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Effects of Storage On The Quality of Tiger Nut (*Cyperus esculentus*) Products

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ABSTRACT

Yoghurt-like products from tiger nuts (Cyperus esculentus) were stored at different conditions; ambient, accelerated and refrigerated temperatures. These yoghurt-like products were produced from their respective aqueous extracts by the following processing methods; hot water blanching, steam blanching and pasteurization. Yoghurt from cow milk served as control. Furthermore, these yoghurt-like products were stored in 500ml disposable containers at different conditions; ambient temperature 32±2^{o}C, accelerated temperature 45±2^{o}C and refrigerated temperature 10±2^{o}C to investigate the effect of storage stability on their quality. In a preliminary study, the peroxide value (PV), pH, total titratable acidity (TTA), Viscosity and sensory evaluation on freshly prepared yoghurt-like samples ranged from 8 to 11mEq/kg, 4.2 to 5.3, 1.3 to 2.4%, 151.5 to 202.3cP and 2.1-4.9 mean scores respectively. In this study, PV, pH, TTA, viscosity and sensory evaluation were determined on stored yoghurt-like sample, at an interval of 2days. At ambient condition, peroxide value (PV), pH, TTA , viscosity and sensory evaluation mean scores ranged from 12.7 to 32mEq/kg, 3.60 to 5.12, 1.36 to 3.89, 97.4 to 194 cP and 1.16 to 3.94 mean scores respectively. At accelerated condition, values ranged from 12 to 33mEq/kg, 3.69 to 4.71, 3.57 to 4.88, 98.4 to 116.7cP and 1.12 to 3.62 mean scores. At refrigerated conditions, values ranged from 10 to 24.8mEq/kg, 3.25 to 5.30, 1.34 to 3.42, 90.10 to 200.40cP and 1.02 to 4.63 mean scores respectively. Physico-chemical parameters and sensory quality of yoghurt-like samples declined with increased storage temperature.

***Keywords**: Yoghurt-like product, ambient temperature, accelerated temperature and refrigerated temperature.*

Introduction

Tiger nut (*Cyperus esculentus*) is a sedge which produces tuberous rhizome at the root tips under the ground. Tiger nuts are also called earth almonds, chufa, rush nuts or Brazil nuts. The tubers or nuts are spherical in shape and are edible. The varieties of tiger nuts readily available in the market are the brown and yellow varieties. The yellow variety is preferred to all other varieties because of its inherent properties such as larger size, attractive color and fleshy body. The yellow variety is also reported to yield more soluble extracts, contains lower fat, more protein and possesses less anti-nutritional factors such as polyphenols (Okafor *et al.*, 2003). When eaten raw, they make a very acceptable snack and have a flavor and texture reminiscent of coconut (Sanful, 2009). Tiger nuts are believed to help prevent heart attacks, thrombosis and cancer, especially of the colon. They are thought to be beneficial to diabetics and those seeking to reduce cholesterol and lose weight (Sanful, 2009 and Duke, 2001).

Earlier studies by Sanful (2009) show that the inherent nutritional and therapeutic advantage of tiger nuts makes it a good alternative source of milk in yoghurt production. Yoghurt is a cultured 'food' obtained by controlled fermentation of milk by mixed culture of lactic acid bacteria selected to produce a characteristic mild clean lactic flavor and typical aroma (Early,1992). Conventionally, yoghurt is produced from cow's milk and a starter culture containing *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (Farinde *et al.*, 2008). Extensive studies have been conducted on alternative sources of milk for yoghurt production. The alternative sources of milk reported for use in yoghurt production are; bambara nuts, soybeans, groundnuts, melon seeds, cashew nuts etc.

In a previous study by Adgidzi (2010), efforts led to the production of acceptable beverages and yoghurt-like products from tiger nuts. The beverage products were found to contain a proximate composition of 1.89 and 2.67% protein, 0.92 and 1.33% fat, 0.16 and 0.21% ash, 0.24 and 0.33% crude fiber, 76.86 and 80.27% moisture and 15.96 and 19.15% carbohydrates. Mineral composition (Calcium (Ca), Potassium (K), Sodium (Na), Magnesium (Mg) and Phosphorus (P) per 100g ranged between 14.90 and 25.60mg, 6.40 and 8.10mg, 1.98 and 3.24mg, 0.046 and 0.054mg, 0.060 and 0.083mg respectively. In a quest to add value to these extracts, a study by Adgidzi, (2010) led to the production of yoghurt-like products from extracts of tiger nuts. The yoghurt-like products were found to contain Total titratable acidity (TTA) of 1.3 to 2.4%. pH 4.2 to 5.3, viscosity at 60rpm 151.1 to 202.3cP and peroxide value(PV) 8-11Meq/kg. Mean scores of sensory evaluation of freshly prepared yoghurt-like products ranged between 2.1 to 4.6, 2.4 to 4.1, 2.2 to 4.9 and 2.4 to 4.6 for flavor, consistency, color and overall acceptability respectively.

With the nutritional composition of the extracts, it was possible to support the growth of lactic acid bacteria (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*) and yield yoghurt-like products. However, yoghurt does not store long under high temperature.

Conventionally, yoghurt is produced from cow's milk and a starter culture containing *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (Farinde *et al.*, 2008). Fresh yoghurt is reported to have shelf life of few days at ambient temperature and 40 days under refrigeration in many parts of Nigeria, particularly, Makurdi and other parts of northern Nigeria. The average daily room and outside temperatures are usually in excess of 30℃ and often above 35℃, these temperatures are very conducive for rapid microbial multiplication and activities as well as rapid chemical reactions. With such high temperatures, the spoilage of food products is expectedly very rapid and yoghurt which is highly nutritious and best consumed fresh is particularly vulnerable to such spoilage (Alkali *et al.*, 2007). Consequently, this study was carried out to determine the

possibility of storing yoghurt-like products from aqueous extracts of tiger nuts at different storage conditions-accelerated, ambient and refrigerated temperatures. It focused on the quality of stored yoghurt-like products from tigernuts (*Cyperus esculentus*).

Materials and Methods

Procurement of Raw Material

Approximately 3kg of yellow tiger nuts (*Cyperus esculentus*) were obtained from a market in Makurdi, Benue State and transported to the Food Science and Technology laboratories in thick polyethelene bag.

Preparation of yoghurt from aqueous tiger nut extracts and cow milk.

Five yoghurt samples were prepared from aqueous tiger nut extracts and from cow milk using the following processing methods. These were;

1. Yoghurt produced from aqueous extract of tiger nuts subjected to hot water blanching for 5min,
2. Yoghurt produced from aqueous extract of tiger nuts subjected to hot water blanching for 30min,
3. Yoghurt produced from aqueous extract of tiger nuts subjected to steam blanching for 20min.
4. Pasteurized yoghurt-like product from untreated tiger nuts
5. Yoghurt-like product from untreated tiger nuts

Five grammes of commercial starter culture (Yoghumet, contains *Lactobacillus bulgaricus and Streptococcus thermophilus*) was dissolved in small quantity of lukewarm water and inoculated into the filtrate (extract). The extract was dispensed into air-tight plastic containers and incubated for 4-6hrs to produce yoghurt samples. The yoghurt samples were stirred, packaged and stored at refrigerated temperature. Others were; yoghurt produced from aqueous extract, pasteurized at 70^{o}C for 15min. Commercial starter culture, 'yoghumet' containing *Lactobacillus bulgaricus* and *Streptococcus thermophillus* was dissolved in small quantity of lukewarm water and inoculated in the pasteurized aqueous extract when temperature dropped to 42-45^{o}C and incubated for 4-6hrs to produce a sample. The sample was stirred, packaged and stored at refrigerated temperature. Yoghurt was also produced from aqueous extract from tiger nuts that was not blanched or pasteurized. Earlier studies by Adgidzi, (2010) outlined the production of tiger nuts aqueous extracts using different processing methods. Five grammes of commercial starter culture (Yoghumet contains *Lactobacillus bulgaricus* and *Streptococcus thermophillus*) was dissolved in small quantity of lukewarm water and inoculated in each sample.

About 1.5ltrs of deionized water was heated to boiling and 250g of powered milk and 30g of sugar were weighed out. One litre of the heated deionized water was used to dissolve the milk and sugar into smooth slurry. The slurry was pasteurized at 70^{o}C for 15min (batch process) in a hot water bath and allowed to cool to 42-45^{o}C. Five grammes of commercial starter culture (Yoghumet contains *Lactobacillus bulgaricus* and *Streptococcus thermophillus*) were dissolved in small quantity of lukewarm water and inoculated into the already pasteurized mixture (Early, 1992). The mixture was dispensed into air-tight plastic containers and incubated at 42-45^{o}C for 4-6hrs to produce cow milk yoghurt (control). The prepared sample was stirred, packaged and stored at refrigerated temperature (10±2^{o}C).

Physical/Chemical Analysis

Total Titratable Acidity (TTA)

Total titratable acidity (TTA) was determined as described by Nielsen (2002).

pH

Ten milliliters of sample was titrated against 0.1M NaOH with phenolphthalein as indicator. pH was determined as outlined by Kirk and Sawyer (1991).

Viscosity

Viscosity was determined by the method described by Onwuka (2005). Ten milliliters of samples were taken and the viscosity measured at room temperature (32±2^{o}C) using the Brookfield viscometer (Type LV-8 Viscometer, UK LTD). Readings were taken after 120 seconds of rotation. Spindle No.1 rotating at 60rpms was used and viscosity read as centipoise.

Peroxide Value

Peroxide value was determined by the method of Kirk and Sawyer (1991). Two milliliters of sample was weighed into a 250ml conical flask, 10ml of chloroform was added and swirled gently until fat was dissolved. To it, 15 ml of glacial acetic acid and 1ml of fresh saturated aqueous KI solution were also added. The flask was stoppered, shaken for 1min and placed for exactly 1min in the dark. Five milliliters of water was added, mixed, and titrated with 0.01M $Na_2S_2O_3$ using soluble starch solution (1%) as indicator. A reagent blank determination (V_o) was carried out, it did not exceed 0.5ml of 0.01M $Na_2S_2O_3$ solution.

Sensory Evaluation

Samples were assessed for sensory characteristics based on colour, consistency, flavour and overall acceptability using a 20-member semi-trained panelists on 5-point hedonic scale, with (5) = extremely like and (1) = extremely dislike. The ratings from hedonic scale were subjected to analysis of variance (ANOVA). The Significant differences between means were determined by Least Significant Difference (LSD) test as described by Ihekoronye and Ngoddy (1985).

Statistical Analysis

The data obtained were statistically analyzed by the GENSTAT package 2000. Sensory ratings were subjected to analysis of variance (ANOVA) as described by Ihekoronye and Ngoddy (1985), least significance difference (LSD) test was used to separate means. Significance level was taken at 5%. Values are means of duplicate samples.

Yoghurt samples were produced from the aqueous milk- like extract subjected to different processing methods; HTY_{30}, HTY_5, STY_{20}, SPY_o, UTY_o and cow's milk CYY_o (control).The samples were packaged in 500ml plastic bottles and stored under the following conditions accelerated temperature of 45^{o}C, ambient temperature of 32± 2°C and refrigerated temperature of 10±2 ^{o}C for a period of 14days (2 weeks). At the interval of 2days, pH, TTA (Total Titratable Acidity), sensory evaluation, PV (Peroxide Value) and viscosity at 12, 30, and 60rpm were determined.

Results and Discussion

Sensory evaluation scores of yoghurt-like products stored at accelerated temperature of 45^{o}C, ambient temperature (32±2^{o}C) and refrigerated temperature

The effect of storage on the sensory quality of yoghurt-like samples is given on Tables 1, 2 and 3.

For yoghurt-like products stored at accelerated temperature of 45^{o}C for 2days, there were significant differences ($p \leq 0.05$) and similarities ($p>0.05$) among samples in terms of flavour, colour and overall acceptability. There was no significant difference ($p > 0.05$) among samples in term of consistency. Mean scores ranged from 1.23 to 2.54, 1.28 to 3.62,1.23 to 2.54 and 1.12 to 1.58 for flavor, color, overall acceptability and consistency respectively.

Yoghurt-like products stored for a period of 4days at ambient temperature (32±2^{o}C) showed significant differences ($p \leq 0.05$) and similarities ($p>0.05$) among samples in terms of flavor, consistency, color and overall acceptability. Mean scores of samples evaluated on the 2nd day of storage ranged from 2.13 to 2.90, 2.34 to 3.82, 2.00 to 3.94 and 2.60 to 3.70 for flavor, consistency, color and overall acceptability respectively. Mean scores of samples evaluated on the 4th day of storage ranged from 1.25 to 2.68, 1.16 to 2.91, 1.27 to 3.63 and 1.26 to 3.55 for flavour, consistency, colour and overall acceptability respectively.

Yoghurt-like products stored for a period of 14 days, at refrigerated temperature (10±^{o}C) showed significant differences ($p \leq 0.05$) and similarities ($p>0.05$) among samples in terms of flavor, consistency, color and overall acceptability. Mean scores of samples evaluated on the 2nd, 4th, 6th, 8th, 10th, 12th and 14th days of storage, in

terms of flavour ranged from 2.48 to 4.06, 1.52 to 4.00, 2.62 to 4.05, 1.28 to 3.90, 1.29 to 3.76, 1.44 to 2.41 and 1.02 to 2.11 respectively. Mean scores of samples evaluated on the 2nd, 4th, 6th, 8th, 10th, 12th and 14th days of storage, in terms of consistency ranged from 2.42 to 4.00, 2.18 to 3.66, 1.50 to 3.87, 1.12 to 3.65, 1.03 to 2.72, 1.30 to 2.32 and 1.35-2.56 respectively. Mean scores of samples evaluated on the 2th, 4th, 6th, 8th, 10th, 12th and 14th days of storage, in terms of colour ranged from 2.30 to 4.56, 2.17 to 4.63, 3.10 to 4.27, 1.62 to 3.34, 2.16 to 3.41, 1.74 to 3.51 and 1.08 to 3.46 respectively. Mean scores of samples evaluated on the 2nd, 4th, 6th, 8th, 10th, 12th and 14th days of storage, in terms of overall acceptability ranged from 2.33 to 4.24, 2.29 to 4.53, 2.47 to 4.16, 1.60 to 3.80, 1.76 to 3.34, 1.35 to 2.42 and 1.08 to 3.46 respectively.

Generally as the days of storage increased for different storage conditions, sensory mean scores for preference of samples declined. The rate of decline was greatest for samples stored at accelerated temperature, followed by ambient temperature and refrigerated temperature being the least. It therefore implies that at elevated temperatures, the rate of spoilage is faster and the (keeping quality) shelf life of products is limited. Physiochemical changes in yoghurt continue during storage, especially at temperatures above 10^{o}C. At accelerated and ambient temperatures, changes may occur affecting the wholesomeness of yoghurt. Temperature accelerates instability of foods as a function of relative reaction rate. Increase in reaction rate varies from 30%-300% for each 10% rise in temperature, noticeable changes that occur during storage are gas production, syneresis, changes in color and viscosity, etc. (Muhammad *et al.*, 2008 and Medallion Labs, 2009). Flavour defects develop at higher rate than textural changes during storage and seem to be the earliest manifestation of product failure (Al-Kadamany *et al.*, 2002). Deterioration in sensory quality as well as microbiological counts has been used as indices for the end of shelf life of dairy products (Muir and Banks, 2000 and Hough *et al.*, 1999). The packaging and storage conditions as well as yeast and mold contamination lead to the formation of off-flavours and other undesirable physicochemical changes that eventually lead to product failure (Muir and Banks, 2000).

Peroxide value (mEq/Kg) of yoghurt-like products stored at different conditions

The effect of storage on peroxide value (mEq/Kg) of yoghurt-like products stored at accelerated, ambient and refrigerated temperature for a period of 2, 4 and 14 days respectively is shown in Table 4. Peroxide value of samples stored at accelerated temperature for 2 days ranged from 8 to 33mEq/Kg, ambient temperature for 4 days ranged from 8 to 32mEq/Kg and refrigerated temperature for 14 days ranged from 8-24.7mEq/Kg.

Peroxide value monitors the development of rancidity through the evaluation of the quantity of peroxides generated in the product. Fresh oils usually have peroxide values below 10 mEq/kg. A rancid taste begins to show up when the peroxide value is between

20 to 40 mEq/Kg (Onwuka, 2005). The values of products stored at ambient and accelerated conditions were higher than that of products stored at refrigerated condition due to the fact that the conditions necessary for acceleration of rancidity (exposure to heat and light) was available for the products.

pH of yoghurt-like products stored at different conditions

The effect of storage on pH of yoghurt-like products stored at accelerated, ambient and refrigerated temperature for a period of 2, 4 and 14 days respectively is shown in Table 5. pH values of stored yoghurt-like samples at different conditions; accelerated, ambient and refrigerated temperatures ranged from 3.69 – 4.71, 3.60-5.12 and 3.25-5.30 respectively.

At accelerated temperature, Sample A (at the 2nd day of storage) had the least pH value, while Sample B (at the 2nd day of storage) had the highest pH value. At ambient temperature, Sample A at the 4th day of storage had the least pH while Sample B at the 2nd day of storage had the highest pH value. At refrigerated temperature, Sample A at the 14th day of storage had the least pH value, while sample B at the 2nd day of storage had the highest pH.

The pH value of yoghurts decreased with increased acidity. At accelerated temperature pH decreased from 4.71 to 3.69, while acidity increased from 3.57 to 4.88%. At ambient temperature pH decreased from 5.12 to 3.60, while acidity increased from 1.36 to 3.89% and at refrigerated temperature pH decreased from 5.30 to 3.25 while acidity increased from 1.34 to 3.42%. The increase in acidity could be as a result of the increase in carboxylic and sulphydryl acids generated from the various milk components (Muhammad *et al.,* 2008). Yoghurt production is a biological process and cooling is one of the most popular methods used to control the metabolic activity of the starter culture and its enzymes. Yoghurt organism's show limited growth and activity around and below 10^{o}C and increased growth activity above 10^{o}C. The primary objective of cooling is to drop the temperature of the coagulum from 45^{o}C to less than 10^{o}C as quickly as possible to control the final acidity of the product (Early, 1992). According to Al-Kadamany *et al*. (2002), decrease in pH and corresponding increase in titratable acidity were exhibited by the labneh samples, with the rate of change increasing in parallel with storage temperature, which is indicative of an increase in acid–producing microorganisms(Lactic acid bacteria). Milk protein coagulation process is followed by the acidification of the environment resulting in the formation of the casein gel of ordered network structure.

TTA values of yoghurt samples stored at different conditions

The effect of storage on TTA of yoghurt-like products stored at accelerated, ambient and refrigerated temperature for a period of 2, 4 and 14 days respectively is

shown in Table 6. TTA values of samples stored at accelerated temperature ranged from 1.26 to 4.88, ambient temperature ranged from 1.26 to 3.89 and refrigerated temperature ranged from 1.26 to 3.42.

It was observed that lactic acid increased with increased storage time. Percentage lactic acid increased more for stored samples at accelerated temperature followed by ambient temperature and then refrigerated temperature. Al-Kadamany *et al*. (2002) reported that at 5℃, lactic acid bacteria exhibited a substantial lag phase initially, with counts increasing thereafter and stabilizing towards the end of storage, whereas at 15℃, microbial counts decreased during the first 3days of storage and increased thereafter. The number of lactic acid bacteria in labneh samples stored at 25℃ increased initially, then decreased markedly, consistent with inhibitory effects of elevated temperatures and increased acidity on the growth of yoghurt cultures. Sokolinska *et al*. (2004) observed increase in TTA by 20% during the period of yoghurt storage for 21days in comparison to their acidity determined directly after production.

Viscosity (cP) of yoghurt samples stored at different storage conditions

The effect of storage on Viscosity of yoghurt-like products stored at accelerated, ambient and refrigerated temperature for a period of 2, 4 and 14 days respectively is shown in Table 7 Viscosities at 60rpm ranged from 98.4 to 202.3cP, 100.4 to 202.3cP and 90.1 to 202.3cP at different storage conditions respectively.

During the period of storage, viscosities of samples decreased. Higher values of viscosities were observed on freshly produced samples than samples stored at various conditions. Muhammad *et al.* (2008) reported that yoghurts with low protein contents tend to have low viscosity due to low water-holding capacity of coagulum. The addition of hydrocolloids (stabilizers) improves the viscosity of yoghurts during storage. Bile and Keya (2002) reported that viscosity declines with increasing time due to syneresis. It was observed by Sokolinska *et al.,* (2004) that during storage period of 21days, apparent viscosity of the milk curds decreased in comparison to the viscosity of curds obtained directly after its manufacture. They also reported that as storage duration of the curd increased, a further increase in the curd acidity and its sensitivity to syneresis were observed.

Conclusion

Physico-chemical parameters and sensory quality of yoghurt samples declined with increased storage temperature. Samples stored at accelerated temperature of 45^{o}C were shelf stable for 2 days; at ambient temperature of 32 $\pm$ 2^{o}C were shelf stable for 4 days and at refrigerated 10±2^{o}C temperature, stable for 14 days.

Physical defects observed during the period of storage include off-odours, bulging and bursting of disposable packaging containers.

Recommendation

To enhance the physico-chemical parameters and sensory quality of yoghurt-like products from tiger nuts, samples should be stored at refrigerated temperature (10±2^{o}C) for at most 14days. In the absence of refrigeration, yoghurt-like products can be stored at ambient temperature (32±2oC) for at most 4days.

References

Adgidzi, E.A (2010) Effect of Processing methods on the yield and quality of aqueous extracts and yoghurt- like products from Tigernuts (*Cyperus esculentus*). MSc Thesis submitted to the Department of Food Science and Technology. University of Agriculture, Makurdi. Benue State. Pp 73

Al-Kadamany, E., Toutell, I and Khattar, M. (2002). Determination of shelf life of concentrated yoghurt (labneh) produced in bag straining of set yoghurt using Hazard analysis. *J.Dairy Sci 85:1023-1030.*

Alkali, J.S. Okonkwo, T.M. and Umoru, S.A. (2004). Effect of Thermization on Shelf Stability of Yoghurt. *EJEAFChe 6(12): 1957-1964.*

Bile P.G. and Keya E.L. (2002). A comparison of some properties of vat-heated and dry-skim milk powder fortified set yoghurts. *The Journal of Food Techn. in Africa 7:21-23.*

Duke, J.A. (2001). *Handbook of Nuts.* CRC Press, New York. Pp.139-141.

Early, R. (1992). *The Technology of Dairy Products.* VCH Publishers Inc. New York.

Gimenez, A., Gaston, A and Gamboro, A (2007). Survival analysis to estimate sensory shelf life using acceptability scores*. J. Sensory Studies 23:571-582.*

Hough, L., Pulgieso, M. L., Sanchez, R and Da Silva, O.M. (1999). Sensory and microbiological shelf life of commercial ricotta cheese. *J. Dairy Sci.82:454-459.*

Ihekoronye, A.I. and Ngoddy, P.O. (1985). *Integrated Food Science and Technology for the Tropics.* Macmillan Education LTD, London. Pp.10-77.

Kirk, R.S. and Sawyer, R. (1991). *Pearson's Composition and Analysis of Foods.* Longman Group LTD, UK. 9th ed. Pp.188-189

Medallion Labs (2009). Food product shelf life. Eds. Sewalds, M and De vries. Pp 1-10. Retrieved 20th September, 2010 from www. Medallionlabs.com.

Muhammed B.F., Alhassan A.J., Kabiru H.J. (2008). Quality evaluation of commercial yoghurts on streets of Kano – Nigeria. *Resource J. of Dairy Science.2(4):63-67.*

Muir, D.D and Banks, J.M (2000). Milk and milk production. In : eds Kilcast, D and Subramanian The stability and shelf life of food. CRC Press, Boca Raton, Florida. Pp.107-219.

Nielsen S.S. (2002). Introduction to the chemical analysis of foods. CBS publishers, New Delhi- India. Pp.81-206.

Okafor, J.N., Mordi, J.I., Ozumba, A.U., Solomon H.M. and Olatunji, O. (2003). *Preliminary studies on the characterisation of contaminants in tiger nut (yellow variety).* In NIFST Proceedings of 27th annual conference/AGM Kano. Pp.210-211.

Onwuka G.I. (2005) Food analysis and instrumentation, theory and practice. Napthali Prints, Lagos. Pp.104-120.

Sokolinska, D.C., Michalski, M.M and Pikul, J.(2004). Role of the proportion of yoghurt bacterial strains in milk souring and the formation of curd quantitative characteristics. *Bulletin of Veterinary Institute Pulway 48:437-441.*

Table 1. Effect of storage on sensory attributes of yoghurt-like products stored at accelerated temperature of 45^{o}C.

Sensory Attributes	Samples	2 days
Flavor	A	2.54^{a} (0.05)
	B	2.16^{b} (0.00)
	C	1.31^{d} (0.01)
	D	1.48^{c} (0.08)
	E	1.15^{f} (0.01)
	F	1.23^{e} (1.13)
	LSD	0.0570
Consistency	A	1.41^{a} (0.03)
	B	1.37^{a} (0.06)
	C	1.23^{a} (1.05)
	D	1.40^{a} (1.13)
	E	1.58^{a} (0.01)
	F	1.12^{a} (0.07)
	LSD	0.8398
Color	A	3.62^{a} (0.03)
	B	2.88^{b} (0.01)
	C	1.71^{d} (0.15)
	D	2.50^{c} (0.07)
	E	1.34^{e} (1.15)
	F	1.28^{e} (0.01)
	LSD	0.2238
Overall Acceptability	A	2.63^{a} (0.05)
	B	2.06^{a} (0.01)
	C	1.19^{b} (0.07)
	D	2.45^{a} (1.05)
	E	1.39^{b} (0.08)
	F	81.66^{a} (1.15)
	LSD	1.1065

Any two mean values bearing the same superscript in the same column are not significantly different ($p<0.05$)
Value in parenthesis is standard deviation

LEGEND

A Cow milk Yoghurt; B Pasteurized yoghurt-like product from tiger nuts; C Yoghurt- like product from to hot water blanched (5min) tiger nuts; D Yoghurt- like product from to hot water blanched (30min) tiger nuts; E Yoghurt-like product from untreated tiger nuts; F Yoghurt- like product from to steam blanched (20min) tiger nuts

Table 2. Changes in the sensory attributes of yoghurt-like products stored at ambient temperature (32±2°C)

Sensory Attributes	Samples	2 days	4 days
Flavour	A	2.90^{a} (0.05)	2.68^{a} (1.10)
	B	2.65^{ab} (0.06)	2.04^{ab}(0.11)
	C	2.60^{abc} (1.01)	$1.96^{ab\ c}$(0.05)
	D	2.33^{bcde} (1.15)	1.90^{abcd}(1.12)
	E	2.13^{bcde} (0.72)	1.73^{abcd}(0.05)
	F	2.40^{abcd} (0.33)	1.25^{cde} (0.79)
	LSD	0.549	1.024
Consistency	A	3.82^{a} (0.91)	2.91^{a} (0.05)
	B	2.93^{c} (0.01)	1.40^{b} (1.25)
	C	3.08^{b} (0.01)	1.38^{bc} (0.04)
	D	2.93^{c} (0.65)	1.23^{c}(0.31)
	E	2.34^{e} (0.15)	1.23^{c}(0.51)
	F	2.61^{d} (0.02)	1.16^{d} (1.25)
	LSD	0.0704	0.168
Colour	A	3.94^{a} (0.06)	3.63^{a} (1.15)
	B	3.60^{b} (0.72)	2.41^{b} (1.02)
	C	2.16^{d} (0.03)	1.90^{c} (0.09)
	D	3.05^{c} (0.72)	2.18^{b}(0.51)
	E	2.00^{e} (1.15)	1.39^{d}(0.51)
	F	2.24^{d} (1.01)	1.27^{d} (0.06)
	LSD	0.122	0.325
Overall Acceptability	A	3.70^{a} (1.00)	3.55^{a} (1.10)
	B	3.35^{ab} (0.51)	2.50^{b} (0.72)
	C	3.01^{abc} (0.07)	1.44^{c} (0.04)
	D	2.88^{abcd} (0.33)	1.26^{de} (0.79)
	E	2.60^{bcde} (0.00)	1.32^{d} (0.31)
	F	2.54^{bcde} (0.01)	1.30^{de} (0.01)
	LSD	0.996	0.086

Any two mean values bearing the same superscript in the same column are not significantly different ($p<0.05$)
Value in parenthesis is standard deviation

LEGEND

A Cow milk Yoghurt; B Pasteurized yoghurt-like product from tiger nuts; C Yoghurt- like product from to hot water blanched (5min) tiger nuts; D Yoghurt- like product from to hot water blanched (30min) tiger nuts; E Yoghurt-like product from untreated tiger nuts; F Yoghurt- like product from to steam blanched (20min) tiger nuts

Table 3. Changes in the sensory attributes of yoghurt-like products stored at refrigerated temperature

Sensory Attributes	Samples	2 days	4 days	6 days	8 days	10 days	12 days	14 days
Flavor	A	4.06^{a} (0.00)	4.00^{a}(1.07)	4.05^{a}(1.15)	3.90^{a}(1.07)	3.76^{a}(1.10)	2.34^{b}(0.69)	2.11^{a}(1.00)
	B	3.90^{a} (0.17)	3.50^{b}(0.90)	3.74^{ab}(0.60)	2.66^{b}(0.25)	2.69^{b}(0.51)	2.41^{a}(0.05)	1.78^{ab}(1.15)
	C	2.61^{bc} (0.70)	2.34^{c}(0.51)	2.98^{bc}(0.01)	1.50^{e}(0.01)	1.29^{f}(1.25)	1.67^{d}(0.00)	1.36^{abcd}(0.88)
	D	2.59^{bcd} (0.91)	1.52^{fg}(0.01)	2.90^{bcd}(0.01)	1.28^{f}(0.00)	1.84^{e}(1.44)	1.92^{c}(0.99)	1.13^{bcde}(0.76)
	E	2.48^{bcd} (0.15)	1.56^{eg}(0.99)	2.62^{cd}(0.00)	2.23^{c}(0.99)	2.27^{c}(0.76)	1.46^{e}(0.95)	1.37^{abc}(0.91)
	F	3.04^{b}(0.51)	2.00^{d}(0.95)	2.62^{cd}(0.01)	2.01^{d}(0.01)	2.08^{d}(0.02)	1.44^{e}(0.00)	1.02^{bcde}(1.22)
	LSD	0.707	0.0404	1.074	0.196	0.023	0.0485	0.812
Consistency	A	4.00^{a}(0.72)	3.66^{a}(0.00)	3.87^{a}(0.79)	3.65^{a}(1.15)	2.72^{a}(0.06)	2.32^{a}(0.51)	2.56^{a}(1.07)
	B	3.35^{b}(0.06)	3.22^{b}(0.15)	2.72^{bc}(0.15)	3.19^{ab}(0.76)	2.05^{b}(0.52)	2.15^{b}(0.76)	1.35^{cde}(0.33)
	C	2.59^{d} (1.15)	2.48^{c}(1.10)	1.50^{d}(1.00)	2.96^{ab}(1.17)	1.22^{d}(0.52)	2.10^{b}(0.33)	2.43^{ab}(0.23)
	D	2.30^{f} (0.34)	2.30^{cde}(0.90)	2.84^{b}(0.76)	1.69^{c}(0.06)	1.03^{f}(0.00)	1.77^{c}(1.15)	1.41^{bcd}(0.01)
	E	2.42^{e} (0.01)	2.18^{cde}(0.01)	2.33^{bc}(0.91)	1.12^{cd}(1.01)	1.28^{c}(0.76)	1.42^{d}(1.07)	1.85^{abc}(0.99)
	F	2.71^{c} (0.15)	2.45^{cd}(1.15)	1.40^{d}(1.07)	1.25^{cd}(0.91)	1.14^{e}(0.95)	1.30^{e}(0.23)	1.18^{cde}(0.95)
	LSD	0.0848	0.3168	0.769	0.886	0.093	0.1192	0.769
Color	A	4.56^{a} (1.00)	4.63^{a}(0.69)	4.27^{a}(1.22)	3.34^{a}(1.05)	3.41^{a}(1.15)	3.51^{a}(0.09)	3.46^{a}(1.15)
	B	3.70^{b} (1.15)	3.25^{c}(0.76)	4.18^{ab}(1.17)	3.20^{b}(0.76)	2.65^{b}(1.12)	3.43^{a}(1.07)	2.39^{b}(1.07)
	C	2.30^{f} (0.34)	2.17^{e}(1.05)	3.59^{abc}(0.33)	2.32^{d}(0.99)	2.46^{bcd}(0.23)	2.48^{b}(0.25)	1.68^{c}(0.51)
	D	3.12^{d} (0.31)	3.40^{b}(0.95)	3.10^{bcde}(1.44)	2.56^{c}(0.33)	2.23^{bcde}(0.91)	1.74^{de}(0.15)	1.63^{cd}(1.25)
	E	2.47^{e} (0.92)	3.18^{d}(0.02)	3.16^{bcde}(1.25)	1.62^{e}(0.01)	2.55^{bc}(1.22)	1.74^{de}(0.15)	1.08^{ef}(0.01)
	F	3.39^{c} (1.25)	3.25^{c}(0.31)	3.24^{abcd}(1.10)	2.21^{d}(0.00)	2.16^{bcde}(1.01)	2.14^{bcd}(0.92)	1.28^{cde}(1.10)
	LSD	0.156	0.0591	1.106	0.159	0.587	0.5635	0.544
Overall Acceptability	A	4.24^{a} (0.01)	4.53^{a} (1.07)	4.16^{a}(1.00)	3.80^{a}(0.15)	3.34^{a}(0.01)	2.30^{a}(0.51)	2.42^{a}(0.01)
	B	3.16^{bc} (0.34)	3.12^{bd}(0.01)	3.14^{bc}(1.01)	3.61^{a}(0.01)	2.19^{c}(0.76)	2.15^{a}(1.01)	1.35^{c}(0.00)
	C	2.33^{bcde}(0.13)	2.29^{cef}(0.51)	2.51^{bcde}(1.15)	2.78^{b}(0.07)	1.76^{f}(1.22)	2.17^{a}(1.44)	1.56^{b}(0.51)
	D	3.20^{b} ±(0.71)	3.08^{bdf}(1.12)	3.18^{ab}(0.76)	1.75^{c}(0.95)	1.87^{e}(1.07)	1.59^{a}(1.10)	1.20^{c}(0.51)
	E	2.61^{bcde} (0.05)	3.42^{bd}(1.25)	2.47^{bcde}(0.99)	1.60^{c}(0.05)	2.62^{b}(1.01)	1.59^{a}(1.10)	1.57^{b}(1.44)
	F	3.05^{bcd} (1.00)	3.62^{b}(1.44)	2.55^{bcd}(0.95)	2.63^{b}(0.01)	2.02^{d}(0.51)	1.65^{a}(0.88)	1.37^{c}(0.07)
	LSD	1.023	0.8704	0.9947	0.576	0.146	1.1524	0.168

Any two mean values bearing the same superscript in the same column are not significantly different ($p<0.05$)
Value in parenthesis is standard deviation

LEGEND

A Cow milk Yoghurt; B Pasteurized yoghurt-like product from tiger nuts; C Yoghurt- like product from to hot water blanched (5min) tiger nuts; D Yoghurt- like product from to hot water blanched (30min) tiger nuts; E Yoghurt-like product from untreated tiger nuts; F Yoghurt- like product from to steam blanched (20min) tiger nuts

Table 4: Effect of storage on Peroxide value (mEq/kg) of yoghurt-like products

Storage period (days)	Storage conditions																	
	Accelerated Temperature						Ambient Temperature						Refrigerated Temperature					
	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F
2	33(0.62)	12(0.51)	12.6(0.01)	14.4(0.01)	13.7(0.02)	17.3(0.23)	24(0.01)	13.5(0.02)	12.7(0.05)	16.1(0.51)	13.4(0.01)	17.3(0.01)	13.7(0.00)	10(0.05)	12(1.00)	12.5(0.51)	14±0.25	12±0.01
4							32(0.51)	15.4(0.25)	16.1(0.01)	20(0.05)	16.9(1.00)	23.1(0.01)	14.1(0.23)	14.5(0.50)	13.8(0.02)	14.2(0.06)	15±0.17	15±0.62
6													17.2(0.07)	19.0(1.00)	15.6(0.00)	17.7(0.00)	16.4±0.10	17.1±1.00
8													20.7(0.05)	20.5(0.03)	17.3(0.01)	19.5(0.00)	18.0±1.15	17.8±0.20
10													22.6(0.15)	22.7(0.51)	20.0(0.06)	21.1(0.07)	18.9±0.00	19.9±1.00
12													23.4(0.25)	24.8(0.25)	21.5(0.50)	22.6±0.10	21.5±0.03	20.6±0.07
14													24.7(0.03)	25.1(0.23)	21.9(0.51)	22.8±0.25	22.4±0.15	21.4±0.06

Value in parenthesis is standard deviation

LEGEND

A Cow milk Yoghurt
B Pasteurized yoghurt-like product from tiger nuts
C Yoghurt- like product from to hot water blanched (5min) tiger nuts
D Yoghurt- like product from to hot water blanched (30min) tiger nuts
E Yoghurt-like product from untreated tiger nuts
F Yoghurt- like product from to steam blanched (20min) tiger nuts

Table 5. Effect of storage on the pH of yoghurt-like products

Storage period (days)	Storage conditions																	
	Accelerated Temperature						Ambient Temperature						Refrigerated Temperature					
	A	**B**	**C**	**D**	**E**	**F**	**A**	**B**	**C**	**D**	**E**	**F**	**A**	**B**	**C**	**D**	**E**	**F**
2	3.69(0.01)	4.11(0.10)	4.65(0.10)	3.98(0.01)	4.71(0.00)	4.05(0.01)	3.97(0.01)	5.12(0.01)	5.09(0.10)	4.58(0.00)	4.37(0.00)	4.66(0.10)	4.59(0.10)	5.30(0.00)	5.10(0.00)	4.82(0.10)	4.54(0.01)	4.71(0.01)
4							3.60(0.00)	4.92(0.01)	4.81(0.01)	4.23(0.01)	4.19(0.00)	4.45(0.00)	3.86(0.01)	4.92(0.01)	5.04(0.01)	4.70(0.01)	4.52(0.00)	4.70(0.00)
6													3.63(0.01)	4.60(0.02)	4.87(0.00)	4.61(0.00)	4.46(0.01)	4.62(0.01)
8													3.50(0.01)	4.62(0.00)	4.73(0.00)	4.29(0.00)	3.85(0.00)	4.59(0.00)
10													3.44(0.01)	3.85(0.00)	4.00(0.10)	4.18(0.10)	3.71(0.20)	4.48(0.10)
12													3.40(0.10)	3.66(0.01)	3.92(0.20)	4.10(0.20)	3.63(0.20)	4.27(0.00)
14													3.25(0.00)	3.60(0.01)	3.88(0.01)	4.04(0.01)	3.59(0.01)	4.18(0.01)

Value in parenthesis is standard deviation

LEGEND

A Cow milk Yoghurt B Pasteurized yoghurt-like product from tiger nuts C Yoghurt- like product from to hot water blanched (5min) tiger nuts D Yoghurt- like product from to hot water blanched (30min) tiger nuts E Yoghurt-like product from untreated tiger nuts F Yoghurt- like product from to steam blanched (20min) tiger nuts

Table 6. Effect of storage on TTA** of yoghurt-like products

Storage period (days)	Storage conditions																	
	Accelerated						Ambient						Refrigerated					
	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F
2	4.88(0.07)	3.57(0.00)	3.89(0.01)	4.13(0.01)	4.30(0.03)	3.81(0.50)	3.23(0.01)	1.86(0.00)	2.19(0.04)	1.62(0.06)	1.70(0.15)	1.86(0.17)	2.57(0.07)	1.46(0.25)	1.62(0.01)	1.34(0.33)	1.67(0.25)	1.78(0.12)
4							3.89(0.10)	2.11(0.03)	2.35(0.05)	1.36(0.15)	2.11(0.33)	2.27(0.51)	2.74(0.10)	1.95(0.01)	2.11(0.01)	1.54(.0.54)	1.81(0.17)	2.11(0.33)
6													2.98(0.17)	2.19(0.15)	2.35(0.01)	1.95(0.00)	2.27(0.01)	2.15(0.04)
8													3.08(0.21)	2.35(0.05)	2.51(0.10)	2.29(0.12)	2.64(0.15)	2.58(0.15)
10													3.26(0.03)	2.63(0.00)	2.78(0.07)	2.51(0.10)	2.96(0.03)	2.7(0.51)
12													3.36(0.51)	2.8(0.40)	2.93(0.03)	2.64(0.10)	2.93(0.12)	3.00(0.00)
14													3.42(0.00)	3.01(0.07)	3.12(0.33)	2.89(0.17)	3.08(0.25)	3.18(0.25)

TTA** expressed as % lactic acid Value in parenthesis is standard deviation

LEGEND

A Cow milk Yoghurt B Pasteurized yoghurt-like product from tiger nuts C Yoghurt- like product from to hot water blanched (5min) tiger nuts D Yoghurt-like product from to hot water blanched (30min) tiger nuts E Yoghurt-like product from untreated tiger nuts F Yoghurt- like product from to steam blanched (20min) tiger nuts

Table 7. Effect of storage on viscosity (cP) of yoghurt-like products

Storage period (days)	Viscosity at 60rpm																	
	ACCELERATED TEMPERATURE						AMBIENT TEMPERATURE						REFRIGERATED TEMPERATURE					
	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F
2	154.2	167.6	116.7	123.6	98.4	98.7	194.0	172.2	135.2	150.9	120.3	118.6	200.4	176.2	122.6	167.7	111.2	120.2
4							190.6	169.6	121.7	138.2	100.4	97.4	198.2	154.4	117.0	165.7	109.1	119.6
6													190.5	132.9	102.5	163.0	100.8	106.1
8													189.3	129.8	98.4	162.2	100.1	104.6
10													187.6	118.9	95.2	160.0	99.6	103.0
12													178.3	99.0	93.3	155.5	99.1	102.5
14													174.6	98.7	90.1	154.6	98.4	101.9

Value in parenthesis is standard deviation

LEGEND

A Cow milk Yoghurt B Pasteurized yoghurt-like product from tiger nuts C Yoghurt- like product from to hot water blanched (5min) tiger nuts

D Yoghurt- like product from to hot water blanched (30min) tiger nuts E Yoghurt-like product from untreated tiger nuts F Yoghurt- like product from to steam blanched (20min) tiger nuts