DEVELOPMENT OF DRINKING YOGURT USING CITRUS FIBER AS A STABILIZER

Samarasingha Vidanelage Hansika Srimali, Weerasingha Vidanelage Viraj Roshan Weerasingha, Wettapperuma Arachchige Deepthi Nayananjalie
Department of Animal and Food Sciences, Faculty of Agriculture
Rajarata University of Sri Lanka, Anuradhapura, Sri Lanka.
*E-mail: wvvirajroshan7@gmail.com

Abstract
The study was conducted to evaluate the potential of citrus fiber as a natural stabilizer for development of yogurt drink. Five different levels of citrus fiber, 0.10%, 0.15%, 0.20%, 0.25%, and 0.30% (w/v) were evaluated to select the best incorporation level of citrus fiber for the development of yogurt drink. The selected citrus fiber level was compared with the optimum level of two stabilizers viz 0.3% and 0.035% (w/v) of gelatin and carrageenan, respectively. Authenticated control was conducted without adding any stabilizers. According to sensory evaluation, citrus fiber incorporated product had the highest overall acceptability compared with other treatments and control sample. The pH of all treatment samples increased with storage period ($p<0.05$) and the highest influence on acidity was observed in yogurt drinks supplemented with citrus fiber. Fat content of citrus fiber added yogurt drinks were significantly higher compared to the control sample. Yeast and mold counts were within the acceptable range during the storage period in all treatments. In conclusion, 0.2% (w/v) level of citrus fiber could be used to develop a yogurt drink with desired physico-chemical, and sensory properties compared with other two stabilizers and it could be stored under refrigerated condition up to 21 days without any hazardous contamination of yeast and molds.

Keywords: carrageenan, gelatin, natural stabilizer, physico-chemical properties, sensory evaluation

Received: 02.04.2019 Received in revised form: 09.07.2019 Accepted: 12.07.2019

1. INTRODUCTION

Yogurt is a fermented dairy product, widely consumed worldwide due to its nutritional, therapeutic and sensory qualities. Generally, yogurt is produced by fermenting raw milk using microbial cultures of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (Motawee and Neveen, 2016).Yogurt imparts several health benefits including improved lactose tolerance, lowering blood serum cholesterol, prevention of coronary heart diseases and act as a probiotic carrier food (Kamruzzaman *et al*.,2002).Yogurt can be categorized into three major groups based on the physical nature of the coagulum as set type, stirred type and drinking type (Yadav *et al*., 2015). Even though drinking yogurt is available in the market for many years, recently there has been a spike in popularity of drinking yogurt among the consumers due to the convenience, handiness and health benefits (Allgeyer *et al*., 2010).

Therefore, the producers are moving towards the production of quality drinking yogurt with improved organoleptic and nutritional properties.

During the manufacturing of drinking yogurt different types of food additives are incorporated and stabilizers play a major role among these additives. Addition of stabilizers helps to prevent syneresis, while improving the body, texture, appearance and mouth feel of the yogurt (Cash and Caputo, 2010; Hussein *et al*, 2011). Gelatin and Carrageenan are the most commonly used stabilizers which are derived from collagen and red seaweeds respectively (Mariod and Adam, 2013; Weiner, 2014). Some of the fruit fibers are also been incorporated in yogurt and ice cream like dairy products and they can be used to replace the stabilizers due to the same textural properties that exert by fruit fibers (Simoneliene *et al*, 2014).

Citrus fibers play a key role among the fruit fibers used in dairy products which can be termed as a natural stabilizer. Citrus fiber is a good source of dietary fiber (DF) normally consists of 70-80% of DF which can be obtained from pulp or peel of the citrus fruits

(Lundberg *et al*., 2013). Several different beneficial characteristics are provided by dietary fibers like citrus fiber in cultured dairy products. Citrus fiber helps to control syneresis with improved solubility, viscosity, gel forming ability, water holding capacity and reduction of caloric content by acting as a bulking agent (Larrauri, 1999; Tungland and Meyer, 2002). Dietary fibers provide promising health benefits including reducing cholesterol and attenuating blood glucose and maintaining gastrointestinal health as well (Tungland and Meyer, 2002). This study was focused to evaluate the use of citrus fiber as a stabilizer for the development of yogurt drink and to compare the organoleptic properties of yogurt drink produced by incorporating citrus fiber with gelatin and carrageenan.

2. MATERIALS AND METHODS

The drinking yogurts were initially developed using 5 levels of citrus fiber as 0.1%, 0.15%, 0.2%, 0.25%, and 0.3% (w/v). The best incorporation level was determined through sensory evaluation and the selected level was compared with 0.3% (w/v) level of gelatin and 0.04% (w/v) of carrageenan respectively. Incorporation levels of gelatin and carrageenan were selected based on the preliminary study. Additionally, authenticated control was carried out without adding stabilizer.

2.1 Development of yogurt drink

Drinking yogurt was produced according to the basic guidelines of stirred yogurt procedure (Sfakianakis and Tzia 2014). In brief, cow milk was standardized up to 2.5% fat level and subjected to preheating (55-60^{0}C) followed by homogenization at 55^{0}C for 15 minutes under 10-20Mpa.Then pasteurization was done at 90-95^{0}C for 10 minutes and sugar 10%(w/v)was added.

There after selected stabilizer levels (0.2 % citrus fiber, 0.04 % carrageenan and 0.3% gelatin) were added and mixed properly. The pasteurized mixture was cooled down up to 44^{0}C and samples were inoculated with a starter culture (0.04g/L) containing *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. Incubation was done for about 4 hours until pH drops to 4.6. Thereafter, cooled sample was subjected to rapid agitation until it became semi solid condition.

2.2 Evaluation of Physicochemical Properties

The pH was measured using pH meter (USA) and titratable acidity was estimated by titrating the drinking yogurt samples with 0.1% NaOH, in weekly intervals during the 21 days of the storage period (AOAC 2002).

Fat and protein content of the drinking yogurt samples were estimated according to the standard procedure described AOAC (2002) protocols.

2.3 Microbiological analysis

All treatments and control were analyzed for the yeast and mold growth by weekly intervals during the storage period by pour plate method using Potato dextrose agar as the media (Ifeanyi *et al*., 2013).

2.4 Sensory evaluations

Sensory analysis was carried out using 30 untrained panelists. The panelists were asked to evaluate the product for appearance, colour, texture, taste and overall acceptability according to the five-point hedonic scale. Initial sensory evaluation test was done to evaluate drinking yoghurt samples developed with different citrus levels of citrus fiber (0.1%, 0.15%, 0.2%, 0.25%, 0.3% w/v). Then the selected citrus fiber level (0.2% w/v) was compared for sensory properties with 0.3 % (w/v) and 0.04 % (w/v) level of gelatin and carrageenan respectively.

2.5 Statistical analysis

Completely Randomized Design (CRD) was used to analyze physiochemical and microbiological properties among drinking yogurt samples.

Data were analyzed using one-way Analysis of Variance (ANOVA) in Statistical Analysis System (SAS), Version 9.0 (SAS 2000). Sensory evaluation data were analyzed using MINITAB (2010) software.

3. RESULTS AND DISCUSSION

3.1 Evaluation of physicochemical properties

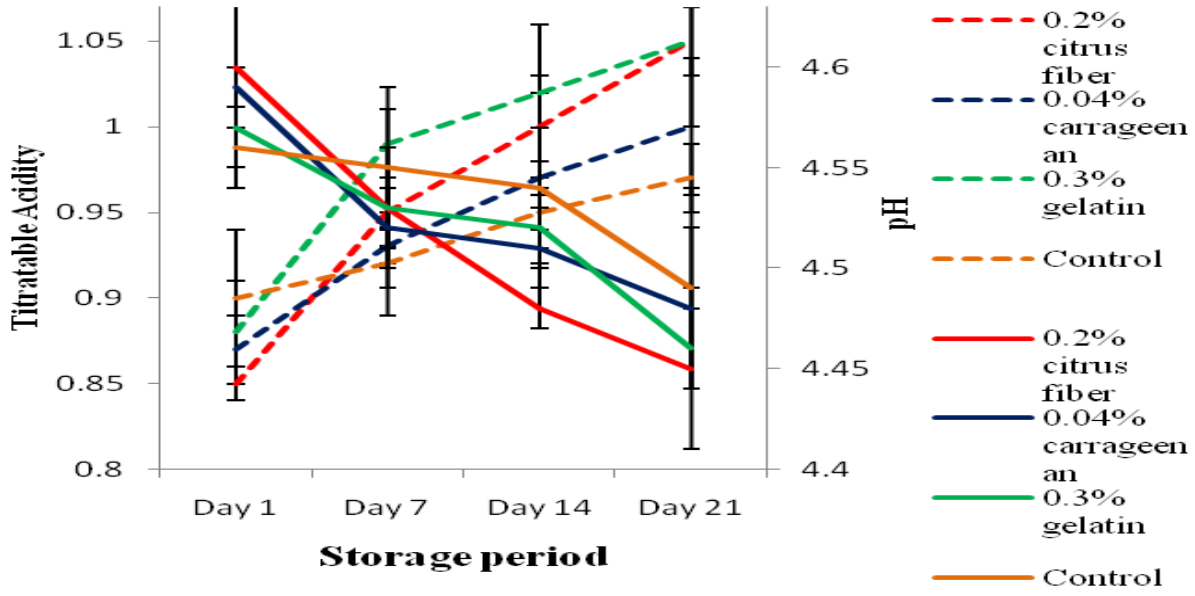

Figure 1: pH and titratable acidity variation during the 21 day storage period in yoghurt drinks produced by incorporating different stabilizer types

Titratable acidity is one of the important quality parameters of the dairy products. Development of acidity affect on whey separation, texture and flavor defects (Henrysson, 2016). Titratable acidity of all treatments and control increased with the storage period (Figure 1). There was a significant difference ($p<0.05$) among all treatments and control yogurt drinks while lactic acid percentage of all treatments and control sample were within the range of 0.85-1.05%. According to the CODEX standards, the minimum titratable acidity for dairy products is 0.6% and it can be varying from 0.8-1.25% according to the Sri Lankan Standard Institution (CODEX, 2010; SLSI 1989). Therefore, all the treatments and control were within the acceptable range during the storage period. Activity of lactic acid bacteria mainly affect on increase of lactic acid concentration due to the conversion of lactose in to lactic acid (Yuliana and Rangga, 2010).Addition of stabilizers could affect the variation of titratable acidity because stabilizers can manage the water amount in the final product which directly affects the lactic acid production by starter microorganisms (Cash and Caputo, 2010; Vergara 2013). Since, citrus fiber has strong water holding capacity compared to other types of stabilizers, water would be unavailable to the metabolic activities of starter organisms. Hence, activity of starter culture could be decreased and lactic acid production is reduced compared to gelatin and carrageenan stabilizers. Yoghurt drink developed with gelatin stabilizer had the highest titratable acidity and these findings could be justified with the previous findings of Gad *et al.* (2010) who investigated that gelatin had the lower water holding capacity.

According to figure 1, pH of all treatments and control sample increased with the storage period and there was a significant difference ($p<0.05$) in pH of the treatments. During the storage period, the pH value of all the treatments was within the range of 4.6-4.45.Maximum pH value recommended for yogurt by SLSI is pH 4.6 (SLSI, 1989). Thus, all the treatments were within the acceptable pH range. The highest influence on acidity was

observed in yogurt drinks supplemented with 0.2% citrus fiber.

3.2 Proximate Analysis: Increase of protein content obviously affects the enhancement of biological value of the yoghurt drinks (Alakali, 2008). The yogurt drink which contains gelatin had the highest protein content, followed by the citrus fiber added sample. Gelatin contains around 98-99% protein derived from collagen of animal tissues. Even though gelatin is considered to have less nutritional properties compared to many other protein sources since it lacks essential amino acids such as lysine and tryptophan (Ward and Courts, 1977).Citrus fiber contains some residual protein in addition to natural pectin, cellulose and hemicellulose and it may contribute a slight increase of protein content due to the incorporation of citrus fiber. However, the protein amount was not significantly different ($p>0.05$) among the 0.2% citrus fiber, 0.04% carrageenan, 0.3% gelatin and control sample (Table 1).

Fat content significantly differs ($p<0.05$) among the 0.2% citrus fiber, 0.04% carrageenan, 0.3% gelatin incorporated yogurt drinks and control sample. Though, there was no significant difference ($p>0.05$) among the yogurt drinks developed using citrus fiber and gelatin. The yogurt drinks which contain citrus fiber had the highest fat content and control yogurt drink had the least among treatments. However, carrageenan also had somewhat lower fat content compared to gelatin and citrus fiber. Generally, carrageenan is used for thickening of products and it does not serve for any nutritional aspects (Webber *et al*., 2012). Perhaps, this could be the reason for the aforesaid observation. According to the composition of citrus fiber, it contains around 2% (w/w) fat and this could provide increased fat content to the final product (Nassar *et al*., 2008).

3.3 Sensory evaluation: Significant differences ($p<0.05$) were observed in appearance, texture, colour, taste and overall acceptability of yogurt drinks produced by adding three different stabilizers according to the preference of panelists (Figure 2).

The results showed that, yogurt drink incorporated with 0.2% citrus fiber had the highest overall sensory acceptance compared to other two stabilizers incorporated yogurt drinks. It could be attributed to the decreased whey separation of the yogurt drink with citrus fiber. As well as citrus fiber incorporation increase the water holding capacity of the product and thereby it increases the firmness (Vergara, 2013). All these properties of citrus fiber could lead to gain the highest sensory acceptance for evaluated properties with 0.2% (w/v) citrus fiber incorporation level in yogurt drink.

Preliminary study revealed that 0.2% incorporation level has higher acceptance than the 0.3% citrus fiber level. Addition of fiber in high concentrations could negatively affect the quality of the final product. The observed results in the present study are in agreement with Guven *et al.* (2005) who observed that the general acceptability scores of low-fat yogurt get decreased with the increased levels of fibers. As it was reported by Subhimaros *et al.* (2013) also, higher concentration of fiber could negatively affect the final product quality.

Table 1: Variation of crude fat, crude protein and dry matter content in yogurt drinks developed by adding citrus fiber, carrageenan and gelatin

Treatments (Types of yogurt drink)	Crude protein %	Crude fat %	Dry matter %
0.20% citrus fiber	3.42 ± 0.05^{a}	3.22 ± 0.01^{a}	24.01 ± 0.02^{a}
0.04% carrageenan	3.26 ± 0.03^{a}	3.20 ± 0.01^{b}	22.81 ± 0.04^{b}
0.30% gelatin	3.50 ± 0.04^{a}	3.21 ± 0.01^{a}	21.09 ± 0.03^{d}
Control	3.24 ± 0.02^{a}	3.19 ± 0.03^{b}	22.50 ± 0.04^{c}

Data are expressed as means ± standard deviation.
$^{a, b, c, d}$ means within the same column with different superscripts are significantly different at $p<0.05$

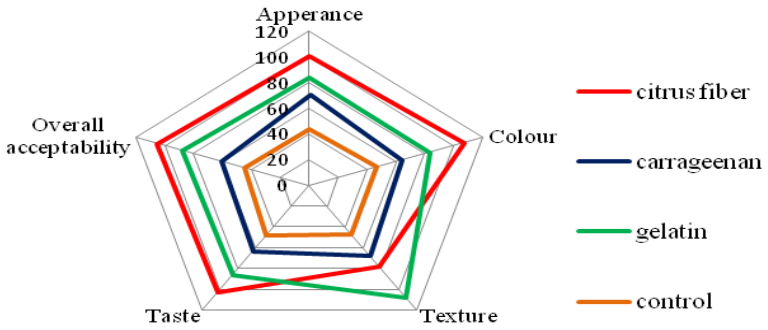

Figure 2: Sensory evaluation of yogurt drinks prepared with different types of stabilizers

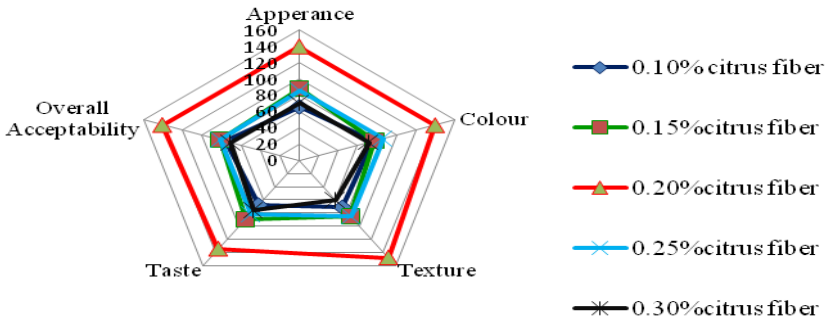

Figure 3: Sensory evaluation of yogurt drinks prepared with different levels of citrus fiber

Bahramparvar and Tehrani (2011) reported that stabilizers are typically added to the mix in order to enhance the body and texture, and firmness, prevents whey separation, and support uniform distribution of ingredients. These finding could be interrelated with the observation obtain for the control yogurt sample in the study. Since there was no added stabilizer in the control sample, it could lead to gain less sensory acceptance compared with treatment samples. When considering the texture of yoghurt drink, the highest score for the texture was observed for the 0.3% gelatin stabilizer containing yogurt drink. According to Mariod and Adam (2013), gelatin has the ability to thicken the milk structure as gelatin-gelatin hydrogen bond network than pectin. Perhaps that could be enhance the textural properties. According to the results reported by Weiner (2014) carrageenan has poor syneresis ability compared to citrus fiber and gelatin. Therefore, yoghurt drink containing 0.04% carrageenan had the poor appearance, color and the taste compared with 0.3% (w/v) gelatin and 0.2% citrus fiber added yogurt drink.

3.4 Microbial Analysis of Yogurt Drinks: There was no yeast and mold growth up to the first week of storage in any treatment or control. Though, the rapid increase of yeast and mold count was observed during the third week of storage. However, none of the observed counts exceed the critical microbial count of 1×10^3CFU/g which was recommended by both SLSI and CODEX during the storage period of 21 days.

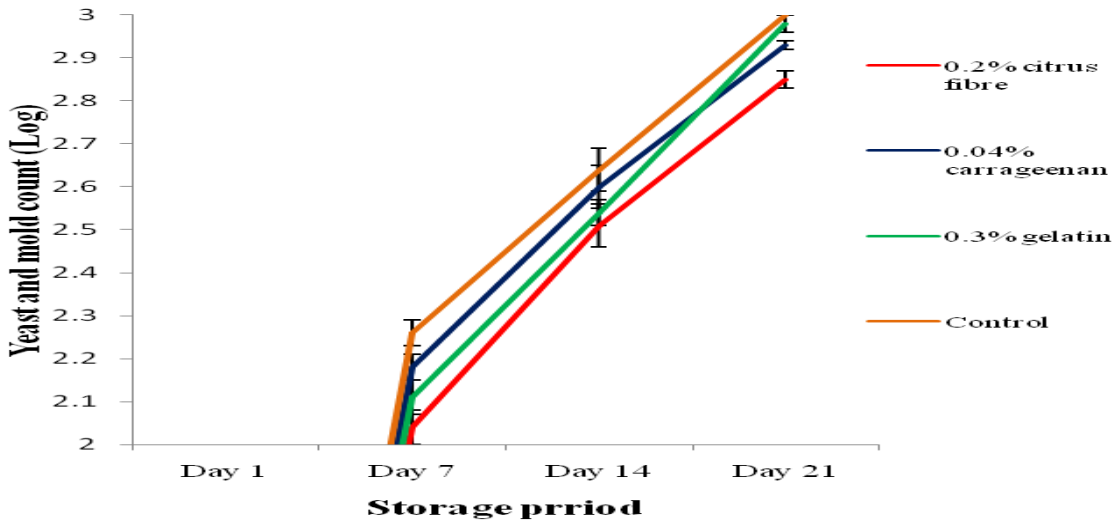

Figure 4: Yeast and mold count in yogurt drinks during the 21 days of storage period

Yogurts with added sugar or fruits are especially susceptible to yeast growth. During the manufacturing of yogurt drink 10% (w/v) sugar was added and it could affect the growth of yeast and mold during later part of the storage period (Atanasova *et al*., 2014). The high yeast and mold counts could be attributed to poor cleaning practices, air incorporation during the stirring of yogurt drink and usage of unhygienic practices. Further, post contamination occurred during the product filling, storage and transportation (Mohammad and El-Zubeir, 2011).

The effect of sucrose of different pretreatment on the solid gain with respect to time of osmosis at different temperatures is shown in Figure 2.After the completion of nine hours processing period, ascorbic and combination of ascorbic and citric acid pretreated samples was showed the highest solid gain is 17.94% and the citric shows the lowest solid gain is 16.41%

4. CONCLUSIONS

It can be concluded that, 0.2 %incorporation level of citrus fiber could enhance the sensory properties of yogurt drink compared to gelatin and carrageenan while improving the nutritional attributes of the final product. Nevertheless, the yogurt drinks developed with citrus fiber could be stored under refrigerated condition (4ºC) up to 21 days without any hazardous contamination levels of yeast and molds.

5. ACKNOWLEDGEMENTS

The authors wish to thank Dairy and Biochemistry Laboratory, Department of Animal and Food Sciences, Faculty of Agriculture, Rajarata University of Sri Lanka for some of the analysis and technical supports.

6. REFERENCES

[1]. Motawee, M. M. and Neveen, S. M. (2016). Effect of Starter Culture as a Source of Microbial Contamination on the Quality and Safety of Yogurt in Giza, Egypt, 6(5): 103–111.

[2]. Kamruzzaman, M. N., Islam, M. N., Rahman, M. M., Pravin, S. and Rahman, M. F. (2002). Evaporation rate of moisture from dahi (yoghurt) at refrigerated condition, *Pakistan Journal of Nutrition*, 1: 209-211.

[3]. Yadav, A., Jaiswal, p., Jaiswal, M., Kumar, N., Sharma, R., Raghuwanshi, S., Prasad, G.B.K.S, and Bisen, P.S. (2015) 'Concise Review: Importance of Probiotics Yogurt for Human Health Improvement', *IOSR Journal of Environmental Science Version. II*, 9(7): 2319–2399.

[4]. Allgeyer, L. C., Miller, M. J. and Lee, S.-Y. (2010). Sensory and microbiological quality of yogurt drinks with prebiotics and probiotics, Elsevier, *Journal of Dairy Science*, 93(10): 4471–4479.

[5]. Cash, M. J. and Caputo,S. J. (2010). Food Stabilizers,Thickeners and Gelling Agents, Available at *http://blog.ub.ac.id/fawzy/flies/Food-Stabilizer.pdf,* Accessed 15 July 2017.

[6]. Hussein, M.M., Fatma, A.M., Hassan, H.H., Abdel D.S.A., Enab, A.K., Asmaa, A. and El-Galil, A. (2011). Utilization of some plant polysaccharides for improving yoghurt consistency, *Annals of Agricultural Science*, **56**: 97–103.
[7]. Mariod, A. A. and Adam, H. F. (2013). Review: Gelatin, source, extraction and industrial applications, *Acta Scientiarum Polonorum, Technologia Alimentaria*, 12(2): 135–147.
[8]. Weiner, M. L. (2014). Food additive carrageenan: Part II: A critical review of carrageenan in vivo safety studies, *Critical Reviews in Toxicology*, 44(3): 244–269..
[9]. Simoneliene, A., Treciokiene, E., Lukosiunaite, G., Vysniauskas, G. and Kasparaviciute, E. (2014). Rheology, technological and sensory characteristics of fortified drink products with fibers, In 9th Baltic Conference on Food Science and Technology *"Food for Consumer Well-Being"*, 72(3): 294.
[10]. Lundberg,B.and Chapman,T.(2013).Citrus fibre as a Food Product Ingerdient-technology benefits, Available at: *https://conference.ifas.ulf.edu/1035 Lundberg.pdf*. Accessed 23 June 2014.
[11]. Larrauri, J. A. (1999). New approaches in the preparation of high dietary fiber powders from fruit by-products, *Trends Food Science and Technology*, 10: 3–8.
[12]. Tungland, B.C.and Meyer, D. (2002). Nondigestible oligoandpolysaccharides (dietary fiber): their physiologyand role in human health and food. *ComprehensiveReviews in Food Science and Food Safety*, 1: 73–92.
[13]. Sfakianakis,P. and Tzia, C. (2014). Conventional and Innovative Processing of Milk Yogurt Manufacture, *A Review Development of Texture and Flavor*, 3(1): 176–193.
[14]. AOAC. (2002). Guidelines for single laboratory validation of chemical methods fordietary supplements and botanicals,*AOAC International*, 6(2): 1–38.
[15]. Ifeanyi,V. O. and Marshall, R.(2013). Assessment of Microbiological Quality of YogurtSold By Street Vendors in Onitsha Metropolis , Anambra State , Nigeria.*British Microbiology Research Journal*, 3(2): 198–205.
[16]. SAS.(2000). Statistical Analysis System. Users Guide Statistics. SAS Institute Inc. Cary, Sri Lanka.
[17]. Minitab (2010). Minitab, version 16.1.0. In. Minitab Inc., State College, Pennsylvania, USA.
[18]. Henrysson,E. M. M. (2016). The effect of mechanical shear in ambient yoghurt,*Jouranal of types of shear*, 43(5): 1–56.
[19]. Codex Alimentarius Commission. (2010). Codex Alimentarius Commission (CAC) Codex standard for fermented milks (Codex Standard 243–2003), Accessed 7 July 2017.
[20]. SLSI 824: (1989). Sri Lanka Standards Specification for Fermented Milk Products. Part 2: Yoghurt. Colombo 08, Sri Lanka.
[21]. Yuliana, N. and Rangga, A. (2010). Manufacture of fermented coco milk-drink containing lactic acid bacteria cultures, *African Journal of Food Science*, 4558–562.
[22]. Vergara, T. C. (2013).Insoluble Dietary Citrus Fibers, *Food Manufaccture*, 23(7): 14–18.
[23]. Gad, A. S., Kholif, A. M. and Sayed, A. F. (2010). Evaluation of the nutritional value offunctional yogurt resulting from combination of date palm syrup and skim milk, *American Journal of Food Technology*, 43(5): 250–259.
[24]. Alakali, J. S., Okonkwo,T. M. and Iordye,E. M. (2008). Effect of stabilizers on thephysico-chemical and sensory attributes of thermized yoghurt, *Africa Journal of Biotechnology*, 7(2): 158–163.
[25]. Ward, A.G and Courts, A. (1977). The science and technology of gelatin. Academic Press, New York.
[26]. Webber, V.,Carvalho,S., Ogliari,P. and Manique,P.L.(2012). Optimization of theextraction of carrageenan from Kappaphycus alvarezii using response surfacemethodology, *Ciência e Tecnologia de Alimentos*, 32(4): 1–7.
[27]. Nassar, A. G., Abdel-Hamied, A. A. and El-Naggar, E. A. (2008).Effect of Citrus by-Products Flour Incorporation on Chemical, Rheological and OrganolepicCharacteristics of Biscuits, *World Journal of Agricultural Sciences*, 4(5): 612–616.
[28]. Guven, M., Yasar, K., Karaca, O.B. and Hayaloglu, A.A. (2005). The Effect of Inulin as a Fat Replacer on the Quality of Set-Type Low-Fat Yogurt Manufacture. *International Journal of Dairy Technology*, 58: 180-184.
[29]. Vergara, T. C. (2013).Insoluble Dietary Citrus Fibers, *Food Manufaccture*, 23(7): 14–18.
[30]. Srisuvor, N., Chinprahast, N., Prakitchaiwattana, C. and Subhimaros, S. (2013). Effects of inulin and polydextrose on physicochemical and sensory properties of low-fat set yoghurt with probioticcultured banana puree, *LWT-Food Science and Technology*, 51(1): 30-36.
[31]. Bahramparvar, M. and Tehrani,M. M. (2011). Application and functions of stabilizers in ice cream, *Food Reviews International*, 27(4): 389–407.
[32]. Weiner, M. L. (2014). Food additive carrageenan: Part II: A critical review of carrageenan in vivo safety studies, *Critical Reviews in Toxicology*, 44(3): 244–269.
[33]. Atanasova J., Danova S. and Iliev I. (2014). Proteolytic Activity in Lactic AcidBacteria from Iraq , Armenia and Bulgaria (April). *Journal of bacteria activity*, 41(3): 34-56.
[34]. Mohammad, E. and El-Zubeir, I.E.M. (2011). Chemical composition and microbial load of set yoghurt from fresh and recombined milk powder, Reserch opinions – Animal and Veterinary Sciences, 1(7): 425-428.