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Production and Evaluation of *Moringa oleifera* Leaves Powder Enriched Yogurt

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Abstract

This study was conducted to evaluate the quality of yogurt enriched with *Moringa oleifera* leaves powder (MOLP). Moringa oleifera leaves were processed into powder and different ratios of the powder (0.5, 1, 1.5, 2.0g) were incorporated in the production of yogurt and coded respectively as MEY_1, MEY_2, MEY_3, and MEY_4. The control (YU) was made from a 100g milk powder and the samples were analysed for chemical and sensory properties. Treatments had total solids within the range of 19.5-21%, total protein 30.68-56.80%, ash 0.4-0.7%, fat 0.9-3.7%, pH 6.44-6.53 and viscosity 0.015-0.019Nsm-2. Result showed that the control (YU) was the best choice and gained highest mean score for all sensory attributes (colour, taste, flavour, mouth-feel and general acceptability). Sample MEY2 had the highest score for general acceptability when compared to other treatments and was second in overall preference. Colour was preferred in control (YU) than other treatments and was typical of a regular yogurt. There were significant differences ($P<0.05$) in the chemical and sensory properties of the yogurt samples. This showed the uniqueness of Moringa oleifera leaves and its possible application in food.

Keywords: *Chemical properties; leaves powder; Moringa oleifera; Yogurt; Sensory properties*

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Introduction

Moringa oleifera is one out of numerous under-exploited crops with great potentials (Magbagbeola., *et al*. 2010). The plant is a small fast growing tree found in the tropical regions, easy to cultivate and resistant to drought (Hassan., *et al*. 2016). This plant is very useful in that most of its parts are edible. *Moringa oleifera* is referred to as a miracle tree or wonder tree (Kasolo., *et al*. 2010) of socio economic importance because of its several nutritional, pharmacological (Caceres., *et al*. 1991) and industrial applications (Makkar and Becker, 1997). Fahey (2005) described moringa as a plant food of high nutritional value, ecologically and economically beneficial, readily available and therefore of great benefit in places where starvation is eminent.

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The *Moringa* tree is known by different names in different places. English common names include: moringa, drumstick tree (from the appearance of the long, slender, triangular seed-pods), horseradish tree (from the taste of the roots, which resembles horseradish), ben oil tree, or benzoil tree (from the oil which is derived from the seeds) (Bashir., *et al*. 2017). It is called the drumstick tree in India due to the long pods or the horseradish tree as the roots may be used to make a spice resembling horseradish. In Senegal it is known as Nebeday, which means "Never Die", it is also known as Ben oil tree in Haiti (El Award, 2003). In Nigeria, the Hausas call it *Zogale, Kilba-Kabbi,* and *Fulani-Kabije* (Dahiru., *et al*. 2006), the Igbos on the other hand call it *okweoyibo* or *Agbaji*.

Moringa leaves are rich in nutrients with the dry leaves containing as much as 30% protein. The leaves are sources of the sulphur containing amino acid such as methionine and cystine which are often in short supply in most legumes (Martin., *et al*. 1998) and contain high amount of vitamin B-complex, calcium, potassium, iron and protein (Hassan., *et al*. 2016). Fuglie (2001) reported that moringa leaves are very high in iron, weight for weight moringa leaves powder contains 14 times more iron than roasted beef (one of the richest iron sources). According to Rweyemamu (2006), 100g of *Moringa oleifera* leaves can meet the daily requirements of vitamin A for 17 children at the age of 1-3 years, 10 pregnant women and 7 lactating mothers. They are rich in phytochemicals/antioxidants such as ascorbic acid, flavonoids, phenolics and carotenoids (Anwar., *et al*. 2005); making them useful in the reduction of oxidative stress which has been implicated in the etiology of a wide range of chronic diseases.

Moringa tree is not only invaluable in the sense that all parts of the tree are edible, but the most amazing aspect of the tree is its exceptional high nutritious value, for this reason the *Moringa* tree has been called "mothers' best friend" (El-Awady, 2003). *Moringa* leaves have been reported to be a rich source of - carotene, protein, vitamin C, calcium and potassium and act as a good source of natural antioxidants like ascorbic acid, flavonoids, phenolics and carotenoids (Dillard and German, 2000). In fact, the leaves of the Moringa tree contain four times the amount of vitamin A in carrots, and seven times the vitamin C in carrots. They are also good sources of vitamin B and other minerals. The leaves are outstanding source of calcium (four times the amount in milk), protein (twice the amount in milk), and potassium (three times the amount in bananas) (Fuglie, 2001). The content of iron is very good as well and the leaves have purportedly been used for treating aneamia in the Philippines (Fahey, 2005).

Moringa leaves are extensively utilized to improve nutritional and sensory evaluation by incorporating its extract into food products like sauces, juices, spices, milk, bread (Mukunzi., *et al*. 2011).

Yogurt is a diary product produced by bacterial fermentation of milk (Willey., *et al*. 2008). The bacteria used to make yoghurt are known as yogurt cultures. These cultures include *Streptococcus salivarius* subspecies *thermophilus* and *Lactobacillus delbrueckii* subspecies *bulgaricus*. Fermentation of lactose by these bacteria produces lactic acid, which acts on milk protein to give yoghurt its texture and characteristic tang (Xue Han., *et al*. 2016). The lactic acid lowers the pH, makes it tart, causes the milk protein to thicken and acts as a preservative since pathogenic bacteria cannot grow in acid condition. The lactic acid produced is also responsible for the characteristic flavour and aroma of yogurt and helps to maintain the quality of the yogurt during storage and packaging (Saint., *et al*. 2006).

The partial digestion of the milk when these bacteria ferment milk makes yogurt easily digestible (David, 2003). The fermented milk could be blended with various ingredients like fruits which provide flavour and colour. Yogurt is a very versatile food stuff, which is consumed both as a food on its own or ingredient in other foods. It is a probiotic product since it contains live active micro-organisms which upon ingestion in sufficient number exert health benefits beyond the inherent basic nutrition and it can be used in marinades, dips, sauces, dressing, baked goods, chilled and frozen dessert amongst others (White and White, 1994). To modify certain properties of yogurt, ingredients like fruits and vegetables are added to the fermentation media to increase the organoleptic properties (Kosikowski, 1987).

Presently, only yogurts enriched with exotic fruits such as raspberry, banana, peach, vanilla, and strawberry are commercially available. However, there are some underutilized tropical fruits and vegetables that can be used in place of these exotic fruits; for instance Moringa oleifera leaf. Until very recently, Moringa has not attracted much research interests when compared with other more popular

species. There is need to promote the utilization and consumption of underexploited species like Moringa. Fewer studies have been carried out on the nutrient promoting potentials of this leaf powder.

Most available researches on Moringa were done outside Nigeria. It is known that geographical location plays a significant role in the chemical composition of plants; hence studying the chemical composition of foods enriched with Moringa leaves from Nigeria will form a basis for comparison with Moringa leaves enriched foods from other geographic locations. Therefore, the objectives of this study are to produce yoghurt enriched with *Moringa oleifera* leaves powder and to evaluate the chemical and sensory properties of yogurt enriched with *Moringa oleifera* leaves powder.

Moringa could be used as a flavouring agent in yoghurt production. When incorporated into yoghurt, it would add to the nutritional quality of the product by providing essential vitamins and minerals, contribute to the protein and calorific value of the product; thereby improving the micronutrient and protein requirements of the consumers.

Material and Methods

Moringa oleifera leaves were collected from a farmyard in the environment of Food Science and Technology Department, Federal University of Technology Owerri, Imo State of Nigeria. Starter culture (*Streptococcus thermophilius* and *Lactobacillus bulgaricus*), powdered milk and other ingredients used for the yogurt production were purchased from a market in Owerri Metropolis.

Processing of Moringa oleifera leaves powder: The fresh leaves of *Moringa oleifera* were manually sorted after harvesting; the diseased and damaged leaves were removed. Selected leaves were washed in running tap water to remove dirt. Water was removed from the surface of the leaves and then allowed to dry in the oven for 30 min at 50°C. The dried leaves were ground and screen of 0.5mm-10mm pore size was used for the separation of the fine powder. Moringa oleifera leaves powder was dried at a temperature of 40°C for 30 min.

Processing of yogurt: The method described by Hassan., *et al*. (2016) was adopted and modified. The powdered milk was divided into five portions and coded as follows: YU, MEY_1, MEY_2, MEY_3 and MEY_4. Sample YU was the control while samples MEY_1, MEY_2, MEY_3 and MEY_4 were mixed with 0.5, 1.0, 1.5, and 2% *Moringa oleifera* leaves powder respectively. The flow diagram for the processing of *Moringa oleifera* leaves powder enriched yogurt is shown in figure 1. The yogurt was refrigerated at (5 ± 1°C) until analysed. Samples were analysed for chemical and sensory properties. All analyses were carried out in duplicate for each sample and results obtained were computed into means. These were subjected to analysis of variance (ANOVA).

Chemical analysis of the yogurt samples

The total solid, fat content and ash content of the samples were determined according to the method described by AOAC (1990); the protein content was determined by a method as described by James (1995); the potential Hydrogen (pH) of the samples was analyzed using a calibrated pH meter with glass electrode; the method described by Onwuka (2005) was adopted for determining the viscosity of the samples.

Sensory evaluation of the yogurt samples

Sensory evaluation was carried out on all the yogurt samples using 20 panelists in F.U.T.O community. The samples were evaluated for quality characteristics such as colour, taste, flavour, mouth feel, general acceptability using 9-point hedonic scale where "9" represents "like extremely" and "1" dislike extremely as described by Ihekoronye and Ngoddy (1985). The panelist were given privacy and instructed to rinse their mouth with clean water which was provided to each of them after testing a sample to avoid carryover effect.

Statistical analysis

The result of the chemical analysis and sensory scores were subjected to the analysis of variance (ANOVA) using Microsoft Excel Package 2007 and the treatment means separated using Fishers Least Significant Difference (LSD).

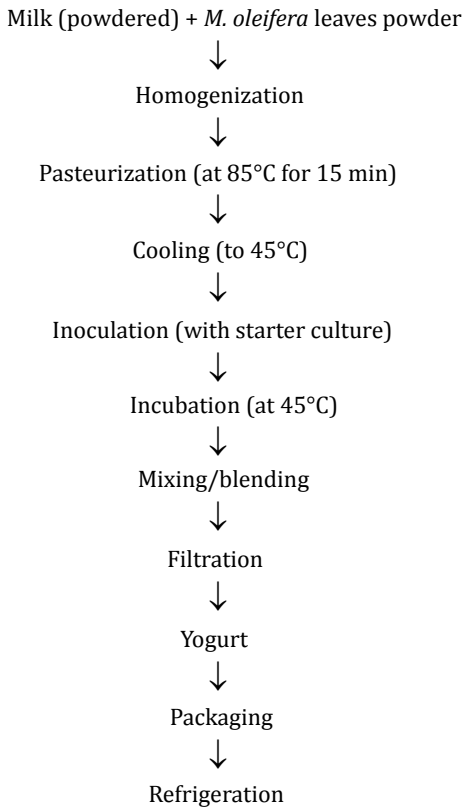

Figure 1: *Flow diagram for the production of Moringa oleifera leaves powder enriched yogurt.*

Results and Discussion

Chemical properties of the yogurt samples

The result of the chemical properties of the yogurt samples are shown in table 1.

Total solids: From the result obtained the total solid content of the samples ranged from 19.5% to 21%. Sample YU and MEY_2 had the highest values (21%) while sample MEY_1, had the lowest value (19.5%). Samples MEY_3, MEY_4; YU and MEY_2 had similar total solid content. Increase in the solids content improves the nutritional value of the yogurt, makes it easier to produce a firmer yogurt and improve its stability (Livescience.com, 2006).

Fat content: Table 1 shows that the fat content of the samples ranged from 0.6% to 2.5%. Samples MEY_3 had the highest value (3.7%) while sample MEY_4 had the lowest value (0.6%). All the samples were significantly different ($P < 0.05$) from one another. Mensah., *et al*. (2012) reported that the fat value in *Moringa* is higher than 0.5% and this is in agreement with the result obtained.

Ash content: The ash content of all the samples ranged from 0.4% to 0.78%. Sample MEY_1 had the highest ash content of 0.07% while samples YU, MEY_2, MEY_3 had the lowest ash content.

Protein content: The protein content result were significantly different ($P < 0.05$). Sample MEY_4 had the highest result while sample YU had the lowest protein result. The increase in protein content is desirable and can be attributed to the composition of *Moringa oleifera* leaves powder. This result is similar to Sodamode., *et al*. (2013), who reported that in *solanum microcapor* leaves protein concentrate is greater than 8.44 ± 0.05%. This means that leaf protein concentrate could be used as nutritionally valuable healthy ingredient to improve protein deficiency of man or animal diet.

Samples	Total solids (%)	Total protein (%)	Ash (%)	Fat (%)	Ph viscosity	(nsm^{-2})
YU	21.00 ± 1.41^{a}	30.68 ± 2.44^{e}	0.400 ± 0.00^{b}	1.500 ± 0.71^{c}	6.49 ± 0.707^{ab}	0.014 ± 0.0^{e}
MEY_1	19.50 ± 0.99^{a}	45.35 ± 0.78^{d}	0.700 ± 0.14^{a}	0.900 ± 0.14^{d}	6.44 ± 0.00^{b}	0.015 ± 0.0^{d}
MEY_2	21.00 ± 3.39^{a}	49.85 ± 0.78^{bc}	0.400 ± 0.28^{b}	2.500 ± 0.85^{b}	6.530 ± 0.00^{a}	0.016 ± 0.0^{c}
MEY_3	20.0 ± 1.41^{a}	52.15 ± 0.78^{b}	0.400 ± 0.28^{b}	3.700 ± 0.71^{a}	6.520 ± 0.00^{ab}	0.018 ± 0.0^{b}
MEY_4	20.0 ± 2.26^{a}	56.80 ± 0.707^{a}	0.500 ± 0.42^{ab}	0.600 ± 0.71^{e}	6.470 ± 0.00^{ab}	0.019 ± 0.0^{a}
LSD	1.691	2.337	0.2182	0.1152	0.081	0.00

Table 1: *Mean values of the chemical properties of the yogurt samples.*

Means with the same superscript in each column are not significantly different (P > 0.05)

KEY:
YU = 100g milk (Control)
MEY_1 = 99.5 gmilk; 0.5g moringa leaves powder
MEY_2 = 99 gmilk; 1.0g moringa leaves powder
MEY_3 = 98.5 gmilk; 1.5g moringa leaves powder
MEY_4 = 98 gmilk; 2.0g moringa leaves powder

pH: The pH of the samples were within the range of 6.44 and 6.53. The samples were significantly different from one another at $P < 0.05$. Sample MEY_2 had the highest value for pH (6.53) and sample MEY_1 had the lowest value (6.44) for pH.

Viscosity: The Viscosity of the samples was within the range of 0.014 and 0.0193. The viscosity for the samples were significantly different from each other at $P < 0.05$.

Sensory properties of the yogurt samples

The result of the sensory evaluation of the yogurt samples is shown in table 2.

Table 2 shows the sensory evaluation properties of yogurt manufactured by blending milk with different ratios of Moringa oleifera leaves powder. The significant differences were measured at $P > 0.05$ for all attributes.

Control had gained highest score in all the sensory parameters (colour, taste, flavour, mouth feel and general acceptability) than other treatments. For colour, average score for all the samples ranged from 6.65 to 8.70.

Samples	Colour	Taste	Flavour	Mouth feel	General acceptabily
YU	8.700 ± 0.571^{a}	8.300 ± 0.801^{a}	8.100 ± 1.165^{a}	8.100 ± 0.968^{a}	8.450 ± 0.686^{a}
MEY_1	6.750 ± 2.173^{bd}	6.000 ± 1.622^{d}	7.600 ± 1.314^{a}	6.100 ± 2.049^{c}	5.750 ± 2.074^{cd}
MEY_2	7.400 ± 0.821^{b}	7.650 ± 1.137^{ab}	7.600 ± 1.314^{ab}	7.250 ± 0.716^{ab}	7.750 ± 0.786^{a}
MEY_3	6.650 ± 2.134^{be}	6.750 ± 1.832^{cd}	7.200 ± 1.881^{b}	6.000 ± 1.686^{cd}	6.350 ± 1.755^{bc}
MEY_4	7.200 ± 1.609^{bc}	7.000 ± 1.487^{bc}	7.400 ± 1.392^{ab}	6.850 ± 1.309^{bc}	6.650 ± 1.30^{9b}
LSD	0.995	0.893	0.899	0.896	0.895

Table 2: *Mean values of the sensory properties of the yogurt samples.*

Means with the same superscript in each column are not significantly different (P > 0.05)

KEY:

YU = 100g milk (Control)

MEY_1 = 99.5 gmilk; 0.5g moringa leaves powder

MEY_2 = 99 gmilk; 1.0g moringa leaves powder

MEY_3 = 98.5 gmilk; 1.5 gmoringa leaves powder

MEY_4 = 98 gmilk; 2.0 gmoringa leaves powder

These results were in agreement with Madukwe., *et al*. (2013) who reported that the colour of the control was preferred over *Moringa* beverages. It is also in agreement with the report of Hassan., *et al*. (2016) who stated that the control had higher whiteness than treatment. Sample YU (control) had the highest score for colour (8.70; liked very much) and was significantly different ($P < 0.05$) from other samples, while sample MEY_3 had the lowest score for colour (6.65; liked slightly). Sample MEY_1 was not significantly different from sample MEY_2; MEY_3 and MEY_4 but was significantly different from sample YU. This could be because MEY_1, MEY_2, MEY_3 and MEY_4 contain *moringa oleifera* leaves powder and the people are already familiar with the colour of regular yogurt. The taste for the sample YU and MEY_2; MEY_1 and MEY_3; MEY_2 and MEY_4 were not significantly different from each other but YU (control) was significantly different ($P < 0.05$) from MEY_1, MEY_3 and MEY_4 and it ranged from 6.0-8.3.

For flavor, the mean score of the samples ranged from 6.0-8.1. There was no significant difference ($P > 0.05$) between samples YU, MEY_1, MEY_2 and MEY_4. The highest score for sample YU may be attributed to the normal yogurt flavour already known by the judges.

The result for mouth-feel showed that sample YU and sample MEY_2 were not significantly different from each other but were significantly different from sample MEY_1, MEY_3 and MEY_4 at $P > 0.05$. This could be attributed to the varying quantities of the *moringa oleifera* leaves powder in the blend and the improper denaturing of the whey protein in the milk.

The general acceptability for the samples ranged from 5.75 to 8.45. Sample YU and MEY_2 were most generally accepted than sample MEY_3 and MEY_4. Sample MEY_1 was the least accepted, the reason may be attributed to the immediate sharp difference in the taste, flavor and mouth feel of the sample when compared with the control.

Conclusion

This study has succeeded in revealing that the nutritional profile of yogurt can be increased by incorporating Moringa oleifera leaves powder. Although, from the sensory analysis, the result of the study has shown that sample YU (control) was more acceptable to the judges than samples MEY_1, MEY_2, MEY_3 and MEY_4. This has been attributed to unfamiliar flavor and a lingering after-bitter taste of *Moringa oleifera* leaves powder to the judges. In general, the yogurt blends contained a good balance of nutrient and also had good sensory attributes. The findings of this study will provide information to the food processor, consumers, researchers, nutrition policy makers etc, as regards Moringa and its processing. It is also believed that results from this work will promote agricultural biodiversity by increasing Moringa cultivation, utilization and consumption.

Recommendation

It is recommended that further work be carried out on this study to ascertain the best processing method of preparing Moringa oleifera leaves powder so as to retain majority of its nutrients. Also, the odour and lingering-after-bitter taste of the leaves powder of Moringa oleifera should be worked on.

References

1. Anwar F., *et al*. "Interprovenance variation in the composition of Moringa oleifera oilseeds from Pakistan". *Journal of American Chemists' Society* 82.1 (2005): 45-51.
2. A.O.A.C. Official methods of Analysis, 15th (ed). Association of official Analytical Chemist, Washington D.C. U.S.A. (1990): 121-142, 223-225.

3. Bashir KA., *et al*. "Exploring the Potential of Drumstick (Moringa oleifera) Leaf Extract as Vegetative Growth Enhancer of Guinea Corn (*Sorghum bicolor* L.)." *International Journal of Current Science and Studies* 1.1 (2017): 9-12.
4. Caceres A., *et al*. "Pharmacological properties of Moringa oleifera: Preliminary screening for antimicrobial activity." *Journal of Ethnopharmacology* 33.3 (1991): 213-216.
5. David BF. Yoghurt making illustration. In: Biology and Chemistry, Clermont Science College, Batavia (2003): 45-103.
6. Dahiru D., *et al*. "Phytochemical Screening and Antiulcerogenic Effect of Moringa oleifera Aqueous Leaf Extract". *African Journal of Traditional, Complementary and Alternative Medicine* 3.3 (2006): 70-75.
7. Dillard CJ and German JB. "Phytochemicals: nutraceuticals and human health: Areview". *Journal of the Science of Food Agriculture* 80.12 (2000): 1744-1756.
8. El Award A. Moringa Tree: Nature's Pharmacy. (2003).
9. Fahey JW. "Moringa oleifera: A review of the medical evidence for its nutritional, therapeutic and prophylactic properties". *Trees for Life Journal* (2005).
10. Fuglie LJ. The Miracle Tree: The Multiple Attributes of Moringa. Church World Service, Dakar, (2001): 172.
11. Hassan FAM., *et al*. "Utilization of Moringa oleifera leaves powder in production of yoghurt". *International Journal of Dairy Science* 11.2 (2016): 69-74.
12. Ihekoronye, AI and Ngoddy PO. Integrated Food Science and Technology for the tropics. Macmillan Publishers Ltd., London, (1985). 178-180, 372-373.
13. James CJ. The analytical chemistry of foods. Chapman and Hall Press, New York, (1995): 86.
14. Kasolo JN., *et al*. "Phytochemicals and uses of Moringa oleifera leaves in Ugandan rural communities". *Journal of Medicinal Plants Research* 4.9 (2010): 753-757.
15. Kosikowski EV. Cheese and Fermented Milk Products. 2nd Edn, Cornell University, Ithca, NY., USA. (1987).
16. Livescience.com Yogurt Culture Evolves. Retrieved 16 January 2012. (2006).
17. Madukwe EU., *et al*. "Nutrient composition and sensory evaluation of dry Moringa oleifera aqueous extract". *International Journal of Basic & Applied Sciences* 13.3 (2013): 100-102.
18. Magbagbeola JAO., *et al*. "Neglected and under-utilized species (NUCS): a panacea for community focus and development to poverty alleviation/poverty reduction in Nigeria". *Journal of Economics and International Finance* 2.10 (2010): 208-211.
19. Makkar HPS and Becker K. "Nutrients and antiquality factors in different morphological parts of the Moringa oleifera tree". *The Journal of Agricultural Science* 128.3 (1997): 311-322.
20. Martin FW., *et al*. Edible Leaves of the Tropics. 3rd Edn. Educational Concerns for Hunger Organization, Inc., N.Ft. Meyers, Florida (1998):194.
21. Mensah JK., *et al*. "Pytochemical, nutritional and antibacterial properties of dried leaf powder of Moringa oleifera (Lam) from Edo central province, Nigeria". *Journal of Natural Product and Plant Resources* 2 (2012):107-112.
22. Mukunzi D., *et al*. "Comparison of volatile profile of Moringa oleifera leaves from Rwanda and China using HS-SPME." Pakistan Journal of Nutrition 10.7 (2011): 602-608.
23. Onwuka GI. Food analysis and instrumentation: theory and practice. Napthali prints Nigeria Limited, Surulere Lagos, Nigeria (2005): 119-121.
24. Rweyemamu LMP. "Challenges in the Development of Micronutrient rich Food Ingredients from Soya Beans and Moringa oleifera Leaves". Conference proceedings: Moringa and other highly nutritious plant resources: Strategies, standards and markets for a better impact on nutrition in Africa. Accra, Ghana, (2006):16-18.
25. Saint A., *et al*. "Influence of Proteins on the Perception of Flavoured Stirred Yoghurts". *Journal of Dairy Technology* 89.3 (2006): 922-933.
26. Sodamode A., *et al*. "Proximate analysis, mineral contents and functional properties of Moringa oleifera leaf concentrate". *IOSR Journal of Applied Chemistry* 4.6 (2013): 47-51.
27. White S and White G. Dairy flavouring. In: Food Flavouring, Ashrust P.R. (Ed), Blackie and sons Ltd, London. (1994): 222-236.

28. Willey JM., *et al*. Prescott Harley and Klein Microbiology. 7th Edition, Mc-Graw Hill, New York. (2008): 1038.
29. Xue Han., *et al*. "Improvement of the Texture of Yogurt by Use of Exopolysaccharide Producing Lactic Acid Bacteria". *BioMed Research International* (2016).