Bangladesh Journal of Veterinary and Animal Sciences, Vol. 7, No. 2, July-December 2019

ISSN 2227-6416

Bangladesh Journal of Veterinary and Animal Sciences

Journal home page: www.bjvas.cvasu.ac.bd

Research Article

Evaluation of quality and vitamin a fortification level of soybean oil available in Bangladesh

Ahmed, T.[1], Sarwar, N.[2*], Ahmad, M.[3] and Sharmin, K. N.[1]

[1] Department of Applied Food Science and Nutrition, Chattogram Veterinary and Animal Sciences University, Chattogram-4225, Bangladesh
[2] Department of Food Processing and Engineering, Chattogram Veterinary and Animal Sciences University, Chattogram-4225, Bangladesh
[3] Department of Applied Chemistry and Chemical Technology, Chattogram Veterinary and Animal Sciences University, Chattogram-4225, Bangladesh

ARTICLE INFO

Article history :
Received : 06/06/2019
Accepted : 19/09/2019

Keywords :
Soybean oil, free fatty acid value (FFA), peroxide value (PV) and Vitamin A fortification.

** Corresponding Author :*
Cell: +8801676961876
E-mail: nazmulsarwar@cvasu.ac.bd

ABSTRACT

Soybean oil is the most commonly used cooking oils in household and food industries of Bangladesh. Fortification of soybean oil with vitamin A is used as an effective strategy to deliver vitamin A among deficient populations. Quality of such commercial soybean oil and vitamin A fortification level is an important concern for Bangladesh. In this study, the quality of soybean oil was investigated by determination of physicochemical characteristics and vitamin A fortification level of seven branded (A, B, C, D, E, F, G) and three non-branded (H, I, J) soybean oil available in the retail market of Chattogram, Bangladesh. Moisture content, Refractive index, Free Fatty Acid Value and Peroxide Value of branded and local soybean oils were found in the range of 0.22-0.51 %, 1.455-1.458, 0.0376-0.3008 % and 0.67-8 meq/Kg, respectively. Results were compared with Bangladesh Standards and Testing Institution (BSTI) standard. The Brand G soybean oil was better compared to others in terms of lower free fatty acid and peroxide content that indicates having good quality for consumption. Peroxide Value of non-branded soybean oil exceeded the limits of BSTI standard. This indicates higher rancidity of non-branded soybean oil. The level of Vitamin A in branded soybean oil was found within the range of 0.93±0.03 to 1.35±0.02 g/kg, wherein non-branded soybean oil it was ranged from 0.70±0.12 to 1.12±0.09 g/kg. Among all the soybean oils investigated brand D possess the highest position in nutritional quality because of its high level of vitamin A. Results of this study will help the consumers in selecting good quality soybean oil for cooking and industrial uses.

To cite this paper : *Ahmed, T., Sarwar, N., Ahmad, M. and Sharmin, K. N. 2019. Evaluation of quality and vitamin a fortification level of soybean oil available in Bangladesh. Bangladesh Journal of Veterinary and Animal Sciences, 7 (2): 38-46*

1. INTRODUCTION

Edible oil is an essential component in the diet of people around the world; regardless, little is known about the physicochemical characteristics of these oils in Bangladesh. Soybean is considered the world's leading source of edible oil and is obtained from soybeans (*Glycine max*) grown in several countries of the world. It has been used as a popular vegetable oil in foodstuffs due to its nutritional qualities, abundance, economy, and desirable

functionality (Brien and Timms, 2004). Soybean oil accounts for about 75% of vegetable oil used in commercial and consumer cooking and is the main element in many processed foods such as salad dressings, sandwich spreads, margarine, bread, mayonnaise, non-dairy coffee creamers and snack foods, including dairy product substitutes (Farhoosh *et al.*, 2009). It is treated as a plethora of oleic acid (28.9%), linoleic (50.7%), and linolenic acids (6.5%) and its fatty acid profile also composed of lauric acid 0.2%, myristic acid 0.1%, palmitic acid 9.8%, stearic acid 2.4%, arachidic acid 0.9%, and hexadecenoic acid 0.4% (Bailey, 1967; Prodhan *et al.*, 2015). But the quality of oil is an important concern for consumers nowadays due to its extensive uses. Poor quality edible oil will leads to degenerative disease in human health.

Physicochemical properties of soybean oil are directly related to their glyceride, fatty acid composition and chemical constitution. Naturally oils are in the triglyceride form but with prolonged storage, triglycerides begin to break down giving rise to free fatty acids (FFA). This hydrolysis is brought about by presence of moisture in the oil, elevated temperature and, most important of all, lipases coming from the source or contaminating microorganisms (Prodhan *et al.*, 2015). Consequently, the neutral oil becomes a mixture of triglycerides, diglycerides, monoglycerides, free fatty acids and glycerol. The presence of excess free fatty acids in oil is an indicator to unnatural state of oil. Also, due to the presence of PUFAs, long chain fatty acids with multiple double bonds and certain metals making it susceptible to oxidation and oxidation occurs on exposure to air and heat resulting in degradation of oil quality with rancid odor (Yehuda *et al.*, 2005). Free fatty acids (FFA) value and peroxide value (PV) are extensively used as indicator of oil quality.

Vitamin A is essential for normal tissue growth and plays crucial role in vision cell differentiation, embryonic development, spermatogenesis, immune response, and epithelial cell integrity. Vitamin A deficiency is a common public health problem in developing countries (WHO, 1982; Ross, 1999) and it is more prevalent among infants, and school-age children, adolescents, pregnant and lactating women (Sommer *et al.*, 1984; Tarwotjo *et al.*, 1987; Dary *et al.*, 2002). Eradicating vitamin A deficiency and its related sequelae are important to ensure global health. Oil fortification is an effective and sustainable strategy to combat vitamin A deficiency and is increasingly feasible option in developing countries like Bangladesh (Akhtar *et al.*, 2012). Most households prefer soybean oil for cooking purposes, fortification of soybean oil with vitamin A would be an effective way to deliver vitamin A to deficient populations. Edible oil has almost 99% penetration in Bangladeshi households and in Marketing Year (MY) 2018/19, soybean production and imports rose 4.9 to 214 thousand Metric Tons (MT) and also the number of oil refineries increased during recent years (Tanvir, 2018). In Bangladesh, in collaboration with government, UNICEF, Global Alliance for Improved Nutrition (GAIN) and relevant stakeholder implement project aims to reduce vitamin A deficiency among women and children through increased market access to fortified edible oil. Government of the People's Republic of Bangladesh plays leading role in the reduction of vitamin A deficiency through imposed law, made edible oil fortification with vitamin A mandatory and prohibited import of unfortified edible oil in Bangladesh (Tanvir, 2018). But, no authentic studies has been carried out in Bangladesh to determine the quality and vitamin A fortification level in commercial soybean oil. In this context, the objective of this research is to investigate physicochemical characteristics and vitamin A fornication level of ten branded and non-branded soybean oil collected from the retail market in Chattogram metropolitan area, Bangladesh.

2. MATERIALS AND METHODS

The experiment was conducted in Department of Applied Food Science and Nutrition; Department of Applied Chemistry and Chemical Technology; and Poultry Research and Training Center (PRTC); Chattogram Veterinary and Animal Sciences University, Chattogram, Bangladesh.

Collection of the oil samples

Total 50 oil samples of which seven branded and three non-branded were collected from different retail outlet (market stall, kiosk/small shop and/or supermarket) from different random locations of Chattogram Metropolitan Area, Bangladesh (Figure 1). Seven branded group of samples were designated as A, B, C, D, E, F and the rest three non-branded as G, H, I.

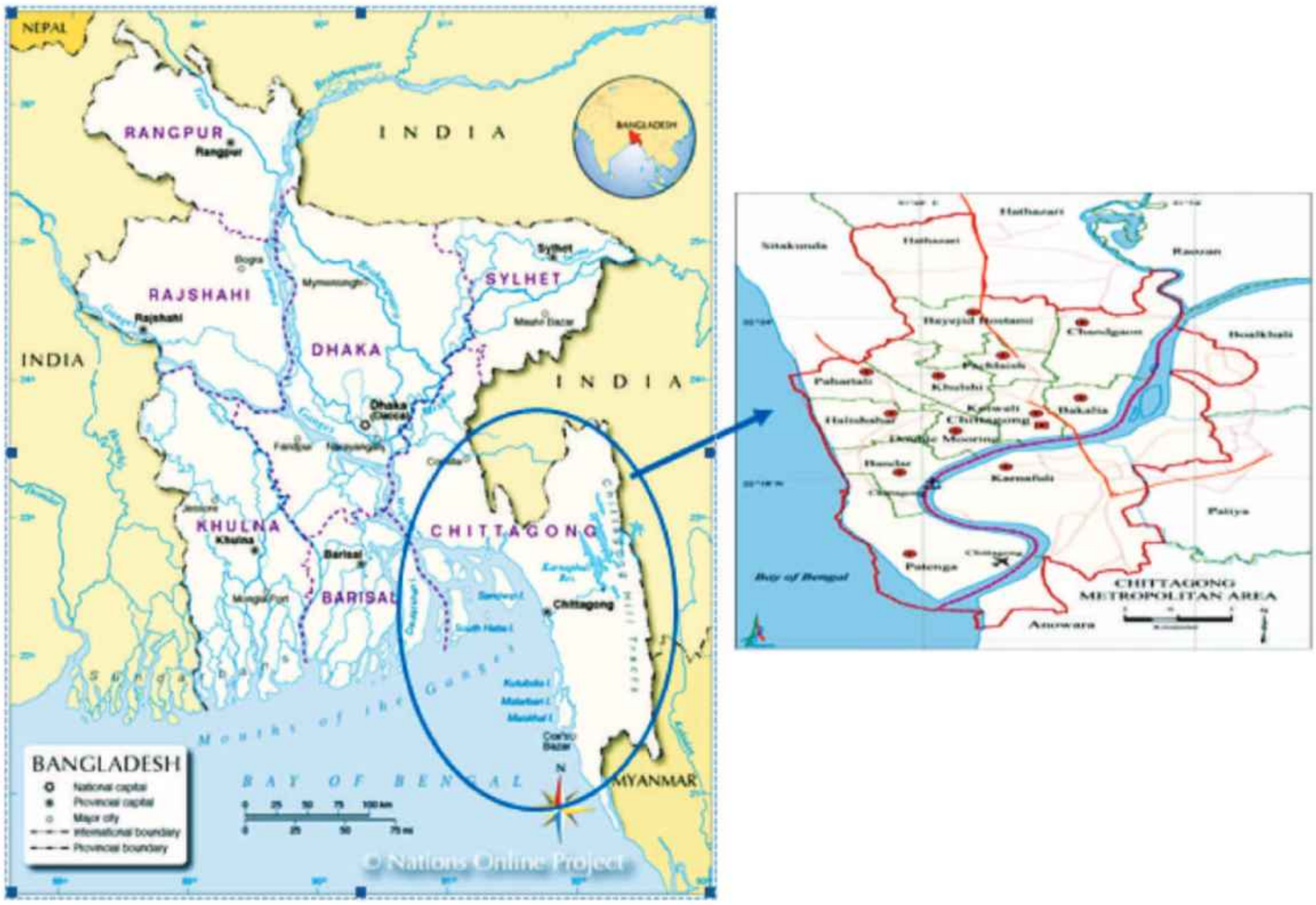

Figure 1. Sampling Locations of Chattogram Metropolitan Area, Bangladesh

Sample preparation

All of the oil bottles were preserved in dry, cool and dark places. The bottles were covered with carbon papers to prevent photo-oxidation. All reagents used were of analytical grade and specified. Samples of oil from different brands and non-brands were prepared for analysis as the method described by Birnin-Yauri and Garba (2011). Oil samples were taken directly from the container after inverting it several times.

Physical Characteristics

Physical characteristics of oil such as physical state, appearance, taste and odor were obtained by sensory evaluation and organoleptic test. Moisture was measured by oven drying at 105°C to constant weight and refractive index was measured by refractive meter (Model: C-1520 Refractometer, Nu-Calgon, USA) (AOAC, 2016).

Chemical Characteristics

Free fatty acid and peroxide value of oil samples were determined by the standard method described in AOAC (2016) for Oils and Fats.

Determination of Free Fatty Acid/Acid Value

Acid value indicates the number of milligrams of KOH needed to neutralize the FFA present in 1g of oil. FFA represents the percentage of free fatty acids present in the oil. Free fatty acids are readily soluble in rectified spirit or absolute alcohol. A suitable amount of oil is therefore mixed with neutralized rectified spirit to extract free fatty acids and the amount of the latter calculated by titrating with standard NaOH or KOH using phenolphthalein indicator. To facilitate extraction, the mixture was warmed to about 70°C and swirled vigorously. Calculation for both acid value and FFA was carried out as follows:

$$\% FFA = \frac{ml\ of\ alkali \times N\ of\ alkali \times 28.2}{Wt.\ of\ sample\ (g)}\ (as\ oleic\ acid)$$

$$Acid\ Value = \frac{ml\ of\ alkali \times N\ of\ alkali \times 56.1}{Wt.\ of\ sample\ (g)}$$

Determination of Peroxide Value

Peroxide value (PV) is an indicator of oxidation of fats and oils at the early stages of marketing. PV predicts the risk of development of flavor rancidity. When a rancid fat or oil sample is treated with potassium iodide after dissolving in an appropriate solvent, peroxides present in the fat liberate iodine. The test is a volumetric one where I_2, formed from KI in the presence of peroxide is determined by titrating with sodium thiosulfate and conducting a blank determination. Accurately (by difference) 5g of fat or oil sample was weighted in the Iodine flask. About 25ml of solvent was added and the air was displaced with CO_2. 1ml of KI solution was also added using a stopper on the flask, and allowed it to stand for 1min (with gentle shaking). 35ml of distilled water was added and a few drops of starch indicator were also added. The appearance of blue color was considered as the presence of free iodine. The liberated iodine was titrated with 0.01N or 0.1N sod-thiosulfate until the blue color disappears. Simultaneously, a blank determination was also carried out (omitting oil). Peroxide value was calculated by using the following equation:

$$PV\left(\frac{meq}{kg}\right) = \frac{N \times (V_S - V_B) \times 1000}{Wt.\ of\ sample\ (g)}$$

Where, N = normality of sod-thiosulfate, V_S = sod-thiosulfate consumed by sample (ml), and V_B = sod-thiosulfate consumed by blank (ml).

Vitamin A Fortification Level in Soybean Oil

Vitamin A content in oil samples was determined by UV-VIS Spectrophotometer (Model: Hitachi U-1900, Hitachi High-Technologies Corporation, USA). Analytical procedures carried out for Vitamin A analysis of the oil samples were as same as the method described by Kambagar and Fawzi (1978); Subramanyam and Parrish (1976); Phillip *et al.* (2007).

Retinyl esters in the fortified oil is determined by diluting the oil in organic solvents such as dichloromethane, chloroform or hexane, followed by reading the absorbance of the solution at 325 nm. For diluting, oil samples were placed in a 50 mL volumetric amber flask. The flask was tarred and 1.0 g of oil was transferred into the flask using a pipette. Solvent dichloromethane was added to the flask to dissolve the oil and makeup to volume and mixed thoroughly. The process was repeated above using blank oil (solvent). The solvent used for diluting the samples was placed into 1 cm quartz UV cuvettes and zero the spectrophotometer at 325 nm. The solvent was used as a spectrophotometric blank. The absorbance of samples was recorded at 325 nm. Reading of the samples was corrected by subtracting the absorbance of the blank. This is the corrected absorbance for the sample used for calculations.

$$Retinyl\ Palmitate\left(\frac{mg}{kg}\right) = \frac{Abs_{corrected} \times (V_f \times C_f)_{spec}}{a \times w}$$

The retinyl palmitate concentration of the oil sample was estimated by using the following equation

Where, Abs corrected = Abs sample – Abs of blank. a = Retinyl palmitate absorption coefficient in dichloromethane ($mg^{-1}cm^{-1}L$) = 0.094 or in hexane ($mg^{-1}cm^{-1}L$) =0.092, V_f = Final volume (mL), w = Weight of the sample (g), CFspec=Correction factor of the spectrophotometer = 1.

Statistical analyses

The obtained data were stored in Microsoft Excel 2007 and then exported into SPSS Version 17.0 software (SPSS Inc., USA) for statistical analysis. Descriptive analysis was performed by using percentages, mean and standard deviation for different variables. The level of significance was set at ≤ 0.05.

3. RESULTS AND DISCUSSION

Physical Characteristics

Physical state, appearance, taste and odor

Physical state, appearance, taste and odor of ten commercial branded and local edible oils of soybean oil are presented in Table 1. All the commercial branded and non-branded oil (A, B, C, D, E, F, G, H and I) satisfies the organoleptic test. Oils were neutral/bland in taste; absence of foreign odors and flavors and all brands satisfy the specifications of BSTI.

Moisture Content

Moisture content of ten commercial branded and non-branded soybean oils were found in the range of 0.22-0.51%. The results of moisture content are shown in Table 2. The moisture content of different soybean oils was found 0.22±0.03% and 0.51±0.03% as lowest and highest values, respectively (Table 2). The values were similar to that observed by Hasan *et al.* (2016). Higher moisture content of the oil signifies its greater impact for food texturing, baking, and frying and industrially in the manufacture of soaps, detergents, cosmetics and oil paints (Birnin-Yauri and Garba, 2011).

Table 1. Physical Characteristics of different brands of soybean oil

Physical Characteristics	Typical
Physical State	Liquid
Appearance	Clear and Brilliant
Taste	Bland, Neutral
Odor	Clean, Free from non-typical odors

Table 2. Moisture and Volatile matter of different brands of soybean oil

Oil sample	Anonym	Moisture Content (%)
Branded oil	A	0.27±0.02
	B	0.22±0.03
	C	0.31±0.01
	D	0.46±0.04
	E	0.42±0.06
	F	0.35±0.02
	G	0.51±0.03
Non-branded oil	H	0.29±0.04
	I	0.41±0.07
	J	0.24±0.02

Results are means ± standard deviation of triplicates

Refractive Index

Refractive index of the branded and non-branded soybean oils was found in the ranges of 1.455-1.458 (Table 3). It was found that Refractive Index (ND 40°C) of Brand A, B and D was 1.458; C, E, F, G and J was 1.457; H and I was 1.455. Bangladesh Standard & Testing Institute (BSTI) standard for Refractive Index (ND 40°C) is 1.466–1.470. The refractive index values obtained were in close agreement with values accepted by BSTI for conventional oils from soybean (1.466-1.470). The values were similar to that observed by Bello *et al.* (2011). The high refractive index of this oil seems to confirm the high number of carbon atoms in their fatty acids (Falade *et al.*, 2008). Refractive index also increases as the double bond increases (Eromosele and Pascal, 2003).

Table 3. Refractive Index of different brands of soybean oil

Oil sample	Anonym	Refractive Index
Branded oil	A	1.458
	B	1.458
	C	1.457
	D	1.458
	E	1.457
	F	1.457
	G	1.457
Non-branded oil	H	1.455
	I	1.455
	J	1.457

Chemical Characteristics

Free Fatty Acid

Free Fatty acid, is estimated in percentage express as oleic acid, of ten commercial branded and non-brand oils are shown in Figure 2.

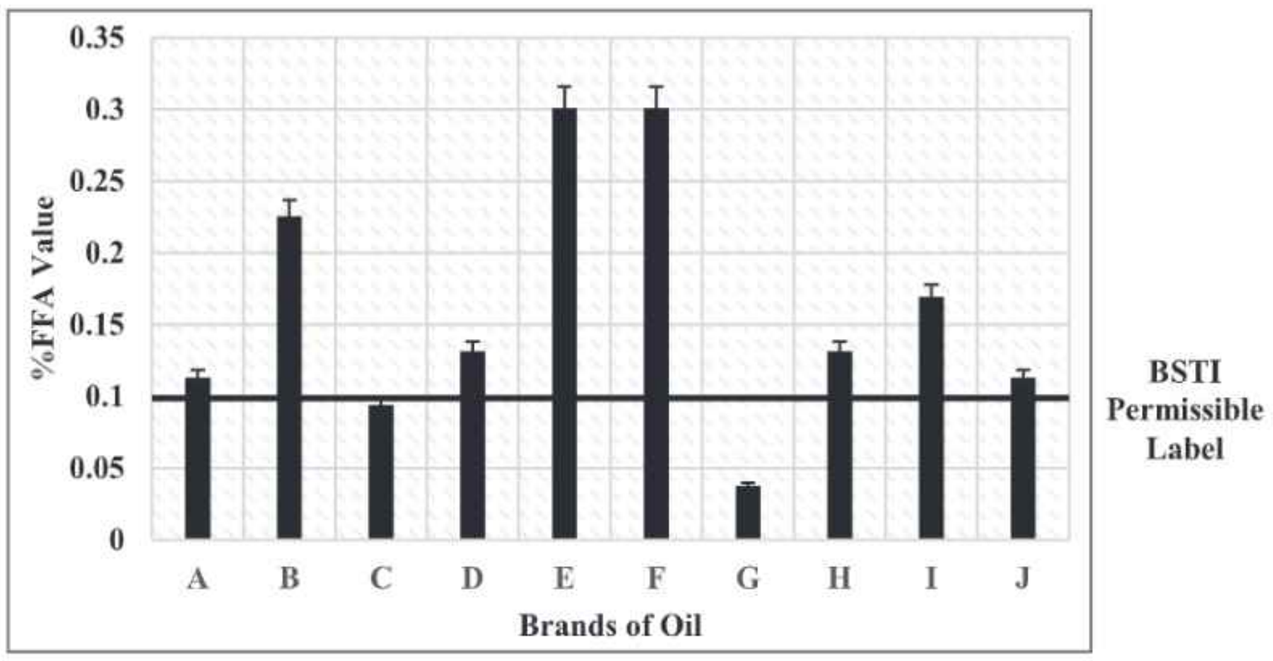

Figure 2. Free Fatty Acid (FFA) Value of different soybean oils (Here A, B, C, D, E, F, and G = Branded Oil Sample; H, I and J= Non branded Oil Sample)

Free Fatty Acid value of oils indicate the amount of free fatty acid present in the oil. It determines the purity of oils. The higher the fatty acid value, the lower the possibility of the oil to be recommended as cooking oil. This parameter is also used to assess frying oil degradation and is related to fried food quality (Peled *et al.*, 1975; Melton *et al.*, 1994; Zahir *et al.*, 2017). Free Fatty Acid (FFA) value of A, B, C, D, E, F, G, H, I and J soybean oil were 0.1128, 0.2256, 0.094, 0.1316, 0.3008, 0.3008, 0.0376, 0.1316, 0.1692 and 0.1128 %, respectively. The analyzed values were lower to FFA value 0.36 that observed by Hasan *et al.* (2016) and Prodhan et al. (2011) in other studies. BSTI standard for acid value is 0.1% maximum expressed as oleic acid. Brand E and F possessed the highest Free Fatty Acid (FFA) among all the oils investigated (Figure 2). Increase in FFA could be attributed to oxidation and hydrolysis. Moreover, FFA content represent simultaneous occurrence of acid production and facilitation of sufficient vapor pressure at frying temperatures to evaporate from the surface (Peled *et al.*, 1975). Prolonged storage of oil leads to break down of triglycerides into free fatty acids (FFA) and glycerol and it brought about by a variety of agents such as moisture in the oil, high temperature and presence of lipases enzyme. Lower Free Fatty Acid value of oils indicate higher purity and safe to be used as cooking purpose.

Peroxide Value (PV)

Peroxide values of ten commercial brand and non-brand edible oils are given in Figure 3.

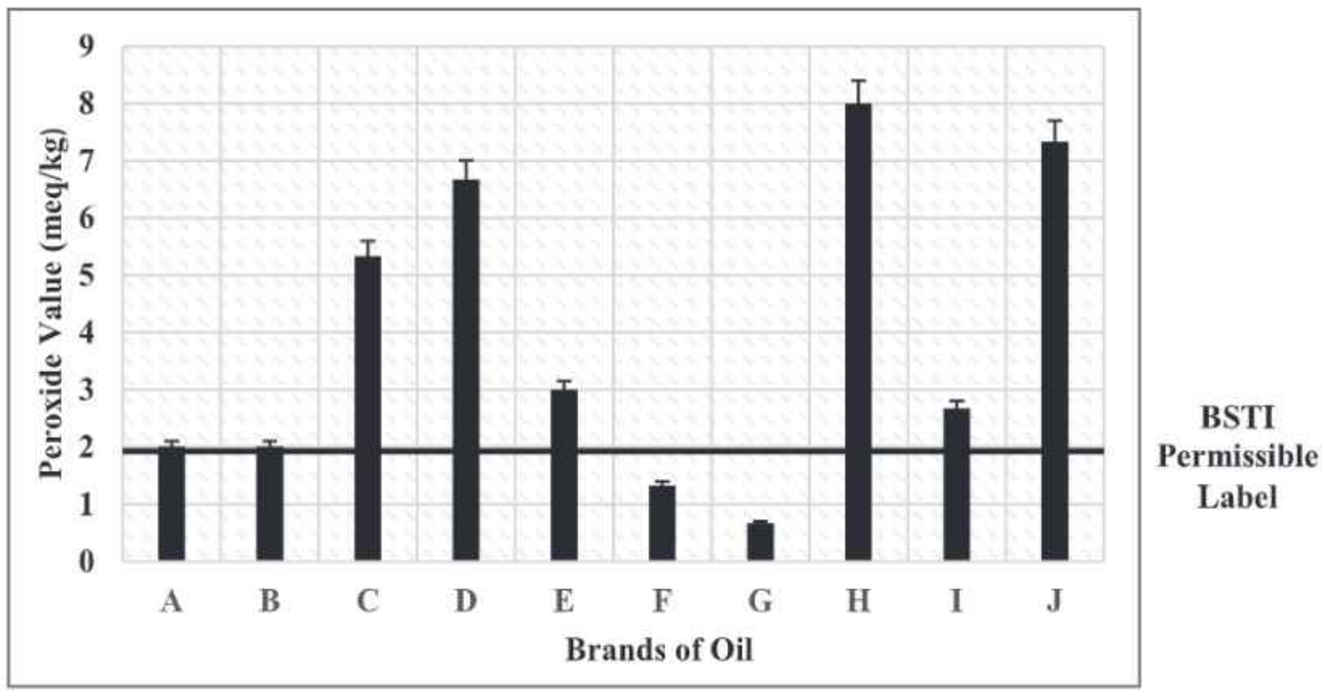

Figure 3. Peroxide Value (PV) of different soybean oils (Here A, B, C, D, E, F, and G = Branded Oil Sample; H, I and J= Non branded Oil Sample)

Peroxide value (PV) is used as a measure of the extent to which rancidity reactions have occurred during storage. It could be used as a quality and stability indicator of fats and oils (Ekwu and Nwagu, 2004). Peroxide Value (PV) of A, B, C, D, E, F and G soybean oil brand were 2, 2, 5.33, 6.67, 2, 1.33 and 0.67 meq/kg, respectively. PV of other three non-branded soybean oil H, I and J were 8, 2.67 and 7.33 meq/kg, respectively. The values were higher than (1.17 meqO_2/kg) observed by Hasan *et al.* (2016). The peroxide value determines the extent to which the oil has undergone rancidity. Peroxide value ranges observed in the present study are closely related to the standard value specified by BSTI. BSTI standard for Peroxide number is 2 mill equivalents maximum of active oxygen per kg oil. Non-brand H and J possessed the highest PV among all brand oils investigated (Figure 3) and this indicates high rancidification of non-brand soybean oil. Rancidification of oil produce unpleasant odors and flavors and leads to formation of free radical which are responsible for cellular damage and onset of degenerative diseases such as diabetes, alzheimer's disease and also cause digestive distress and deplete the body of vitamins B and E (Sen, 2015).

Vitamin A Fortification Level

Level of Vitamin A in branded soybean oils was found in the ranges of 0.93±0.03 to 1.35±0.02 g/kg and in non-brand soybean oil were 0.70±0.12 to 1.12±0.09 g/kg. Levels of Vitamin A fortification in oils are shown in Table 4.

Table 4. Vitamin A fortification level of different brands of soybean oil

Oil sample	Anonym	Vitamin A (g/Kg)
Branded oil	A	1.26±0.03
	B	1.29±0.05
	C	0.93±0.03
	D	1.35±0.02
	E	1.15±0.07
	F	1.11±0.11
	G	1.25±0.06
Non-branded oil	H	0.91±0.08
	I	1.12±0.09
	J	0.70±0.12

Results are means ± standard deviation of triplicates

Vitamin A level of branded oil A, B, C, D, E, F and G were 1.26±0.03, 1.29±0.05, 0.93±0.03, 1.35±0.02, 1.15±0.07, 1.11±0.11 and 1.25±0.06, respectively. Whereas Vitamin A in non-brand oil (H, I and J) were 0.91±0.08, 1.12±0.09 and 0.70±0.12, respectively (Table 4). BSTI standard for Vitamin A is 1.5-3.5 mg/g. Non-brand H and J contain a very negligible amount of Vitamin A. Mandatory fortification of soybean oils with vitamin A was not fulfilled BSTI standard in most of the sampled oil in Bangladesh. But branded oils resemble higher Vitamin A fortification level compared to non-branded oil. Vitamin A fortification in oil can be enriched by capacity development of all refineries by providing technical and logistic support, capacity development of the Bangladesh Standards and Testing Institute (BSTI) for implementation of a standard regulatory monitoring system to ensure fortified edible oil contains adequate amounts of vitamin A, establish sustainable monitoring system for quality production and population coverage for access, develop and implement mass communication package to raise consumer awareness and demand about availability and benefits of qualified vitamin A fortified edible oil.

However, there were some limitations in this study such as vitamin A in vegetable oil degradation can occur from the time manufacture to the time it is sold at retail and impact will vary depending on distribution and cooking methods. Such types of analysis were not done in this studies that have significant effects. Additionally, studies of potential carcinogenic hazards associated with the vitamin A fortification in edible oil were not identified.

4. CONCLUSIONS

Investigation on quality of ten different brand and non-brand of soybean oils in Bangladesh revealed that

all the brand and non-brand oil satisfies the organoleptic test whereas moisture content and refractive index are in close range to the standard value specified by BSTI. Free Fatty Acid (FFA) values of some brands are higher than the standard and Peroxide Value (PV) of non-brand was higher than the commercial brand. Brand G soybean oil was better compared to other soybean oil due to its lower FFA and PV than others that indicates higher molecular weight and degree of unsaturation. Although other brands of soybean oil were qualitatively lower than brand G but depending on the significance of all physical and chemical parameter of oil, the values were between standard range and ideal for consumption. Among all the Soybean oils investigated brand D possess the highest position in nutritional quality because of its high level of Vitamin A and most of the brands possess lower content of vitamin A than BSTI standard. The study shows non-brand oil has the lowest level of Vitamin A content in comparison with commercial brands of edible soybean oil. The results of this study will be able to create awareness among people to choose soybean oil whether it will be good for health or not.

5. ACKNOWLEDGEMENT

Authors are highly thankful to R&D (2018-19) Grant, Ministry of Science and Technology, Bangladesh for supporting this research work. Authors would like to express gratefulness to Department of Applied Food Science and Nutrition and Poultry Research and Training Center (PRTC) of Chattogram Veterinary and Animal Sciences University (CVASU) for institutional support and assistance.

6. REFERENCES

Akhtar, H., Tahir, L., Mahmud, S. and Hamid, S. 2012. Loss of vitamin A in fortified edible oils and ghee during cooking in Asian traditional style. Bangladesh Journal of Scientific and Industrial Research, 47(2): 243-248.

Allen, L.H., De-Benoist, B., Dary, O. and Hurrell, R. 2006. World Health Organization (WHO) Food and Agricultural Organization of the United Nations (FAO). Guidelines on food fortification with micronutrients. WHO Press, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland.

AOAC. 2016. Official Methods of Analysis. 20th Edition, Association of Official Analytical Chemists. Washington, DC., USA. P. 226.

Bailey, A. E. 1967. Industrial Oil and Fat Products. Interscience Publishers. p.635.

Brien, R. D. and Timms, R. E. 2004. Fats and Oils-Formulating and Processing for Applications. European Journal of Lipid Science and Technology, 106(7), pp.451-451.

Birnin-Yauri, U. A., Garba, S. 2011. Comparative studies on some physicochemical properties of baobab, vegetable, peanut and palm oils. Nigerian Journal of Basic and Applied Sciences, 19(1): 64-67.

Dary, O. and Mora, J. O. 2002. Food fortification to reduce vitamin A deficiency: International Vitamin A Consultative Group recommendations. The Journal of nutrition, 132(9): 2927S-2933S.

Ekwu, F. C. and Nwagu, A. 2004. Effect of processing on the quality of cashew nut oils. Journal of Science and Agriculture, Food Technology and Environment, 4:105-110.

Eromosele, C. O. and Paschal, N. H. 2003. Characterization and viscosity parameters of seed oils from wild plants. Bioresource Technology, 86(2): 203-205.

Falade, O. S., Adekunle, A. S., Aderogba, M. A., Atanda, S. O., Harwood, C. and Adewusi, S. R. 2008. Physicochemical properties, total phenol and tocopherol of some Acacia seed oils. Journal of the Science of Food and Agriculture, 88(2):263-268.

Farhoosh, F., Einafshar, S. and Sharayei, S. 2009. The effect of commercial refining steps on the rancidity measures of soybean and canola oils. Food Chemistry, 115(3): 933-938.

Fiedler, J. L., Lividini, K. and Bermudez, O. I. 2015. Estimating the impact of vitamin A-fortified vegetable oil in Bangladesh in the absence of dietary assessment data. Public health nutrition, 18 (3):414-420.

Food and Agriculture Organization of the United Nations (FAO). 2013. FAO STAT database, Commodity balances. Rome, p. 13.

Hasan, M. S., Rownok, J. M., Alam, A., Khatun, M. K. and Al-Reza, S. M. 2016. Study on Physicochemical Properties of Edible Oils Available in Bangladeshi Local Market. Archives of Current Research International, 6(1):1-6.

Kambagar, T. and Fawzi, A. B. 1978. Spectrophotometric Determination of Vitamin A in Oils and Fats. Journal Association of Official Analytical Chemists, 61(3):753-755.

Melton, S. L., Jafar, S., Sykes, D. and Trigiano, M. K. 1994. Review of stability measurements for frying oils and fried food flavor. Journal of the American oil chemists' society, 71(12):1301-1308.

Mounts, T. L., Warner, K., List, G. R., Kleiman, R., Fehr, W. R., Hammond, E. G. and Wilcox, J. R. 1988. Effect of altered fatty acid composition on soybean oil stability. Journal of the American Oil Chemists' Society, 65(4):624-628.

Peled, M., Gutfinger, T. and Letan, A. 1975. Effect of water and BHT on stability of cottonseed oil during frying. Journal of the Science of Food and Agriculture, 26(11):1655-1666.

Phillip. M., Monica, G. and Omar, D. 2007. Manual for internal monitoring of oil fortified with vitamin A. 1st ed. East, Central and Southern African Health Community (ECSA-HC) publisher. Tanzania. pp: 14-21.

Prodhan, U. K., Islam, M. A., Quoser, J., Linkon, M. R., Rahman, M. S. and Rahman, M. N. 2015. Chemical Characteristics of Different Brands of Soybean Oil Available in Bangladesh. International Journal of Engineering Research & Technology (IJERT), 4(4):338-343.

Ross, A. C. 1999. Vitamin A and retinoids. In: Shils ME, Olson J, Shike M, Ross, AC, eds. Modern nutrition in health and disease. 9th ed. Baltimore, Md, USA: Lippincott Williams & Wilkins. pp 305–27.

Sen, D. J. 2015. Cooking oil rancidification during deep frying causes health hazards. Journal of drug discovery and therapeutics, 3(26):1-6.

Singh, V. and West, K. P. 2004.Vitamin A deficiency and school-aged children in Southeastern Asia. European Journal of Clinical Nutrition, 58(10): 1342–1349.

Sommer, A., Katz, J. and Tarwotjo, I. 1984. Increased risk of respiratory disease and diarrhea in children with preexisting mild vitamin A deficiency. American Journal of Clinical Nutrition, 40(5): 1090–1095.

Subramanyam, G. B. and Parrish, D. B. 1976. Colorimetric Reagents for Determining Vitamin A in Feeds and Foods. Journal - Association of Official Analytical Chemists, 59(5):1125-1136.

Tanvir, H. 2018. Bangladesh Oilseeds and Products Annual. Global Alliance for Improved Nutrition (GAIN) Report. Report Number: BG1802. Washington DC., USA. p 12.

Tarwotjo, I., Sommer, A., West, K. P., Djunaedi, E., Mele, L. and Hawkins, B. 1987. Influence of participation on mortality in a randomized trial of vitamin A prophylaxis. The American journal of clinical nutrition, 45(6):1466–71.

World Health Organization (WHO). 1982. Control of vitamin A deficiency and xerophthalmia. World Health Organ Technical Report Server, 672:1–70.

Yehuda, S., Rabinovitz, S. and Mostofsky, D. I. 2005. Mixture of essential fatty acids lowers test anxiety. Nutritional Neuroscience, 8 (4): 265–267.

Zahir, E., Rehana, S., Mehwish, A. H. and Anjum, Y. 2017. Study of physicochemical properties of edible oil and evaluation of frying oil quality by Fourier Transform-Infrared (FT-IR) spectroscopy. Arabian Journal of Chemistry, 10: 3870–3876.