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PHYSICAL, CHEMICAL AND SENSORY CHARACTERISTICS OF VEGAN CAKE

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ABSTRACT

The objectives of this research were to investigate physical, chemical and sensory quality attributes and their relation of newly formulated vegan cake. Tiger nut milk (TNM) and alginate-lecithin gel (ALG) were used as the replacement of buffalo' s milk and whole egg at the levels of 50 and 100 %, respectively, in addition to, 50 % mixture (50 % TNM and 50 % ALG) and 100 % mixture (100 % TNM and 100 % ALG) . The results revealed that the lactose content of buffalo' s milk was 5.56%, while, TNM was free lactose. TNM is a good source of many elements as buffalo' s milk such as K, P, Ca, Na and Mg. Whole egg had significantly higher foam capacity than the alginate-lecithin gel . In contrast, alginate-lecithin gel exhibited higher foam stability than whole egg. The foam volume of alginate-lecithin gel characterized with stability during 60 min under testing as compared with whole egg that collapsed after 20 min. Concerning emulsifying activity index (EAI), both ALG and whole egg not showed significant difference ($p>0.05$). Emulsifying stability index (ESI) of alginate-lecithin gel was stable during 60 min under testing as compared with the whole egg that was stable till 40 min. The presence of replacement increased the batter viscosity at ambient temperature over the control value from 19.65 to 21.71-44.54 poise. Among different replacement, 100 % mixtures showed the highest batter viscosity of 44.54 p followed by 100% ALG (38.72 p), 50% ALG (34.29 p) and 50% mixtures (31.03 p). Control batter had a specific gravity of 0.892 g/cc, whereas batter replacing with 50% ALG, 100% ALG, 50% mixtures and 100 % mixtures had a batter specific gravity of 0.992, 1.009, 1.013 and 1.047 g/cc, respectively. The protein and fat contents of control samples were higher (10.42% and 26.63 %, respectively) than vegan cake samples replaced with TNM and ALG. The total carbohydrate content increased with increasing the replacement levels of TNM and ALG in vegan cake. High staling values (high freshness) of vegan cake samples reached 336.59 % and 334.08 % with vegan cake containing 100 % mixtures and 100 % ALG, respectively, in comparison to the staling of control (299.19 %) at zero time. The lower reduction in staling value was achieved in vegan cake prepared 100 % mixtures and 100 % ALG, since the staling value reduced by 10.29 % and 12.41 %, respectively, in comparison to 15.68 % for control sample after 21 days of storage at room temperature. High stability in specific volume during storage was achieved in the presence of 100 % ALG and 100 % mixture since, the specific volume was reduced by only 7.88 % and 8.83 %, respectively, in comparison to 25.99 % for control sample. The presence of ALG and mixtures decreased the hardness value from 79.46 to 36.28 and 66.11 Newton, indicating improvement in the texture of cake. Cakes containing ALG and mixtures showed lower decrement in moisture content and lower increment in hardness during storage at room temperature. Cake samples prepared with different levels of ALG and mixtures were better quality and showed significantly superior sensory properties scores than cake samples prepared with different levels of TNM which coincided with control sample at zero time. Vegan cake samples stored gave higher values and were be desirable till the end of storage period. Therefore, vegan cake could be successfully made from tiger nut milk and alginate-lecithin gel as the fully replacement of buffalos' milk and whole egg, respectively. In addition to, increase freshness, specific volume and storage at room temperature for 21 days.

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INTRODUCTION

In cake making, wheat flour, eggs, sugar, milk and fat are the major ingredients. Among different ingredients used in cake making, eggs are the most costly ingredients and significant source of cholesterol. The use of vegetable materials for partial or total substitution of eggs and milk in cake formulations appears, therefore, to be an interesting objective, and especially so for the people with specific dietary needs or restrictions (vegans, vegetarians, high cholesterol people, etc.). Vegetarians who don, t eat anything derived from creature, including eggs, milk, butter or cheese **(Kamel and Rasper, 1988)**. Cake produced from buffalos, milk and eggs is consumed only by the healthy persons, however, the demand for alternatives to buffalos, milk and egg are growing due to problems with allergenicity, desire for vegetarian alternatives. Thus are ideal candidates for simultaneous milk and egg replacement. Buffalos, milk in its various forms has been used as an ingredient in bakery products and provide a wide range of functionalities that affect flavor and mouthfeel **(Mannie and Asp, 1999)**. Attempts have been made to replace the milk with other plant material in baked products to make milk-like products (Vegan Products) for people are very allergic to milk, and demand healthier products. Replacement of milk by plant materials, such as, soy milk would have economical and health advantages. The soy milk, rich in protein and carbohydrates is an excellent economical dairy substitute, therefore, used in production soy-fruit beverages, soy candy, chocolate-peanut soy beverage and is also used extensively in infant formulas and yogurt-like product **(Shirai, *et al* 1992; Genta, *et al* 2002; Farnworth, *et al* 2007; Deshpande, *et al* 2007 and Potter, *et al* 2007)**. The major health benefit of soy products is their use as a dairy substitute in lactose intolerant patients.

Tiger nut (*Cyperus esculentus*) is a weed plant of tropical and Mediterranean regions .The tubers are edible, with a slightly sweet, nutty flavor, tiger nuts have excellent nutritional qualities with a fat composition similar to olives and a rich mineral content, especially phosphorus and potassium. Tiger nuts are also gluten- and cholesterol-free, and have low sodium content. Its tubers are widely eaten under different forms in West and Central Africa, unprepared, soaked in water or dried and mixed with roasted groundnut **(Temple, *et al* 1990)**. Development of a new products from tubers can enhance the interest this crop. In this respect, different opportunities are offered to the crop as source of dietary fiber, production of dairy like beverage, use of its oil in cooking or salad preparation, production of caramel to be used as food additive **(Pascual, *et al* 2000)**. In Spain, tubers are used principally to make a milky-like beverage called "Horchata de chufa" **(Richard**, ***et al*** **2006)**. Horchata de chufa is of high nutritional quality and therefore has great potential in the food market, it can replace milk in the diet of people intolerant to lactose **(Selma, *et al* 2003)**.

The almost unique foaming, emulsifying and heat coagulation properties of egg proteins confer them a very important functional role in the definition of cake characteristics, namely volume and texture. This makes it extremely difficult to replace eggs successfully by a different source of proteins, even by the use of several types of additives, such as hydrocolloids in cakes **(Arozarena, *et al* 2001)** and analyzed the possibility of total substitution of egg proteins in small ratio yellow cakes with use of optimum leavening agent, emulsifiers and xanthan gum levels in this system. **Miller and Setser (1983)** suggested the use of xanthan gum to partially replace egg white content in cakes. **Miller and Hoseney (1993)** showed that the cakes obtained after the inclusion of xanthan gum in the batter formulation similar or better characteristics, in terms of volume, height and shrinkage, than those of the control cakes. The reasons for replacing egg with hydrocolloids and emulsifiers are related to their functional properties. Hydrocolloids have good functional attributes such as water binding, viscosity, foaming, emulsifying, gelling, solubility and textural improvement while emulsifiers are known for their crumb softening and anti staling effect **(Yang, *et al* 2002 and Ashwini, *et al* 2009)**.

The objectives of this research were: to formulate vegan cakes, the buffalo, s milk and whole egg of a conventional cake were fully replaced with tiger nut milk and alginate-lecithin gel, respectively, in addition to mixture of them, and to investigate their influences on some quality attributes of newly formulated cake batters. The changes in physical and sensory characteristics of the cakes samples during storage at room temperature were studied.

MATERIALS AND METHODS

Materials

Ingredients

Dried tiger nut tubers, bought from Rashid, Behira, Egypt (season, 2008) (major components were, moisture 9.47%, protein 3.32%, fat 27.52%, ash 2.12% and carbohydrate 67.04%), Buffalo' s milk was obtained from the herd of Fac. Agric., Ain Shams Univ., Cairo, Egypt, whole eggs was purchased from the local market in Cairo (compositions were, moisture 73.16%, protein 49.13%, fat 44.04%, ash 3.09%, and carbohydrate 3.74 %). Wheat flour (72% extraction, contained 12.37% moisture, 11.52% protein, 1.18% fat, 0.65% ash and 86.65% carbohydrate) was obtained from Cairo South Company of Milling (El-Haram Milling). Lecithin produced by Extraction Oils and Product Company and obtained from the Egyptian Company for Food (Biscomisr), Ammeria, Cairo, Egypt . Sodium alginate was obtained from Sigma Chemical Co. USA. Sucrose (commercial grade), fat (palm oil), baking powder (sodium bicarbonate and cream of tarter), vanilla (pure vanillin) and salt were purchased from local market in Cairo, Egypt.

Methods

Soaking and extraction of the milky beverage (tiger nut milk, TNM)

The tiger nut tubers were washed with tap water to remove sands and other undesirable materials, and sun dried for 48 hr. at ambient temperature. Soaking experiment, according to **Turhan, *et al* (2002),** was conducted in 500 ml beakers containing 400 ml distilled water at 80ºC. The beakers were placed in water bath at constant temperature. For each experiment, 20g of tubers were immersed in the beaker for 5 hr at the same temperature. At the end of soaking process, the soaked tubers were removed and ground using a blender. The paste obtained was placed in nylon cloth and the beverage extracted by pressing. The milky beverage was weight for the determination of extraction yield, expressed as percentage of milk obtained from tubers (as dry weight basis). The glass bottles were filled with milk. Bottles were kept refrigerated at 3 ± 1ºC until analysis and processing.

Preparation of alginate-lecithin gel (ALG)

Gels were prepared according to **Sobczynska and Setser (1991)** by mixing the alginate and water in the ratio of 0.5:100 & 1.0:100 at high speed with an electric mixer and heating the solution in a water bath until solubilized. The amount of water in the sample was corrected after heating and the heat alginate solution was blended for 90 sec with lecithin (0.5% & 1.0%, respectively). The solution was stored at 3 ± 1ºC for 24 hr. On cooling gels were obtained .Replacement of 1.0 part of whole egg with 1.0 part of alginate-lecithin gels was carried out.

Vegan cake formulations

Cake samples were prepared according to **Bennion and Bamford (1997)** with the following recipe :

Constituents	Weights (g)
Wheat flour	100
Shortening	50
Sugar	140
Whole fresh eggs	60
Alginate-lecithin gels	50 & 100 % (on whole egg basis)
Fresh milk	110
Tiger nut milk	50 & 100 % (on fresh milk basis)
Baking powder	9.0
Vanilla	2.0
Salt (sodium chloride)	1.6

Wheat flour, baking powder, vanilla and salt were sifted; sugar and shortening were creamed for 3 min using a Kitchen machine (National Japan). Fresh milk or tiger nut milk and whole fresh eggs or alginate-lecithin gels were added and the mixture was whipped for 3 min. Finally flour, baking powder, vanilla and salt were added, mixed for 2 min until homogeneous. The cake batter was transferred into a cake pan (7.0x19.5x6.5 cm) and baked at 175º.C for 25 min. After baking, cakes were cooled for 30 min. and packed in polyethylene bags. All bags were heat sealed and stored at room temperature (25 ± 5 ºC) until analysis.

Analytical methods

Chemical analysis

Moisture, protein, fat and ash contents of raw materials and different cake samples were determined according to **A.O.A.C. (2000)**, pH value was measured using pH meter (HANN-Instruments, USA). The minerals were measured as described in the **A.O.A.C. (2000)** using Atomic Absorption Spectrophotometer (Spectra AA-20, GTA-96, Varian, Australia). HPLC- liquid chromatography series 1050, with R.I. detector HPX-87C column 300x7.8 mm, was used for identification of sugars according to **A.O.A.C. (2000)**.

Functional properties

Foam capacity (FC%) and Foam stability (FS%), were assay by the procedure of **Patel *et al* (1988)**. Emulsifying activity index (EAI m^2/g^{-1}) and emulsifying stability index (ESI m^2/g^{-1}) were determined according to **Pearce and Kinsella (1978)**.

Characteristics of the vegan cake batter

Batter viscosity

Batter viscosity was measured by using the Rotational Viscometer (Rheotest 2 Germany), according to **Kim and Walker (1992),** as follows:

$$\eta = \tau / \gamma$$
$$\tau = z \cdot \alpha$$

Where : η : dynamic viscosity (poise)
τ : shear stress (dynes/cm^2)
γ : shear rate (sec $^{-1}$)
z : cylinder constant
α : read out value

Batter specific gravity

Specific gravity of each vegan cake batter at room temperature (25 ± 5 ºC) was calculated by dividing the weight of a standard measure of the batter by the weight of an equal volume of water **(Marx *et al* 1990)**.

Physical characteristics of vegan cake

Vegan cake specific volume

The weight and volume of the baked cakes (means of three replicates) were measured after one hour of baking and during storage **(Randez-Gil, *et al* 1995)**. The ratio of volume to weight was also calculated to obtained the specific volume.

Vegan cake staling

For the baked cakes, staling was periodically measured throughout the days of storage, cake was cut into small pieces, dried at 130 ºC for 4 hr. and then ground. The cake staling was measured by alkaline water retention capacity (AWRC) according to **Mahmoud and Abou-Arab (1989)**.

Vegan cake hardness

Cake hardness, was measured on an Instron Universal Testing Machine (Model 43202, England) according to the method described by **A.A.C.C. (1996)**. A load cell used had a maximum capacity of 1000 N . The rate of compression was 2 mm/min. and the chart speed was 50 mm/min.

Sensory evaluation of vegan cake

Sensory evaluation of vegan cake samples was determined according to the method described in **A.A.C.C. (1996)** by regular score from the staff members of the Food Science Department, Faculty of Agriculture, Ain Shams University. The parameters like symmetry, volume, thickness, crust color, flavor and overall acceptability were evaluated for the maximum score of 10, while parameters like grain and moistness which were considered significant for vegan cake were evaluated for maximum score of 15, the softness was considered very significant for vegan cake was evaluated for maximum score of 20.

Statistical analysis

Data were averaged and presented as mean ± Standard Error (SE). Analysis of variance of the scores was conducted and Least Significant Difference (LSD) test used to carry out multiple comparisons at the 0.05 probability level using the Statistical analysis System (SAS) according to User' s Guide of Statistical analysis System **(SAS, 1996)**.

RESULTS AND DISCUSSION

Gross composition of tiger nut and buffalos' milk

Data presented in **Table (1)** show the chemical composition of tiger nut and buffalos' milk used in vegan cake making. It is clear that buffalo' s milk had percentages of total solids, protein, fat and ash higher than their corresponding values of tiger nut milk. Lactose is considered as the predominant sugar in buffalo' s milk was reached 5.56 %. Meanwhile, a noticeable that tiger nut milk did not contain any lactose **(Selma, *et al* 2003)**. While, tiger nut and buffalo' s milk recorded similar value of pH (6.78 and 6.67), respectively. These values are in accordance with those obtained by **Gortes *et al* (2005)**. Also, the same Table show that both tiger nut and buffalo' s milk contain relatively variable amounts of mineral matter. Tiger nut milk is considered as a good source of many important elements. It exhibited higher amounts of K, P, Na and Mg than buffalo' s milk. While, buffalo' s milk contained higher level of Ca **(Table, 1)**.

Functional properties of alginate-lecithin gel and whole egg

It was noticed from the results summarized in **Table (2)** that whole egg had significantly higher foam capacity than the alginate-lecithin gel. In contrast, alginate-lecithin gel exhibited higher foam stability than whole egg. The foam volume of alginate-lecithin gel characterized with stability during 60 min under testing as compared with whole egg that collapsed after 20 min. **Awazuhara and Nakamura (1986)** observed that albumin foam

Table 1. Proximate composition* of tiger nut and buffalo' s milk used in vegan cake making

Parameters (%)	Tiger nut milk	Buffalo' s milk
Moisture	83.44 ± 0.94	82.53 ± 1.38
Total solids	16.56 ± 0.67	17.47 ± 0.82
**Protein (NX6.38)	1.08 ± 0.22	3.64 ± 0.37
**Fat	4.53 ± 0.48	6.72 ± 0.29
**Ash	0.51 ± 0.08	0.93 ± 0.12
***Total carbohydrates	10.44 ± 0.54	6.18 ± 0.73
pH	6.78	6.67
Glucose	0.37	0.12
Fructose	0.09	0.00
Lactose	0.00	5.56
Sucrose	0.00	0.00
Minerals content	mg/l	mg/l
Phosphorus (P)	975.80± 10.44	643.54 ± 13.95
Potassium (K)	1647.2 ± 15.38	1386.23 ± 17.12.
Calcium (Ca)	834.5 ± 9.86	1254.87 ± 14.43.
Sodium (Na)	741.3 ± 12.64	549.58 ± 11.25
Magnesium (Mg)	315.08 ± 6.77	134.12 ± 9.54

*** Means of three replicates ± SE**
****Wet weight basis**
*****Total carbohydrate was calculated by difference**

Table 2. Foaming properties for alginate-lecithin gel and whole egg used in vegan cake making

Properties	Alginate-lecithin gel	Whole egg
Foam capacity %	530.0 B	610.0 A
Foam stability % after		
20 min	100	100
40 min	100	84
60 min	100	72

A,B: Different capital letters within the same row are significantly different (p<0.05)

forms a rigid membrane surrounding the polyhedric bubbles, while the bubbles in egg yolk foam were round and smaller with no membrane. Egg yolk is considered to be an inhibitor to albumin foaming. The lipid constituents of egg yolk complete with the protein for the interface and sharply reduce the foaming power **(Poole *et al* 1986)**. The foaming capacity was the highest when the blend contained albumin only. Egg yolk exhibited lower drained volume than albumin. This important stability of egg yolk foams can be explained by the presence of particulate material, such as the granules that strengthen the interfacial film around bubbles, as in the case of Madeira cake. Solutions of the gum exhibit pseudo-plasticity, generally used to thicken, suspend, stabilize gel and modify flow characteristics of aqueous solution or suspensions **(Dziezak, 1989)**. Also, the emulsifier promote increased aeration of the products **(Sobczynska and Setser, 1991)**. However the excellent foaming and stabilization properties of sodium alginate indicated its potential use as a replacement for whole egg in bakery products **(Sharma, 1981).**

The results illustrated in **Table (3)** showed that alginate-lecithin gel and whole egg had a similar trend of emulsifying activity index (EAI). Analysis of variance showed no significant differences in EAI

Table 3. Emulsifying activity index (EAI) and emulsifying stability index (ESI) values of alginate-lecithin gel and whole egg used in vegan cake making

Properties	Alginate-lecithin gel	Whole egg
EAI (m^2/g^{-1})	40.67A	42.82A
ESI after		
20 min	40.67 (00)*	42.82 (00)
40 min	40.67 (00)	42.82 (00)
60 min	40.67 (00)	37.51 (12.40)

A: Different capital letters within the same row are significantly different (p<0.05)
***Data between brackets are the percentage decrease of ESI compared with the zero time.**

between alginate-lecithin gel and whole egg (p>0.05). However, the emulsifying stability index (ESI) of alginate-lecithin gel had higher stability as compared with the whole egg after 60 min. Alginate-lecithin gel was stable in ESI during 60 min. under testing as compared with the whole egg that was stable till 40 min. The percentage decrease of ESI were zero in alginate-lecithin gel but was 12.40 % in whole egg after 60 min. These results agree with those obtained by **Bringe *et al* (1996) and Aluko & Mine (1997)** they mentioned that egg yolk had the highest emulsifying properties. Phospholipids (Lecithin) and the lipoproteins (main component of egg yolk) are excellent emulsifiers. Gums are long chain polymers which dissolve or disperse in water to give a thickening or viscosity, building and stabilizer binder. Also, gums may be used as a adhesives and binders for cereal products and bakery formulations **(Ward and Andon, 2002)**. In the case of the cake with shortening present, the emulsifier functions to stabilize the oil-in-water emulsion and to prevent the fat from interfering with foam formation of the soluble proteins **(Sobczynska and Setser, 1991)**.

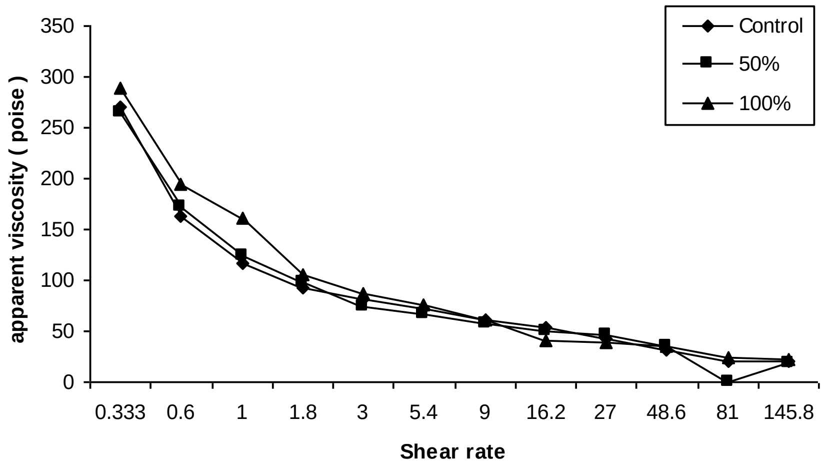
Vegan cake batter characteristics

Effect of incorporating tiger nut milk (50 and 100% TNM), alginate-lecithin gel (50 and 100 % ALG), in addition to, 50% mixtures (50 % TNM and 50 % ALG) and 100 % mixtures (100 % TNM and 100 % ALG) on batter viscosity is illustrated in **Fig. (1)**. The presence of replacement increased the batter viscosity at ambient temperature over the control value from 19.65 to 21.71 - 44.54 poise. Among different replacement 100% mixtures showed the highest batter viscosity of 44.54 p followed by 100% ALG (38.72 p), 50% ALG (34.29 p) and 50% mixtures (31.03 p) .This results may be due to gum' s unique, rod-like conformation, which is more responsive to shear than a random-coli conformation **(Urlacher and Noble, 1997)**. Also, the increase in viscosity as explained by **Turabi, *et al* (2008)** might be due to the synergistic interaction between hydrocolloid and emulsifier in the cake batter. While, slight increased in the viscosity was observed with 100 % TNM (21.71 P), may be due to that natural horchata is rich in starch has high molecular weight and its influence on the viscosity **(Gortes *et al* 2005)**.

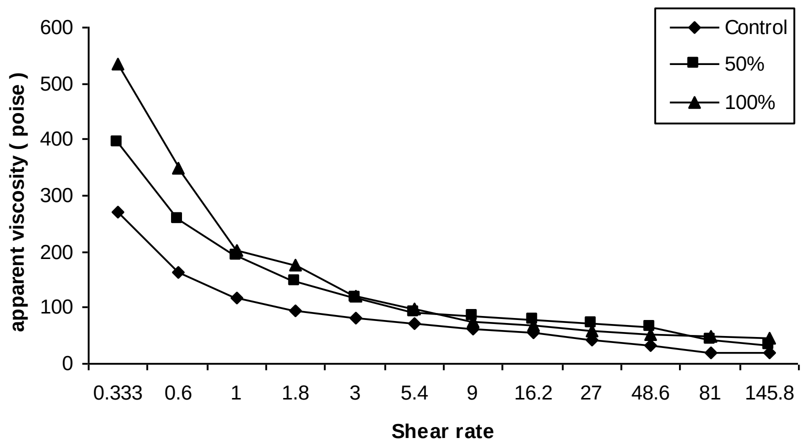
The specific gravity of batter is a very important physical property since, it represents retain of the small bubbles, which are initially incorporated into the batter during mixing time, lower specific gravity is desired in cake batter since it indicates that more air is incorporated into the batter **(Ashwini, *et al* 2009)**. **Fig. (2)** shows the specific gravity of cake batter with different replacement. Control batter had a specific gravity of 0.892 g/cc , whereas batter replacing with 50% ALG, 100% ALG, 50% mixtures and 100 % mixtures had a batter specific gravity of 0.992, 1.009, 1.013 and 1.047 g/cc, respectively .This indicates that batter with ALG and mixtures were heavier and lacks the proper aeration. While TNM not effected on specific gravity. The low specific gravity of the cake batter could have allowed more air to be incorporated, but, the low cake volume indicates that the membranes around the air cells were readily collapsed by gas expansion during baking **(Bath, *et al* 1992)**.

Chemical analysis of vegan cake

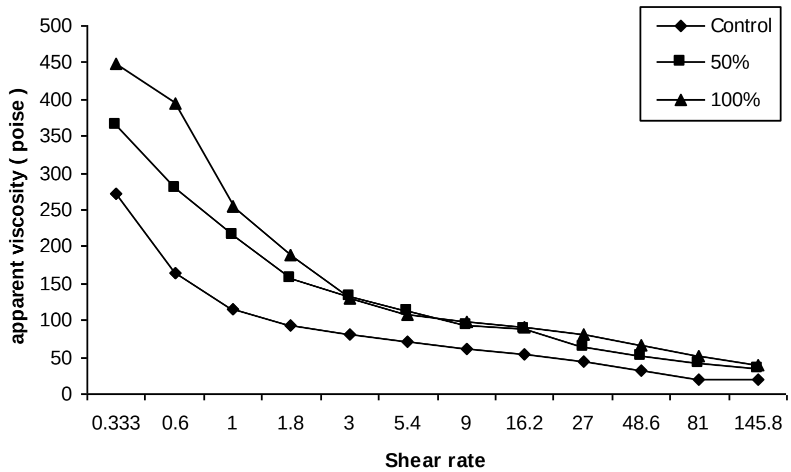
The chemical analysis of different cake samples prepared with different levels of tiger nut milk (TNM) as buffalos' milk replacement (50 and 100%) and alginate-lecithin gel (ALG) as whole egg replacement (50 and 100 %), in addition to, 50% mixtures (50 % TNM and 50 % ALG) and 100% mixtures (100 % TNM and 100 % ALG) are



(a) Tiger nut milk



(b) alginate-lecithin gel



(c) Mixture of tiger nut milk and alginate-lecithin gel

Fig. 1. Effect of (a) tiger nut milk, (b) alginate-lecithin gel and (c) mixture of tiger nut milk and alginate-lecithin gel substitutions on the apparent viscosity (poise) of the vegan cake batters

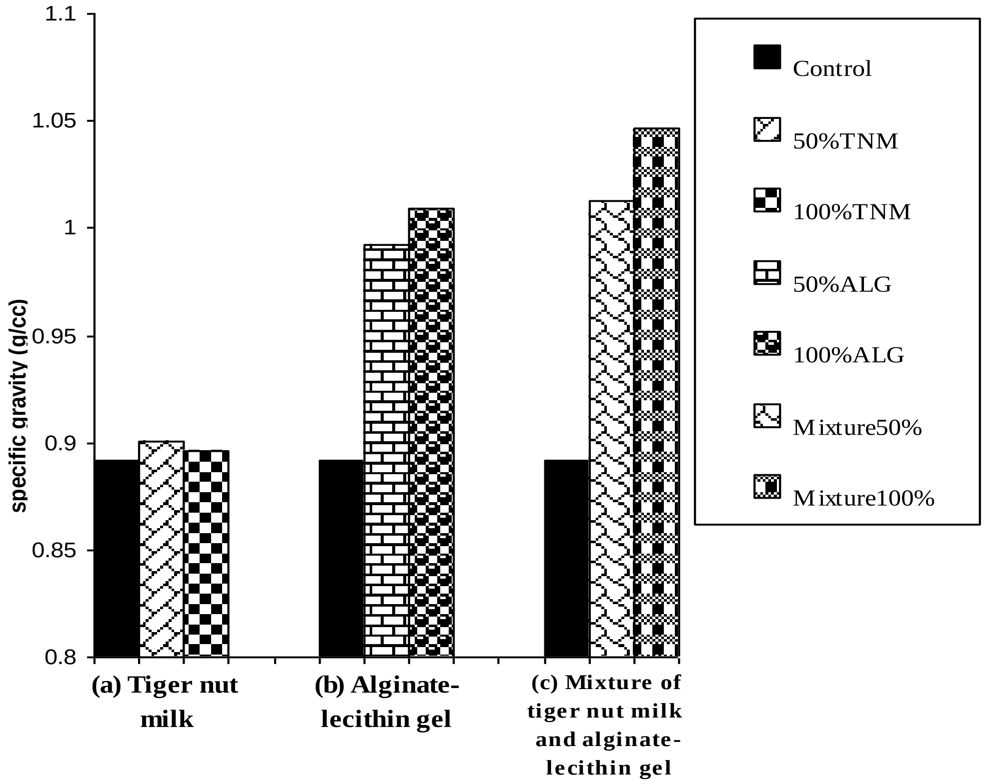


Fig. 2. Effect of (a) tiger nut milk, (b) alginate-lecithin gel and (c) mixture of tiger nut milk and alginate-lecithin gel substitutions on the specific gravity (g/cc) of the vegan cake batters.

presented in **Table (4)**. A significant difference (p< 0.05) was observed in the moisture content when TNM, ALG and mixtures were added, highest moisture content was observed in the case of 100% mixtures (21.78 %), followed by 50 % mixtures (19.54 %) and 100% ALG (19.49 %). The increase in the moisture content in vegan cake with mixtures and ALG is explained by the ability of hydrocolloids to hydrate at room temperature **(Leon *et al* 2000)**. Also, **Sobczynska and Setser (1991)**, mentioned that the emulsifiers absorbed water and maintained moisture in the bakery products. The protein and fat contents of control samples (100 % buffalo' s milk and 100% whole egg) were higher (10.42% and 26.63%, respectively) than vegan cake sample replaced with 100% mixture (4.72% and 13.09%, respectively). This variation in protein and fat contents between control and replaced cakes could be due to the differences in the chemical properties between buffalo' s milk & TNM and whole egg & ALG. On the other hand, the difference in ash content between control and vegan cake samples is negligible. The total carbohydrate content increased with increasing the replacement levels of TNM and ALG in vegan cake.

Storage stability of vegan cake samples

Physical properties

Table (5) appears changes in staling and specific volume of the vegan cake samples produced with tiger nut milk (TNM) and alginate-lecithin gel (ALG) as replaced buffalos' milk and whole egg, respectively, in addition to, mixture of them during storage at room temperature .The staling of vegan cake samples produced with replacement were significantly affected (p< 0.05) at zero time. High staling value of vegan cake samples reached 336.59 % and 334.08 % with vegan cake containing 100 % mixtures and 100 % ALG, respectively, in comparison to the staling of control (299.19 %) at zero time. It could be noticed that, there was significantly decrease in freshness for all different

Table 4. Proximate chemical analysis of prepared vegan cakes with tiger nut milk and alginate-lecithin gel as replaced buffalo' s milk and whole egg (on dry weight basis)

Replacement	Components (%)				
	Moisture	* Protein	Lipid	Ash	**Carbohydrates
Control	18.73±0.22BC	10.42±0.68A	26.63±0.84 A	1.03±0.07 AB	61.92±0.89 E
TNM (50%)	19.46±0.35 B	9.71±0.36 B	25.81±0.42 A	1.13±0.05 AB	63.35±1.02 D
TNM (100%)	18.29±0.44C	9.01±0.48 C	26.44±0.79 A	1.05±0.11 AB	63.50±0.92 D
ALG (50%)	18.77±0.52 BC	8.41±0.46 D	20.84±0.93 B	0.98±0.03 B	69.77±1.49 C
ALG (100%)	19.49±0.65 B	6.32±0.25 F	13.38±1.02 C	0.97±0.08 B	79.33±1.30 B
Mixtures (50%)	19.54±0.37 B	7.61±0.22 E	21.35±0.59 B	1.17±0.14 A	69.87±1.44 C
Mixtures (100%)	21.78±0.72 A	4.72±0.39 G	13.09±0.82 C	1.11±0.21 AB	81.08±1.56 A
LSD	0.934	0.398	1.002	0.170	1.303

A,B,C :Different capital letters within the same column are significantly different (p<0.05)
*** Protein = NX6.25 **Carbohydrates was calculated by difference**

Table 5. Changes in the staling (%) and specific volume (cm^3 / g) of vegan cake samples produced with tiger nut milk and alginate-lecithin gel and stored at room temperature

Storage period (days)	Control	TNM (50%)	TNM (100%)	ALG (50%)	ALG (100%)	Mixtures (50%)	Mixtures (100%)	LSD
Staling (%)								
Zero	299.19Ae	294.76Ae	300.22Aed	321.03Abc	334.08Aab	313.85Acb	336.59Aa	13.146
7	278.96Be	285.49ABe	291.05ABed	308.33Abc	317.29Bb	300.76AB	329.68Aa	12.193
14	269.41BCd	276.88Bd	279.61Bcd	291.53Bbc	308.33BCa	294.58BCb	311.93Ba	12.554
21	258.64Cc	255.58Cc	258.99Cc	283.69Bb	297.20Ca	277.73Cb	305.19Ba	12.235
LSD	13.069	14.316	12.824	15.360	13.860	14.717	9.337	
Specific Volume (cm^3/g)								
Zero	2.86Ac	2.99Abc	2.90Ac	3.06Aab	3.15Aa	3.13Aa	3.08Aab	0.133
7	2.79Ac	2.66Bd	2.63Bd	2.91Bb	3.09ABa	3.05ABa	2.91Bb	0.111
14	2.41Bc	2.59Bb	2.52Bbc	2.84Ba	2.98BCa	2.93Ba	2.84Ba	0.178
21	2.27Ce	2.42Bd	2.28Ce	2.65Cc	2.92Ca	2.77Cbc	2.83Bab	0.127
LSD	0.130	0.243	0.133	0.094	0.164	0.121	0.116	

- Capital and small letters were used for comparison between means in the vertical and horizontal directions, respectively.
- Means with the same letter are not significantly different, (p>0.05)

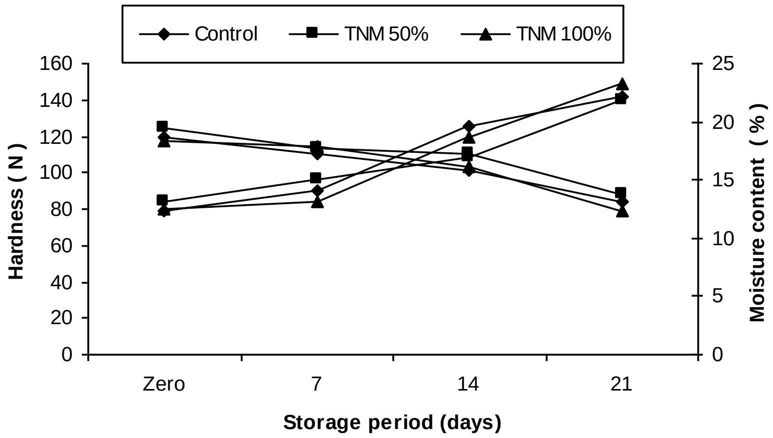
cake samples during storage period. The lower reduction in staling value (high freshness) was achieved in vegan cake prepared with 100 % mixtures and 100 % ALG, since the staling value reduced by 10.29 % (from 336.59 % to 305.19 %) and 12.41 % (from 334.08 % to 297.20 %), respectively, in comparison to 15.68 % (from 299.19 % to 258.64 %) for control sample after 21 days of storage. These corresponding 18.00% and 14.91% improvement in cake freshness, respectively. These observations are probably due to increase water retention of cake samples contained 100 % mixtures and 100 % ALG, the increase in moisture content of cake makes it more tender and improved cake freshness **(Singh and Bawa, 2002)**. Hydrocolloids have good functional attributes such as water binding, viscosity, foaming, emulsifying, gelling, solubility and textural improvement while, emulsifiers are known for their crumb softening and anti staling effect **(Ashwini, *et al* 2009).** With respect to the effect of storage on specific volume , the same Table shows that specific volume of cake formulated with 100% ALG and 50% mixtures was significantly increased (p>0.05). According to **Gomez, *et al* (2006)**, the influence of hydrocolloids on the final cake volume is due to increase in batter viscosity that slows down the rate of gas diffusion and allows its retention during the early stages of baking. **Shelke, *et al* (1990)** suggested that lower viscosity of the batter during heating is one of the reasons for decreased volume of the end product, it is possible that, in the presence of a less viscose batter, carbon dioxide evolved and water vapor produced might not be trapped in the air cells during baking, thus resulting low volume cakes. Specific volume of cake samples had the same trend observed for staling, it could be noticed that, there was significantly decrease in specific volume for all different cake samples during storage period High stability in specific volume was achieved in the presence of 100 % ALG and 100 % mixture, since the specific volume was reduced by only 7.88 % (from 3.15 cm^3/g to 2.92 cm^3/g) and 8.83 % (from 3.08 cm^3/g to 2.83 cm^3 /g), respectively, in comparison to 25.99% (from 2.86 cm^3/g to 2.27 cm^3/g) for control sample. Specific volume stability of vegan cake samples produced with ALG and mixture can be referred to the ability of these material to bind and absorb water **(Perry *et al* 2003).**

Textural measurement (Hardness) and moisture content of vegan cake samples prepared by TNM and ALG as replaced buffalos' milk and whole egg, respectively, in addition to, mixture of them were examined at zero time and during storage at room temperature . The obtained data were presented in **Fig. (3)**. The presence of ALG and mixtures decreased the hardness value from 79.46 Newton (control sample) to 36.28 and 66.11 N (100 % mixtures and 50 % ALG, respectively) indicating improvement in the texture of cake. Using of 50 % and 100 % TNM increased the hardness value (84.17 and 80.42 N) showing adverse effect on the texture of cake. The moisture content were conflicted with the hardness values. Among different replacement tried, 100 % mixtures showed the highest increased in moisture content 21.78 % (18.73 % for control sample). The increased in the moisture content value due to addition of TNM and ALG improved in the moistness of the vegan cakes. In addition, gums can absorb water and hold water molecules tightly **Rosel, (2001).** Therefore, cakes containing ALG and mixtures showed lower decrement in moisture content and lower increment in hardness during storage at room temperature .

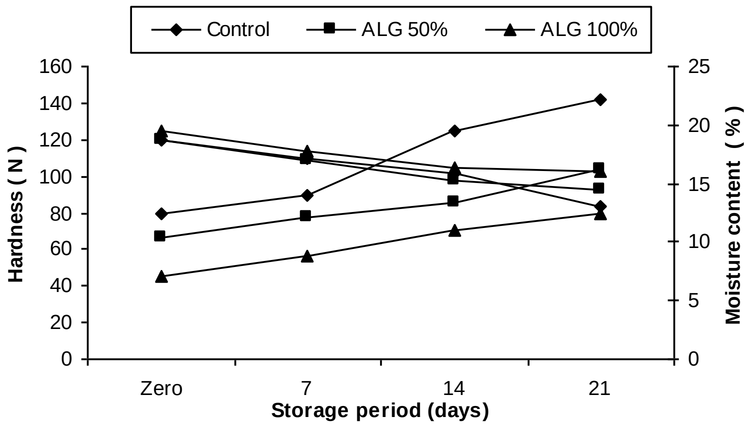
Sensory evaluation

Sensory evaluation of vegan cakes with different replacements **(Table 6)** showed that the use of mixtures and ALG improved the attributes of vegan cakes. Generally, cake samples prepared with different levels of ALG and mixtures were better quality and showed significantly superior sensory properties scores than cake samples prepared with different levels of TNM which coincided with control sample at zero time. Similar results were found for cakes and cookies **(Landis and Altman, 1996).** Also, **Armbrister and Setser (1994)** found that reduction in fat by 50 % and 70 % of the gum mixture increased chewiness in cookies. Chewiness of the moon cake surface skin increased with an increase in the level of gums **(Hsu and Chung, 2000)**. While, cake samples produced with TNM was lower scores than cake produced with ALG. These finding are in agreement with the results obtained by **Gortes, *et al* (2005)** who found that natural horchata is rich in starch and it cannot be heated above 72ºC as this would cause the starch to gel and would alter organoleptic characteristics of the product. Cake samples stored at room temperature significantly reduced all their sensory properties. The minimum reduction was observed in mixtures and ALG followed by TNM and the maximum reduction was shown by control sample . Changes in attributes were much faster in control sample followed by ALG, then, mixtures. In addition to, vegan cake samples stored gave higher values and were be desirable till the end of storage period. These results agree with **Yang *et al* (2002) and Perry, *et al* (2003)**, they reported that the gums, has ability to absorb high moisture and improves the structure of the moon cake by the absorbing water, which makes a food system smoother similar to the function of fat.

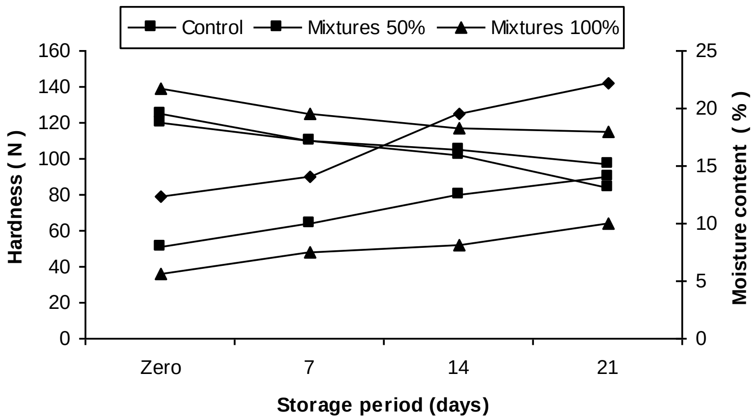
In summary, the data showed that tiger nut milk (TNM) and alginate-lecithin gel (ALG) were good source plant food. In addition to, alginate-lecithin gel had higher foaming and emulsifying stability. The prepared cake samples using TNM and ALG and mixture showed a suitable high freshness and volume and sensory attributes. It could be concluded that the possible utilization of TNM and ALG and mixture in baking products especially cake.



(a) Tiger nut milk



(b) Alginate-lecithin gel



(c) Mixture of tiger nut milk and alginate-lecithin gel.

Fig. 3. Changes in the hardness (Newton) and moisture content (%) of vegan cake samples produced with (a) tiger nut milk, (b) alginate-lecithin gel and (c) mixture of tiger nut milk and alginate-lecithin gel as replaced buffalo' s milk and whole egg during storage at room temperature

Table 6. Sensory characteristics of vegan cake samples during storage at room temperature

Storage period (days)	Control	TNM (50%)	TNM (100%)	ALG (50%)	ALG (100%)	Mixtures (50%)	Mixtures (100%)	LSD
				Symmetry (10)				
Zero	8.25Ab	8.50Ab	8.50Ab	8.45Ab	9.10Aa	9.10Aa	9.35Aa	0.416
7	7.70Bb	7.90Bb	8.05Bb	8.00Bb	8.70Ba	8.50Ba	8.80Ba	0.449
14	7.15Cc	7.30Cc	7.30Cc	7.75Bb	8.00Cab	8.10Ca	8.25Ca	0.316
21	5.35Dd	5.85Dc	6.05Dc	6.90Cb	7.10Db	7.50Da	7.60Da	0.356
LSD	0.379	0.566	0.415	0.329	0.317	0.313	0.375	
				Volume (10)				
Zero	7.95Ad	8.55Abc	8.60Abc	8.40Ac	8.90Aab	9.10Aa	9.25Aa	0.431
7	7.25Be	7.95Bd	8.21Abcd	8.05Bcd	8.40Babc	8.55Bab	8.75Ba	0.439
14	6.60Cf	7.05Ce	7.30Bde	7.50Ccd	7.80Cbc	7.90Cab	8.15Ca	0.342
21	5.60Dd	6.05Dc	6.05Cc	7.15Db	7.05Db	7.70Ca	7.80Ca	0.283
LSD	0.308	0.397	0.526	0.326	0.389	0.342	0.366	
				Thickness (10)				
Zero	7.95Ad	8.65Abc	8.30Acd	8.60Ac	9.05Aab	9.15Aa	9.05Aab	0.447
7	7.30Bd	8.20Bbc	8.05Ac	8.30Abc	8.50Bab	8.75Ba	8.75Aa	0.386
14	6.70Cd	6.95Ccd	7.25Bc	7.60Bb	7.70Cb	8.10Ca	8.10Ba	0.303
21	5.65De	6.05Dd	6.35Cd	7.15Bc	7.35Cbc	7.50Dab	7.80Ba	0.327
LSD	0.281	0.443	0.354	0.464	0.396	0.322	0.333	
				Grain (15)				
Zero	12.15Ab	12.60Ab	12.45Ab	12.95Ab	13.85Aa	13.95Aa	14.25Aa	0.810
7	11.15Bd	11.80ABc	11.95ABc	12.60Ab	13.30Ba	13.35Ba	13.45Ba	0.523
14	10.60Ce	11.10Bd	11.20Bd	11.85Bc	12.05Cbc	12.40Cab	12.75Ca	0.439
21	9.05Dd	9.50Cd	9.45Cd	10.60Cc	11.40Db	12.06Cab	12.50Ca	0.768
LSD	0.494	0.978	0.904	0.633	0.496	0.453	0.465	
				Moistness (15)				
Zero	12.40Ac	12.60Ac	12.75Abc	13.50Aab	13.65Aa	13.95Aa	14.05Aa	0.897
7	11.05Bc	11.75Ab	12.05Ab	12.85ABa	13.20Aa	13.35Ba	13.50ABa	0.687
14	10.45Cd	10.75Bd	10.90Bd	12.25Bc	12.50Bbc	12.80Cab	13.15BCa	0.457
21	8.65Dd	9.45Cc	9.20Cc	11.15Cb	11.60Cb	12.20Da	12.60Ca	0.506
LSD	0.382	0.930	0.839	0.704	0.556	0.452	0.644	
				Softness (20)				
Zero	17.05Abc	16.85Ac	17.20Abc	18.00Aab	18.45Aa	18.70Aa	18.80Aa	0.970
7	15.95Bd	16.45Ad	16.65Acd	17.35Abc	17.55Aab	18.10Aab	18.30Aa	0.825
14	12.60Cc	12.90Bc	13.00Bc	15.50Bb	15.85Bab	16.75Ba	16.95Ba	1.113
21	9.21De	9.80dCe	10.10Cd	12.90Cc	13.30Cc	14.20Cb	15.05Ca	0.808
LSD	0.428	1.337	1.111	1.151	0.927	0.715	0.670	
				Crust Color (10)				
Zero	8.52Abc	8.30Ac	8.45Abc	8.80Aab	9.25Aa	9.15Aa	9.20Aa	0.464
7	7.65Bc	7.75Ac	8.00ABbc	8.30Bab	8.50Bab	8.40Bab	8.55Ba	0.527
14	7.10Cd	7.10Bd	7.55Bc	7.80Cbc	8.25Ba	8.15Bab	8.35Ba	0.370
21	6.60Dc	6.50Cc	6.55Cc	7.10Db	7.30Cab	7.50Ca	7.40Cab	0.329
LSD	0.458	0.568	0.470	0.391	0.333	0.353	0.434	
				Flavor (10)				
Zero	8.70Ac	9.30Aab	9.10Ab	9.35Aab	9.45Aa	9.45Aa	9.40Aab	0.308
7	7.70Bc	8.50Bb	8.55Bb	8.70Bab	8.70Bab	9.00Ba	8.80Bab	0.384
14	7.15Cc	7.35Cbc	7.60Cb	8.05Ca	8.05Ca	8.35Ca	8.30Ca	0.355
21	5.80De	6.20Dd	6.25Dd	6.80Dc	7.05Dbc	7.20Dab	7.45Da	0.308
LSD	0.276	0.345	0.389	0.413	0.274	0.366	0.329	
				Overall acceptability (10)				
Zero	7.75Ac	8.45Ab	8.40Ab	8.70Ab	9.15Aa	9.20Aa	9.20Aa	0.444
7	7.16Bd	8.00Bc	7.90Bc	8.05Bbc	8.45Bab	8.75Ba	8.75Ba	0.439
14	7.15Bcd	7.00Cd	7.40Cc	7.95Bb	8.10Bab	8.20Cab	8.35Ca	0.291
21	5.90Cd	6.15Dd	6.55Dc	7.15Cb	7.40Cab	7.40Dab	7.55Da	0.322
LSD	0.326	0.407	0.412	0.341	0.415	0.406	0.384	

-Capital and small letters were used for comparison between means in the vertical and horizontal directions, respectively .
- Means with the same letter are not significantly different, (p>0.05)

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