Pak. j. sci. ind. res. Ser. B: biol. sci. 2018 **61B**(3) 182-186

Review

Probable Ingredients for *Trans* Free Margarine with Omega-3 Fatty Acids

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(received October 20, 2015; revised July 25, 2017; accepted July 31, 2017)

Abstract. Margarine is widely used as table spread, in cooking and bakery products. Awareness of consumers regarding the intake of omega fatty acids has led the food industry to develop foods which are rich sources of omega fatty acids. Harmful effects of *trans* on the development of cardiovascular diseases have steered the researchers to find out wide range of *trans* free options, without compromising on functional and physical properties of fats. Nutritionists recommend margarine for the growing and school going babies, it is usually manufactured from the combination of hard and soft fats, followed by the addition of vitamins A, D and E. However, little is known regarding the supplementation of margarines with omega fatty acids of chia oil. This paper summarizes the physical and chemical characteristics of few ingredients that may be used in the formulation of *trans* free margarine with higher magnitude of omega fatty acids.

Keywords: margarine, omega fatty acids, *trans* free, chia oil

Introduction

Margarine is usually prepared from vegetable fats, the feedstock may originate from partially hydrogenated, interesterified and transesterified. Different categories of margarine are produced at industrial level e.g. table margarine, bakery margarine etc. According to the Codex Standards, margarine should contain at least 80% fat and 16% moisture at maximum (Codex, 2001). Margarine is used as an alternate source of butter. It can be manufactured from a wide range of materials including a combination of hydrogenated and non-hydrogenated stuffs (Richmond, 2007). Ever increasing population has led to a great deal of increase in the production of margarine during the last few decades. Now a days, most of the margarines are made from hydrogenated oils, partial hydrogenation of oil can induce *trans* fatty acids which have many health hazards (Shahidi, 2005). The partial hydrogenation of vegetable oils chemically transforms some of the unsaturated fats into the novel forms of *trans*-fatty acids leading to an increase in the proportion of saturated fats in these oils. *Trans* fatty acids are not required for any biochemical function in human body (Richmond, 2007). Health benefits associated with the intake of omega-3 margarine fortified foods is well known. Increased knowledge of food connected health ailments has considerably increased the demand of functional foods. Healthful properties of margarine can be improved through the fortification of omega-3 fatty acids with *trans* free options. Food is the basic requirement of life. Therefore, it should be safe. Scientific studies have proved that foods are directly related with many diseases such as cancer, cardiovascular diseases, obesity and hypertension etc. (Astrup *et al.,* 2011). Functional foods are getting popularity all over the world and researchers are trying to utilize the non-traditional sources of foods to develop functional foods with added health advantages (Kris-Etherton *et al*., 2002). This paper summarizes the physical and chemical characteristics of ingredients that can be used in the formulation of *trans* free margarine with numerous health benefits of omega-3 fatty acids.

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Chemical composition of margarine. Fat content in margarine ranges from 80 to 90%. Margarine is a water-in-oil emulsion and fat phase is a network of fat crystals and agglomerates of fat with liquid oil entrapped in between. Ingredients like fat soluble flavours, vitamins, colourants and emulsifiers are the contents of fatty phase of margarine. Aqueous phase contains maximum 16% of water and remaining 4% are water-soluble ingredients. To produce the desired quality margarine, it is favourable to have optimum processing and desirable fat blending. Types of margarine are dependent on the solid fat content, melting point of fat, structure and characteristics of margarine (Vereecken, 2010).

***Trans* fatty acids.** Most of *trans* fatty acids enter in body through the intake of partially hydrogenated fats. There is scientific evidence that *trans* fatty acids are not necessary for any physiological function of the human body (Lokuruka, 2007). The concentration of *trans* fatty acids in partially hydrogenated fats depends upon temperature and hydrogen gas pressure. Higher the concentration of nickel catalyst, temperature, gas pressure and catalyst dose, greater would be the degree of geometric isomerization (Shahidi, 2005). As per recommendation of American Heart Association, intake of *trans* fatty acids should not be more than 2g/ day (AHA, 2000). In USA, coronary heart disease is the most common killer, many people are suffering from high blood pressure, stroke and rheumatic fever, with about 41.2% deaths due to cardiovascular diseases (AHA, 2000). Nadeem *et al.* (2014) reported that the concentration of *trans* fatty acids in partially hydrogenated fat was more than 21%. The existence of a strong correlation between harmful HDL cholesterol and *trans* fatty acids has led to the development of large number of *trans* free options. Nadeem *et al*. (2017) showed that margarine prepared from palm oil, palm kernel oil and chia oil blends *trans* fatty acids in margarine. Use of fractionation, inter esterification, trans esterification and blending of fats and oils in appropriate ratios can lead to the successful manufacturing of margarine, partially hydrogenated fat (used commonly in subcontinent) and shortening with similar plasticity, melting point and solid fat index without partial hydrogenation (O'Brien, 2008). Karabulut and Tauran (2006) analyzed 15 types of margarine available in Turkey and showed that concentration of *trans* fatty acids ranged from 8.5% to as high as 39%. Oil processing industries have started focusing on the development of blends which have higher concentration of beneficially unsaturated fatty acids with lower/zero *trans* to minimize the risk of cardiovascular diseases (Miskandar *et al*., 2005).

Table 1. Fatty acid composition of chia oil and some vegetable oils

Fatty acid	Chia oil	Sunflower oil	Soybean oil	Canola oil
C16:0	9.6	6.5	10.2	3.8
C18:0	4.3	1.8	3.8	4.2
C18:1	6.8	3.9	22.8	63.7
C18:2	17.6	68.1	52.8	16.4
C18:3	64.1	1.2	7.6	9.5
Reference	Jin *et al.* (2012)	O'Brien (2008)	Shahidi (2005)	Anwar *et al.* (2007)

Chemical characteristics of chia oil. Chia (*Salvia hispanica* L.) is native to Mexico; it was the staple food in Mexico in pre-historic times. It is an emerging oil seed crop that contains about 35-40% praise worthy oil. Chia oil contains α-linolenic acid up to 68% (Ayerza, 1995). Chia oil also contains significant concentrations of natural antioxidant such as chlorogenic acid, caffeic acid, myricetin, quercetin and kaempferol (Reyes-Caudillo *et al.,* 2008).

Chia oil a powerhouse of beneficial omega fatty acids. Omega-3 poly unsaturated fatty acid are essential fatty acids, which must be consumed through the diet (Nadeem *et al*., 2017). Chia oil is a great source of Omega-3 and Omega-6 fatty acids, which are essential for proper development and functioning of brain and it is also cellular component within the body (Jin *et al.,* 2012). Chia oil is the most efficient source of omega-3 fatty acids. This omega-3 fatty acids obtained from fish have fishy flavour, which limits the application of omega-3 fatty acids in large number of foods. Whereas, omega-3 fatty acids obtained from chia oil is not associated with any flavour defect and unfavourable physiological function (Ayerza *et al.,* 2002). Chia seeds have high content of omega-3 fatty acids, which have been implicated in the reduction of cholesterol level. They prevents blood clotting, improve tissue regeneration, control sugar level in blood, diabetes, cardiovascular diseases, regulate the immune system and development of retina and brain (Vuksan *et al.,* 2007). Eicosapentaenoic acid and decosapentaenoic acid prevent the cardiovascular disease and their daily recommendation is 500 mg for cardiovascular disease risk reduction (Gebauer *et al.,* 2006). A number of medical and epidemiological studies demonstrated that consumption of lipids that contain omega-3 fatty acids reduce the risk of cardiovascular disease (Zhao *et al.,* 2004). Chia oil has good oxidative stability, it was the part of Mexican diet in pre-historic times (Beltran-Orozco and Romero, 2003). Increased intakes of omega fatty acids have been related with low cholesterol level in blood, reduces the blood pressure, prevent the growth of tumors and also decreases the risk of heart attack (Ruiz-Rodriguez *et al.,* 2010). Omega-3 fatty acids are anti-carcinogenic, anti-atherogenic, anti-lipogenic, prevent the hypertension, control immune disorders and

possess immuno-suppressive properties (Williams, 2000). Omega-3 fatty acids have antiarrhythmic, antithrombotic, anti-inflammatory and vasodilator properties. It may also prevent type-2 diabetes and insulin resistance (Lombardo and Chicco, 2006). Docosahexaenoic acid (DHA) which contains 22 carbons and 6 double bonds is the largest unsaturated fatty acid in human body. DHA has been related to alleviation of a number of human illnesses, including heart diseases, cancers and neurological disorders (Stillwell *et al*., 2006). DHA is the major structural fatty acid in nervous system and retina. Pregnant and nursing women should take about 2.6g of omega-3 fatty acids and 100-300 mg of DHA on daily basis. The intake DHA during preschool years may also have a beneficial role in prevention of attention deficit hyperactivity disorder and increase learning ability and academic concern (Gebauer *et al.,* 2006). Concentration of omega-3 fatty acids in margarine can be increased through chia oil, which is a rich source of beneficial omega-3 fatty acids. Nadeem *et al*. (2016a) blended milk fat with high oleic acid fraction of *Moringa oleifera* oil, blends had higher magnitude of unsaturated fatty acids with no *trans* fatty acids. Nadeem *et al*. (2016b) added interesterified *Moringa oleifera* oil in ice cream, physical and oxidative stability characteristics of ice cream were improved without generation of harmful *trans* fatty acids.

Milk fat. Milk fat is usually regarded as precious fat for having appreciable amounts of short-chain fatty acids. The rich natural aroma of milk fat is mainly the contribution of short-chain fatty acids (McSweeney and Fox, 2003). It also contains about 22-26% oleic acid, with scientifically proven health benefits. Further, fats having an appreciable amount of oleic acid are getting a high degree of fame because of large number of health benefits and superior oxidative stability. Fatty acids and triglycerides composition of milk fat restricts its application in large number of bakery and other food products. Milk is mainly used in the manufacturing of butter and butter oil, whereas, partially hydrogenated fats have a wide range of applications in large number of food products (Deffense, 2002). Milk fat is good source of essential fatty acids and fat-soluble vitamins (A, D, E, and K). Short-chain fatty acids in milk fat are mainly responsible for superior sensory characteristics of dairy products, use of milk fat in margarine may improve the sensorial. Milk fat also contains about 1.5-2% omega-6 fatty acids and 0.5-0.7% omega-3 fatty acid (Nadeem *et al*., 2017; 2016a)

Palm oil. Palm oil has melting point 37-39 °C and iodine value is 50-55 (Nadeem *et al*., 2017). Palm oil is solid at room temperature which allows its application in large number of food preparations, such as Vanaspati, margarine, bakery and cake shortenings etc. without partial hydrogenation and generation of *trans* fatty acids. Palm oil is used worldwide in margarine manufacturing and also food products as an ingredient. Palm oil is most important for food industry in manufacturing of *trans* free margarine (Gillespie, 2012). Fatty acid (about 50% saturated and 50% unsaturated) and triglyceride composition of palm oil suggest wide range of *trans* free options (Mukherjee and Mitra, 2009**).** It is rich source of palmitic acid (44%), oleic acid about (40%) and stearic acid 5%. It has high oxidative stability and possesses reasonable amounts of antioxidants like beta-carotene (DeGraef, 2009). It has beneficial health perspectives as it contains no *trans* free fat, high beta-carotene and vitamin E (Henderson and Osborne, 2000). Palm oil has superior thermal stability, therefore, it can be successfully added into large number of bakery products (Foster *et al.,* 2009).

Conclusion

Margarine may be produced from wide range of *trans* free options, such as blending, inter esterification, trans esterification etc. Palm oil, palm olein, palm kernel oil and milk fat may be used for the preparation of *trans* free margarine. Concentration of omega-3 fatty acids in margarine may be improved with chia oil.

Acknowledgement

Financial assistance for this project was provided by Higher Education Commission of Pakistan (HEC/4947/NRPU).

References

AHA,2000. *Cholesterol.Heart and Stroke Guide*. American Heart Association. <http://www. americanheart. org.com > (17 April, 2001).

Anwar, F., Hussain, A.I., Iqbal, S., Bhanger, M.I. 2007. Enhancement of the oxidative stability of some vegetable oils by blending with *Moringa oleifera* oil. *Food Chemistry*, **103:** 1181-1191.

Astrup, A., Dyerberg, J., Elwood, P., Hermansen, K., Hu, F.B., Jakobsen, M.U., Kok, F.J., Krauss, R.M., Lecerf, J.M., LeGrand, P., Nestel, P., Riserus, U., Sanders, T., Sinclair, A., Stender, S., Tholstrup, T., Willett, W.C. 2011. The role of reducing intakes

of saturated fat in the prevention of cardiovascular disease: where does the evidence stand in 2010? *American Journal of Clinical Nutrition*, **93:** 684-688.

Ayerza, R., Coates, W., Lauria, M. 2002. Chia as an omega-3 fatty acid source for broilers influence on fatty acid composition, cholesterol and fat content of white and dark meat, on growth performance and on meat flavour. *Poultry Science*, **81:** 826-837.

Ayerza, R. 1995. Oil content and fatty acid composition of chia (*Salvia hispanica* L.) from five northwestern in Argentina. *Journal of American Oil Chemists Society*, **72**:1079- 1081.

Beltran-Orozco, M.C., Romero, M.R. 2003. La chia, alimento milenario. Mexico, Departamento de Graduados e Investigacion en Alimentos, E. N. C. B., I. P. N, Mexico.

Codex Alimentarius. 2001. Codex general standard for margarine. vol **8**, 2nd edition, FAO & WHO, Remo, Italy.

DeGraef, V. 2009. Microstructural Properties of Isothermal Palm Oil Crystallization. *PhD Thesis*. Ghent University, Belgium. 181pp.

Deffense, E. 2002. Fractionation of butterfat, In: *Oils and Fats Series*, Ch.5. *Dairy Fats*, Edn. B. Rossell.

Foster, R., Williamson, C.S., Lunn, J. 2009. Culinary oils and their health effects. *Nutrition Bulletin*, **34:** 4-47.

Gebauer, S.K., Psota, T.L., Harris, W.S., Kris-Etherton, P.M. 2006. Omega-3 fatty acid dietary recommendations and food sources to achieve essentiality and cardiovascular benefits. *American Journal of Clinical Nutrition*, **83:** S1526.

Gillespie, P. 2012. The challenges of corporate governance in Indonesian oil palm opportunities to move beyond legalism? *Asian Studies Review*, **36:** 247-269.

Henderson, J., Osborne, D.J. 2000. The oil palm in all our lives: how this came about. *Endeavour*, **24:** 63-68.

Jin, F., Nieman, D.C., Sha, W., Xie. G., Qiu, Y., Jia, W. 2012. Supplementation of milled chia seeds increases plasma ALA and EPA in postmenopausal women. *Plant Foods for Human Nutrition*, **67:** 105-110.

Kamla-Raj. 2009. Health effects of palm oil. *Journal of Human Ecology*, **26:** 197-203.

Karabulut, I., Tauran, S. 2006. Some properties of margarines and shortenings marketed in Turkey. *Journal of Food Composition and Analysis*, **19:** 55-58.

Kris-Etherton, P.M., Hecker, K.D., Bonanome, A., Coval, S.M., Binkoski, A.E., Hilpert, K.F., Griel, A.E., Etherton, T.D. 2002. Bioactive compounds in foods: their role in prevention of cardiovascular disease and cancer. *American Journal of Medicine*, **113:** 71-88.

Lokuruka, M.N.I. 2007. Role of fatty acids of milk and dairy products in cardiovascular diseases: A review. *African Journal of Food, Agriculture, Nutrition and Development*. **7:** 1-16.

Lombardo, Y., Chicco, A.G. 2006. Effects of dietary polyunsaturated omega-3 fatty acids on dyslipidemia and insulin resistance in rodents and humans. A review. *Journal of Nutrition and Biochemistry*, **17:** 1-13.

McSweeney, Paul, L.H., Fox, P.F. 2003. *Advanced Dairy Chemistry, Proteins*. Parts A&B, vol. **1,** 3rd edition, Kluwer Academic Plenum Pub, NY, USA.

Miskandar, M.S., Che Man, Y.B., Yusoff, M.S.A., Rahmann, R.A. 2005. Quality of margarine: fats selection and processing parameters. *Asia Pacific Journal of Clinical Nutrition*, **14:** 387-395.

Mukherjee, S., Mitra, A. 2009. Health effects of palm oil. *Journal of Human Ecology*, **26:** 197-203.

Nadeem, M., Imran, I., Taj, I., Ajmal, M., Junaid, M., 2017. Omega-3 fatty acids, phenolic compounds and antioxidant characteristics of chia oil supplemented margarine. *Lipids in Health and Disease*, **16:** 102.

Nadeem, M., Rahman Ullah. 2016a. Enhancement of oleic acid in butter oil by high oleic fraction of *Moringa oleifera* oil. *Pakistan Journal of Scientific and Industrial Research. Ser. B: biol. sci*. **59:** 105-110.

Nadeem, M., Rahman Ulla and Ansar Ullah. 2016b. Improvement of the physical and oxidative stability characteristics of ice cream through Interesterified *Moringa oleifera* oil. *Pakistan Journal of Scientific and Industrial Research*. *Ser. B: biol. sci.* **59:** 38-43.

Nadeem, M., Situ, C., Mahmud, A., Khalique, A., Imran, M., Rahman, F., Khan, S., 2014. Antioxidant activity of sesame (*Sesamum indicum* L.) cake extract for the stabilization of olein based butter. *Journal of the American Oil Chemists Society*, **91:** 967- 977.

O' Brien, R.D. 2008. *Fats and Oils*: *Formulating and Processing for Application*. 3rd edition, 680 pp., CRC Press; Taylor & Francis Group, FL, USA.

Reyes-Caudillo, E., Tecante, A., Valdivia-López, M.A.

2008. Dietary fibre content and antioxidant activity of phenolic compounds present in Mexican chia (*Salvia hispanica* L.) seeds. *Food Chemistry*, **107:** 656-663.

Richmond, H.D. 2007. *Dairy Chemistry, A Practical Handbook for Dairy Chemists and Others having Control of Dairies*. 3rd edition, C Griffin & Co., London, UK.

Ruiz-Rodriguez, A., Reglero, G., Ibanez, E. 2010. Review-recent trends in the advanced analysis of bioactive fatty acids. *Journal of Pharmacy and Biomedicine Analysis*, **51**:305-326.

Shahidi, S. 2005. *Baileys' Industrial Edible Oil and Fat Products*. 6th edition, John Wiley and Sons, Pub. Co., NY, USA.

Singh, M. 2003. Nutrition, brain and environment. How to have smarter Babies? *Indian Pediatrics*, **40**: 213-220.

Stillwell, W., Shaikh, S.R., LoCascio, D., Siddiqui, R.A., Seo, J., Chapkin, R.S., Wassall, S.R., Hauppage. 2006. The role of polyunsaturated lipids in membrane raft function. *Scandinavian Journal of Food and Nutrition*, **50:** 107-113

Vereecken, J. 2010. Effect of Acylglycerol Composition on the Microstructural and Functional Properties of Bakery Fats and Margarines. *Ph.D Thesis*, Ghent University, Belgium. 251pp.

Vuksan, V., Whitman, D., Sievenpiper, J., Jenkins, A., Rogovik, A., Bazinet, R., Vidgen, E., Hanna, A. 2007. Supplementation of conventional therapy with the novel grain Salba (*Salvia hispanica* L.) Improves major and emerging cardiovascular risk factors in type 2 diabetes. *Diabetes Care*, **30:** 2804-2810.

Williams, C.M. 2000. Dietary fatty acids and human health. *Annales de Zootechnie,* **49:** 165-180.

Zhao, G., Etherton, T.D., Martin, K.R., West, S.G., Gillies, P.J., Kris-Etheron, P.M. 2004. Dietary linolenic acid reduces inflammatory and lipid cardiovascular risk factors in hypercholesterolemic men and women. *Journal of Nutrition*, **134:** 2991-2997.