaluation of pate bread supplemented with sunflower butter as replacement of fat compared with control pate bread (without sunflower butter)

Treatments	Color	Odor	Degree of chawing	Taste	Texture	Overall acceptability
Control (pate bread without sunflower butter)	8.612±0.929[c]	8.889±0.601[ab]	8.222±0.667[b]	8.167±0.707[b]	9.402±0.701[a]	8.444±0.527[c]
Sample (pate bread with sunflower butter)	9.501±0.500[ab]	9.000±0.707[a]	9.333±0.866[a]	9.500±0.498[a]	9.291±0.673[a]	9.222±0.441[ab]
L.S.D.	0.5547	0.7202	0.6647	0.5368	0.6215	0.4158

Oxidative Stability Test

Peroxide Value (PV) and 2-Thio-Barbituric Acid (TBA) of Sunflower Butter During Storage at 4° C The peroxide value (PV) is a measure of the peroxides and hydroperoxides formed during the initial stages of oxidation. The results from the peroxide value assay are shown in Table 7. During the storage period, the peroxide values ranged from 2.397 to 16.451meq/kg. The peroxide value significantly peaked at the end of the storage period. The antioxidant content in sunflower seeds exhibited lower peroxide values during the 3-month storage period, indicating greater oxidative stability. The results shown in Table 7 also indicate that TBA values are an indirect measure of the aldehydes formed during lipid oxidation.

Aldehydes are secondary or tertiary byproducts of fatty acids in the product. During the 3-month storage, TBA values ranged from 0.02 to 1.25 mg malondialdehyde per kg fat. Sunflower butter, which contains high levels of antioxidants such as vitamin E, exhibited lower TBA values, indicating the greatest oxidative stability. These results are consistent with the findings of Warsner et al. (2003), who reported that vitamin E, a primary lipid-soluble antioxidant in the body, is found in sunflower seeds. Consuming a quarter cup of sunflower seeds can provide approximately 90% of the daily vitamin E requirement. An ideal hypothetical scenario in lipid oxidation would involve an initially low or zero peroxide value. If all the peroxides formed could remain intact, the oxidative stability would be maximized, as suggested by Ambrosone et al. (2006).

Table 7. Peroxide values and TBA values for sunflower butter sample during storage period at stored 4 °C

Storage time	Peroxide value (meq/kg)	TBA (mg malonaldehyde/kg fat)
Zero time	2.397±0.241^{e}	0.021±0.002^{f}
2 weeks	3.957±0.399^{de}	0.083±0.008^{f}
4 weeks	5.063±0.510^{d}	0.299±0.030^{e}
6 weeks	8.194±0.825^{c}	0.434±0.044^{d}
8 weeks	9.187±0.925^{c}	0.651±0.065^{c}
10 weeks	13.237±1.333^{b}	0.961±0.097^{b}
12 weeks	16.451±1.657^{a}	1.251±0.126^{a}
L.S.D.	1.6923	0.1192

TBA: Alphabetically, the averages are arranged from best to worst.
Peroxide: Alphabetically, the averages are arranged worst to best.
Reported values are the mean ±St.D of three replicated.
Means in the same column with different superscript letters were significant ($p < 0.05$).

Table 8 shows that the results revealed no growth of *E. coli*, molds, or yeasts during the 3-month storage period at refrigerator temperature (4°C). These results are consistent with Grompone (2005), who found that the moisture content of sunflower seed butter was below 10%, which is within the limit necessary to prevent enzymatic reactions. Furthermore, these findings align with Aryana et al. (2003), who reported that microbial contamination could be linked to bacteria, fungi, or both. If microbes are present, they could pose a safety risk or cause spoilage. Due to the high lipid content of seeds, they are prone to oxidation if stored in conditions that promote rancidity, especially in the absence of proper antioxidants such as vitamin E.

4. Conclusion

The current study provides valuable insights into the health benefits of sunflower seeds. To promote sustainable development in health and nutrition, sunflower seed butter serves as a slightly allergenic alternative to dairy and other plant-based butters, making it particularly useful for individuals with peanut allergies. Sunflower butter can also be used as a fat substitute. When incorporated into pate bread, sunflower butter enhances the product's quality by improving its color, aroma, chewiness, and overall texture. Therefore, it is essential for the food industry to focus on developing value-added products that utilize sunflower seeds.

Table 8. Microbiology examination of sunflower butter during storage period at refrigerator temp. 4°C

Microbial Count (log CFU/g)	Sunflower butter
E. coli	Negative
Molds	Nil
Yeasts	Nil

References

A.O.C.S. (1985). The Official and Tentative Methods of the American Oil Chemists, Soc., 14th ed. Pub. By American oil Chemists, Society. 508 South Street, Champaign, Illinois 61820, USA.

Alvarez-Jubete, L., Auty, M., Arendt, E.K. and Gallagher, E. (2010). Baking properties and microstructure of pseudocereal flours in gluten-free bread formulations. European Food Research and Technology, Zeitschrift fur Lebensmittel- Untersuchungund Forschung. A, 230, 437–445.

Ambrosone, L., Mosca, M. and Ceglie, A. (2006). Oxidation of water emulsified olive oils. Food Hydrocoll 20:1080–1086.

AOAC (2015). Official methods of analysis of Association of Official Analytical Chemists. AOAC, Washington, USA.

AOAC, (2012). AOAC official methods of analysis (18th ed). Gaithersburg, USA: AOAC international.

Aparadh, V.T, Naik, V.V and Karadge, B.A. (2012). Antioxidative properties (TPC, DPPH, FRAP, metal chelating ability, reducing power and TAC) within some *Cleome* species. *Annali Di Botanica*, 2:49–56.

Aryana, K., Resurreccion, A.V.A., Chinnan, M.S. and Beuchat, L.R. (2003). Functionality of palm oil as a stabilizer in peanut butter," Journal of Food Science, vol. 68, no. 4, pp. 1301–1307.

Bazzano, L.A. (2009): Folic acid supplementation cardiovascular disease: The state of the art. Am J Med Sci338: 48-49.

Boyce, J., Assa'ad, A. and Burks, W. (2010): Guidelines for the diagnosis and management of food allergy in the United States. J Allergy Clin Immunol 126:301–402.

Brand-Williams, W., Cuvelier, M.E., Berset, C. (1995): Use of a free-radical method to evaluate antioxidant activity. LWT Food Sci. Technol., 28, 25-30.

Copetti, M., Santurio, J., Cavalheiro, A., Alves, S. and Ferreiro, L. (2009): Comparison of different culture media for mycological evaluation of commercial pet food. Acta Sci. Vet. Porto Alegre, RS 37, 329–335.

El-Hadedy, D. and El-Nour, S.A. (2012): Identification of Staphylococcus aureus and *Escherichia coli* isolated from Egyptian food by conventional and molecular methods. Journal of Genetic Engineering and Biotechnology, 10(1), pp.129-135.
https://doi.org/10.1016/j.jgeb.2012.01.004

El-Rawas, A., Hvizdzak, A., Davenport, M., Beamer, S., Jaczynski, J. and Matak, K. (2012). Effect of electron beam irradiation on quality indicators of peanut butter over a storage period, Food Chemistry. 133(1):212–219, https:doi.org/10.1016j.foodchem.2011.12.078,2-s2.0-84857111069.

Gorrepati, K., Balasubramanian, S. and Chandra, P. (2015). Plant based butters. J Food Sci Technol. 52:3965–3976.

Grompone, M.A. (2005). Sunflower oil. In: Shahidi, F. (ed.) Bailey's Industrial Oil and Fat Products. Volume 2, Edible Oil & Fat Products. Edible oil. 6th ed.

Holliday, R. and Phillips, K. (2001). Health benefits of the sunflower kernel. Cereal Foods World. 46: 205-208.

Jeyakumari, A., Murthy, L. and Kumar, A. (2018): Biochemical quality assessment of shrimp and shrimpery products. ICAR-Central Institute of Shrimperies Technology, Cochin.

Katalinic, V., Milos, M., Kulisic, T. and Jukic, M. (2006). Screening of 70 medicinal plant extracts for antioxidant capacity and total phenols. Food Chemistry. 94(4), 550–557.

Lima, I.M. and Guraya, H.S. (2005). Optimization analysis of sunflower butter. J Food Sci., 70: S365–S370.

Maier, T., Schieber, A., Kammerer, D.R., Carle, R. (2009). Residues of grape (Vitis vinifera L.) seed oil production as a valuable source of phenolic antioxidants. Food Chem., 112: 551-559.

Oliver, M. (2000). Cholesterol and strokes: Cholesterol lowering is indicated for strokes due to carotid atheroma. BMJ., 320: 459-460.

Penfield, M.P. and Campbell, A.M. (1990). Shortened Cakes. In "Experimental Food Science," 3rd ed. Academic Press, Inc. San Diego, CA. pp. 452-70.

Pepra-Ameyaw, N.B., Lo Verde, C., Drucker, C.T., Owens, C.P. and Senger, L.W. (2022). Preventing chlorogenic acid quinone- induced greening in sunflower cookies by chlorogenic acid esterase and thiol-based dough conditioners. LWT, 174, 114392. https://doi.org/10.1016/j.lwt.2022.114392

Prosky, L., Asp, N.G., Schweizer, T.F., DeVries, J.W. and Furda I. (1992): Determination of insoluble and soluble dietary fiber in foods and food products: Collaborative study. J. AOAC., 75:360–367.

Radnitz, C., Beezhold, B. and DiMatteo, J. (2015). Investigation of lifestyle choices of individuals following a vegan diet for health and ethical reasons. Appetite, 90:31–36.

Silva, C.A., Pinheiro, J.W., Fonseca, N.A.N., Cabrera, L., Novo, V.C.C., Silva, M.A.A., Canteri, R.C. and Hoshi, E.H. (2002). Sunflower meal to swine on growing and finishing phase: digestibility, performance and carcass quality. Revista Bras. Zootec. 31(2):982-990.

Singleton, V.L. and Rossi, J.A. Jr. (1965): Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents, AJEV., 16:144-158.

Sinnhuber, R.O. and Yu, T.C. (1977). The 2-thiobarbituric acid reaction. An objective measure of the oxidative deterioration occurring in fats and oils. Abura Kagaku., 26:259-267.

Skrypetz, S. (2003): Sunflower seed: Situation and outlook. Agric Agri-Food Can Bull., 16:1-12.

United States Department of Agriculture (USDA) (2017). Foreign Agricultural Service. Oilseeds: World.

Van Soest, P.J. (1967). Development of a comprehensive system of feed analysis and its application to forages. J. Anim. Sci., 26(1):119-128.

Warsner, K., Vick, B., Kleingartner, L., Isaat, R., Doroff, K. (2003). Compositions of sunflower, Nusun (mid- oleic sunflower) and high-oleic sunflower oils. In: Proc. sunflower res. workshop, fargo. Mandan, ND: NSFA., pp. 16-17.

Wintergerst, E.S., Maggini, S. and Hornig, D.H. (2007). Contribution of selected vitamins and trace elements to immune function. ANM., 51: 301-323.

World Health Organization, (1963). International standards for drinking-water. 2nd ed., WHO, Geneva.