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Non-Dairy Alternative Milk for People with Lactose and Casein Intolerance

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ABSTRACT

This study aimed to prepare healthy and tasty alternative milk for lactose and casein intolerance. Plant materials which used to prepare alternative milk were grated coconut, potato powder, corn grain, tiger nut, sorghum seeds, dry bean seeds, sesame seeds and cantaloupe seeds. Chemical, minerals, physical, sensory and color of the alternative milk were determined. Results showed that, there were significant differences between all milk samples in chemical composition (dry weight basis). Protein ranged between 18.26% in cantaloupe seeds milk and 2.10% in white corn milk. Coconut milk had high fat content followed by sesame milk and cantaloupe seeds milk. Ash ranged between 4.24% in dry bean milk and 0.74% in corn milk. Total solid was the highest in coconut milk. Cantaloupe seeds milk had the highest amount of phosphorus, magnesium and iron. Sesame milk had higher amounts of potassium, copper, zinc, manganese and selenium. TSS is higher in tiger nut and lowest value in cantaloupe seeds milk. Sedimentation stability was the highest in coconut and dry bean milk. Specific gravity of all milk types was not significantly different among all samples. Milk of coconut had the highest values in all sensory attributes for color, taste, flavor, mouth feel, texture and similarity of milk, respectively. Dry bean milk recorded the lowest value for all sensory attributes. Coconut milk had high L*. While a*-value higher in tiger nut milk. Milk of cantaloupe seeds had high b*-value.

***Keywords*:** Non-dairy alternative milk, lactose and casein intolerance, Nutrients

INTRODUCTION

Non-dairy alternative milk is a nutritious alternative for consumers who cannot consume dairy milk. The production of vegetable milk solids of acceptable taste and quantity is however an important consideration (Asante *et al.*, 2014). The growing popularity of non-dairy milk can be attributed to many factors. More and more people are consuming non-dairy alternatives, whether due to an allergy, lactose intolerance or adherence to a vegan/plant-based diet (Bridges, 2018).

Heyman (2006) shows that developing alternative milk and milk products obtained from vegetable sources due to the inadequacy of dairy milk source, variety of consumers diet preferences (vegan/vegetarian diet, special diet for religious reasons) and allergen and sensitivity of dairy products (lactose intolerance, milk allergies).

Among beverages, milk is considered as a whole complete food providing macro (fat, proteins, and carbohydrates) and micronutrients (calcium, selenium, riboflavin, vitamin B12, and pantothenic acid vitamin B5) in balanced proportions. However, limited access to milk in some regions of globe, low availability of certain minerals (iron), vitamins (folate), and other biomolecules (amino acids) compounded with issues like milk allergy, lactose intolerance, and hypercholesterolemia have forced some specific population groups to search for better milk alternatives which are more or at least equi-nutritional to conventional milk (Paul *et al.*, 2020). Coconut milk used for health benefits such as anticarcinogenic, anti-microbial, anti-bacterial, and anti-viral. It contains a saturated fat, lauric acid which is present in mother's milk and has been related to promote brain development (Belewu and Belewu, 2007). Potato milk as non-dairy beverages Fat-free; soy-, nut-, gluten and casein-free while the Cons that Very low-protein; not widely available; may contain allergenic additives (Bridges, 2018). Corn milk has pleasant taste, nutritive value and overcomes the problems of lactose intolerance and saturated fat of cow milk (Padghan *et al.*, 2015). Tiger nut milk helps control heart attacks; thrombosis; improvement in blood circulation and contributes in reducing risk of developing colon cancer (Ukwuru *et al.*, 2011). Sesame milk can overcome the limitations of soy milk consumption such as presence of flatulence causing factors, prevalence of allergies towards soy proteins and beany or off flavor (Ahmadian-Kouchaksaraei *et al.*, 2014). The aim of this study was to produce acceptable alternative milk contains the required nutrients without other additives for people with lactose and casein intolerance.

MATERIALS AND METHODS

Materials

Grated coconut (*Cocos nucifera*), tiger nut (*Cyperus esculentus*) and cantaloupe seeds (*Cucumis melo* L.) obtained from local market, in Tanta, AL-Gharbia Egypt. White sesame seeds (*Sesamum indicum* L.) Shandaweel 3, dry corn grain (*Zea mays* L.) white variety (hybrid singles 10), sorghum grains (*Sorghum bicolor* L.) and dry bean seeds (*Phaseolus lunatus* L.) obtained from Filed Crops Institute, Agricultural Research Center, Giza, Egypt. Potato powder (*Solanum tuberosum*) obtained from Tayiba Food Industries Company-Burj Al Arab -Alexandria, Egypt.

Methods

Preparation of alternative milk

Tiger nut, sesame seeds, corn grain, sorghum grain and dry bean seeds were cleaned from foreign materials,

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bad/cracked nuts and seeds, then washed and rinsed with portable water. Cantaloupe seeds were removed from fruits, and washed carefully with tap water, then placed into a perforated basket to drain the water and sun dried. Dried cantaloupe seeds were put in oven dryer at 50ºC for 20 min.

Coconut milk prepared according to Belewu *et al.* (2013) with some modifications. The dry grated coconut mixed with water at ratio1:5 (w/v) and allowed to hydrate in refrigerator temperature (4˚C) for 12 hours. Hydrated coconut was heated at 65-75˚C for 10 min in water bath.

Potato powder was mixed with water at ratio 1:13 (w/v) and allowed to hydrate in refrigerator temperature (4°C) for 12 hours, then heated to 45–60ºC for 10 min in a water bath.

White corn grain was milled in a laboratory hammer mill into fine flour (whole meal flour). Corn flour was mixed with water at ratio1:16 (w/v), and allowed to hydrate in the temperature of the refrigerator for 6 h (Manzoor, 2017), then heated at 75–80ºC for 10 min in a water bath.

Known weights of tiger nuts, sorghum and bean were soaked in tap water for 12 hours in refrigerator. Soaked water of tiger nut, sorghum and bean were removed. Tiger nut, sorghum and bean were mixed with water at ratios 1:6, 1:7 and 1:5 (w/v), respectively (Sanni *et al.*, 1999; Awonorin and Udeozor, 2014), then, crushed in blender and heated at 80˚C/10 min for tiger nut and sorghum and at 80˚C/30 min for bean in a water bath.

Both of sesame and cantaloupe seeds were grounded in an electrical blender (Bastıoğlu *et al*., 2016). The grounded seeds were mixed with water at ratios 1:5 and 1:10 (w/v) for sesame and cantaloupe, respectively and heated at 80–85˚C for 30 min in a water bath (Akubor and Ogbadu, 2003).

Chemical analysis

Moisture, crude protein, crude fat and ash content in raw materials were determined according to the method described by A.O.A.C. (2010). Total fat of alternative milk were determined according to James (1995). Total carbohydrate content (on dry weight basis) was calculated by difference according to Onivogui *et al.* (2014). Energy value of alternative milk was estimated according to the method described by Hunt *et al*. (1987).

The mineral contents of alternative milk samples were determined by the dry ash extraction method following each specific mineral element as described by James (1995). The experiments were conducted at the Agricultural Research Center, Giza, Egypt.

Physical analysis

Total acidity calculated as percentage lactic acid, pH value and total soluble solids measured as described by A.O.A.C. (2010). Specific gravity was determined according to the method described by Omole and Ighdaro (2012). The total solid contents (%) were determined according to the method described by Niveadhitha and Ramasamy (2018). Sedimentation stability of the alternative milk was determined using the method of Quasem *et al*. (2009). The experiments were conducted at the Agricultural Research Center, Giza, Egypt.

Determination of color characteristics

Color of milk samples was measured using spectro colorimeter (Tristimulus Color Machine) with the CIELAB color space (International Commission on Illumination) as mentioned by Sapers and Douglas (1987) and Hunter (1975). The color values were expressed as L* (lightness or brightness/darkness), a* (redness/greenness), and b* (yellowness/ blueness). The Hue (H)*, Chroma (C)*, and browning index (BI) were calculated according to the method of Palou *et al.* (1999). The experiments were conducted at the National Research Center. Dokki Egypt.

Sensory evaluation

Alternative milk samples were subjected to sensory evaluation using twenty members randomly selected from Food Technology Research Institute, Agricultural Research Center, Giza, Egypt. Members judged the products for overall acceptability and sensory attributes of color, taste, viscosity, flavor, mouth feel and similarity of milk. Milk samples were served chilled. Scores were based on a hedonic scale of 1 to 10 where 1 = dislike very much 10 = like very much (Ihekoronye and Ngoddy, 1985; Watts *et al*., 1989).

Statistical analysis

Analysis of variance was carried out according to Gomez and Gomez (1984). Treatment means were compared by Duncan′s (1955). The significance level was 0.05 only. All statistical analysis was performed using analysis of variance technique by means of MSTAT computer program (Bricker, 1991).

RESULTS AND DISCUSSION

The nutritional compositions of plant material and alternative milk were presented in Table (1). There were significant differences ($p< 0.05$) between all milk samples in nutritional compositions on dry weight basis. Cantaloupe seed milk had high protein content (18.26%) followed by dry bean milk (16.34%). Among tested plant, the highest protein contents found in dry bean (31.37%) and cantaloupe (28.78) seeds. Omole and Ighodaro (2012) reported that, melon seeds (*Citrullus vulgaris*) milk had 11.02% protein content as dry weight basis. Also, coconut milk contained 5.42% protein. Ladokun and Oni (2014) reported that coconut milk had 7.17% protein content. While white corn milk recorded the lowest percentage of protein content (2.10%).

Coconut milk had the highest fat content, it was 41.97% followed by sesame milk (26.52%). Patil *et al.* (2017) mentioned that coconut milk at three different stages of maturity in Thailand ranged between 17.28- 44.20 g/100g. Cantaloupe seeds milk had an amount of fat (16.25%) that is worth considering. Tiger nut milk contained 9.11% fat content, these result were approximate with Bristone *et al.* (2015) who found that tiger nut milk contained 9.39% fat. Minor fat content was found in sorghum milk (1.37%) and dry bean milk (1.46%).(Table 1).

Also from the same Table (1), it is noticeable that, ash content is a reflection of the mineral compositions of the milk samples and is quite comparable (Ladokun and Oni, 2014). Table (1) illustrated that dry bean milk recorded a good amount of ash (4.24%) followed by cantaloupe seed milk (2.80%). Tunde-Akintunde and Souley (2009) found that soy milk in Nigeria had 4.01% ash content as dry weight basis, while Akubor and Ogbadu (2003) reported that melon (*Citrullus colocynthis*) seeds milk prepared by boiled method had 9.76% ash as dry weight basis. Coconut milk in this study contained 1.62% ash. These results were consistent with Ladokun and Oni (2014) who found ash in coconut milk was 1.49%. On the other hand, tiger nut milk contained 1.49% ash, these result were in agreement with Chima *et al.* (2013) which reported that tiger nut milk in Nigeria had total ash 1.80% as dry weight basis.

Data in Table (1), also showed that, there were significant differences ($p<0.05$) among all samples in carbohydrate. Coconut milk recorded 50.99% carbohydrate; it was lower than other milk samples. As well, tiger nut milk contained 85.46% carbohydrate content, these results were contrast with Chima *et al.* (2013) who revealed that tiger nut milk had 58.01% carbohydrate content on dry weight basis.

Table1. Chemical composition of alternative milk samples (on dry weight basis).

Samples		Protein, %	Fat, %	Ash, %	Carbohydrate %	Energy value, kcal/100g	Total solids, %	Moisture, %
Coconut	Grated	11.98	66.39	1.83	9.61	683.87	96.96	3.04
	Milk	5.42[d]	41.97[a]	1.62[cd]	50.99[h]	603.37[a]	18.51[a]	81.49[g]
Potato	Powder	14.85	2.79	1.66	80.15	405.11	90.87	9.13
	Milk	4.27[e]	2.81[e]	1.07[ef]	91.76[c]	402.34[f]	8.43[e]	91.57[c]
White corn	Grain	14.80	4.94	1.61	76.92	411.34	88.97	11.03
	Milk	2.10[g]	1.06[g]	0.74[f]	96.10[a]	402.18[f]	8.08[f]	91.92[b]
Tiger nut	Tuber	8.92	20.86	1.93	64.16	480.06	88.46	11.54
	Milk	3.94[e]	9.11[d]	1.49[c]	85.46[d]	439.59[d]	9.38[d]	90.62[d]
Sorghum	Grain	13.87	4.02	1.61	79.11	408.10	90.73	9.27
	Milk	2.66[f]	1.37[fg]	0.82[ef]	95.15[b]	403.57[e]	10.91[c]	89.09[e]
Dry bean	Legume	31.37	1.27	4.74	61.03	381.03	94.07	5.93
	Milk	16.34[b]	1.46[f]	4.24[a]	77.96[e]	390.34[g]	6.61[g]	93.39[a]
Sesame	Seed	30.74	51.41	2.85	11.93	633.37	96.59	3.41
	Milk	13.38[c]	26.52[b]	1.19[de]	58.91[g]	527.84[b]	12.03[b]	87.97[f]
Cantaloupe	Seed	28.78	31.79	3.40	2.97	413.11	93.72	6.28
	Milk	18.26[a]	16.25[c]	2.80[b]	62.69[f]	470.05[c]	9.64[d]	90.36[d]

In a column, means having the same superscript letters are not significantly different at 5% level.

Data present in Table (2) showed that the minerals contents of alternative milk sesame seeds milk was rich in macro- and micro- elements content followed by tiger nut compared with other milk samples. The milk of dry bean seeds had the higher content of calcium (24.03 mg/100g) followed by cantaloupe seeds milk (22.94 mg/100g) and then coconut milk (14.78 mg/100g). Tiger nut milk contained 3.63 mg/100g calcium content, these result approximate with Ukwuru *et al.* (2008) who reported that tiger nut (*Cyperus esculentus*) milk in Nigeria had calcium 2.8 mg/100g. Phosphorus in cantaloupe seeds milk was reported 48.71 mg/100g followed by sesame seeds milk (39.16 mg/100g) and dry bean seeds milk (25.23 mg/100g), then coconut milk which contained 22.82 mg/100g phosphorus.

Magnesium content was high in cantaloupe seeds milk, sesame seeds milk, coconut milk and dry bean seeds milk. It was 245.82, 156.47, 148.66 and 99.35 mg/100g, respectively. At the same Table (2), the higher sodium content was in sesame seeds milk (77.02 mg/100g) followed by dry bean seeds milk (71.66 mg/100g) and tiger nut milk (69.22 mg/100g), then coconut milk (56.64 mg/100g). These results nearly were in agreement with those of Omole and Ighodaro (2012), who mentioned that melon seed (*Citrullus vulgaris*) milk in Nigeria contained copper 0.061, zinc 0.38, manganese 0.193 and iron 0.654 mg/100g, but disagree in calcium 92.0, phosphorus197.0, magnesium 16.0, sodium 3.7and potassium 68.0 mg/100g.

Strickland (2009) stated that magnesium is a mineral intervene in more than three hundred biochemical reactions in the body. It helps maintain normal nerve function, supports a healthy immune system, helps to regulate blood glucose levels, is involved in the synthesis of protein and energy production, and helps regulate blood pressure.

Sesame seeds, tiger nut and potato powder milk had higher amounts of potassium, it was 390.85, 307.85 and 210.55 mg/100g, respectively (Table 2).

Micro-elements in tested alternative milk samples were diverse as shown in Table 2. Sesame seeds milk had the highest value of Cu, Zn, Mn and Se, but cantaloupe seeds milk was the higher in Fe. Potato powder and tiger nut milk had good amounts of Micro-elements.

Rehman *et al.* (2004) stated that coconut-natural milk blend in Pakistan had 56.0 mg/100g calcium, 21.0 mg/100g magnesium, 52.0 mg/100g sodium, 196.0 mg/100g potassium and 0.73 mg/100g iron.

Table 2. Minerals content of alternative milk samples

Alternative	Macro-elements, mg/100g					Micro-elements, mg/100g				
milk samples	Ca	P	Mg	Na	K	Cu	Zn	Mn	Fe	Se
Coconut	14.78	22.82	148.66	56.64	91.01	0.09	0.19	0.21	0.49	0.17
Potato	9.17	12.33	56.70	47.67	210.55	0.59	1.76	0.54	0.90	1.73
White corn	3.89	10.33	51.86	33.82	134.05	0.22	1.27	0.29	0.27	1.44
Tiger nut	3.63	16.23	53.94	69.22	307.85	0.68	1.63	0.197	0.58	2.58
Sorghum	6.96	19.58	71.04	28.92	147.27	0.40	1.89	0.63	0.55	2.24
Dry bean	24.03	25.23	99.35	71.66	86.43	0.09	0.51	0.07	0.87	0.28
Sesame	7.12	39.16	156.47	77.02	390.85	1.88	3.72	0.97	0.78	3.22
Cantaloupe	22.94	48.71	245.82	45.88	38.87	0.12	0.31	0.18	0.97	0.26

Results in Table (3) indicated that,physical analysis of alternative milk, there were significant differences ($p< 0.05$) between all alternative milk samples in physical analysis except for specific gravity.

The pH values of milk samples present in Table (3). Milk samples had mild acidic values ranged between 6.51 (tiger nut milk) and 5.90 (corn milk). Coconut milk had pH 6.0. These results were approximate with those of Belewu and Belewu (2007), who reported that coconut milk had pH 6.23. Also tiger nut milk had pH 6.51 these were consistent with Belewu and Belewu (2007) and Udeozor (2012), who found that tiger nut milk had 6.64 and 6.70 pH, respectively. Udeozor (2012) stated that, the pH value for tigernut milk (6.70) was higher than other used samples; this shows that tigernut is less acidic and implies that milk prepared from tigernut will be acceptable to patient with ulcer and other related problems since it is less acidic. This confirms the assertion of David (1986) that tiger nuts are regarded as stimulant and tonic and it can be used in the treatment of indigestion, colic diarrhea and dysentery.

Results in the Table (3) showed that, the milk of cantaloupe seeds had 6.36 pH these results were in agreement with Akubor *et al.* (2002) who mentioned that melon seeds milk (*Citrullus colocynthis* L.) in Nigeria had 6.36 pH value. Manzoor (2017) stated that pH values below 7 (neutral) is an indication milk sample will safe from microbial attack or growth.

The total acidity of white corn milk was higher (0.28%) than other alternative milk samples. There were no significant difference between sorghum, dry bean, sesame and cantaloupe seeds milk for acidity. Grobler *et al.* (1985) and Edwards *et al.* (1999) reported that the total titratable acidity is a more accurate measure of the total acid content of a drink, and may be a more realistic means of predicting erosive potential.

Total soluble solids (TSS) are the most important quality parameters used to indicate sweetness of fresh and processed horticultural food products (Magwaza and Opara, 2015). Also Pereira *et al.* (2013) mentioned that TSS or Brix represents the percentage by mass of total soluble solids of a pure aqueous sucrose solution. The sugars and acids, together with small amounts of dissolved vitamins, proteins, pigments, phenolics, and minerals, are commonly referred to as soluble solids (Tadeo *et al.*, 1987; Ito *et al.*, 1997; Chope *et al.*, 2006; Kader, 1999 and 2008). Table (3) illustrated that TSS ranged between 9.6 % in tiger nut milk and 6.0% in cantaloupe seed milk. These results were contrast with those of Akubor and Ogbadu (2003) who revealed that melon seed (*Citrullus colocynthis* L.) milk in Nigeria had 7.0°Brix.

Table 3. Physical analysis of alternative milk samples from tested plant raw materials

Alternative milk samples	pH	Acidity as lactic acid, %	TSS, %	Specific gravity, g/cm^3	Sedimentation stability
Coconut	6.00^{bcd}	0.09^{bc}	9.0^{b}	1.033^{a}	NS
Potato	5.94^{cd}	0.21^{a}	6.8^{e}	1.028^{a}	0.63^{bc}
White corn	5.90^{d}	0.28^{a}	7.4^{d}	1.027^{a}	0.50^{c}
Tiger nut	6.51^{a}	0.17^{ab}	9.6^{a}	1.034^{a}	0.86^{ab}
Sorghum	6.31^{abc}	0.03^{c}	7.9^{c}	1.035^{a}	0.97^{a}
Dry bean	6.16^{abcd}	0.05^{c}	6.9^{e}	1.035^{a}	NS
Sesame	6.22^{abcd}	0.08^{bc}	7.0^{e}	1.024^{a}	0.19^{d}
Cantaloupe	6.36^{ab}	0.06^{bc}	6.0^{f}	1.024^{a}	0.18^{d}

In a column, means having the same superscript letters are not significantly different at 5% level. NS = Not Sedimentation, TSS= total soluble solids

Specific gravity is the ratio of the density of milk compared to the density of water at a certain temperature (Williams *et al.* 2012). Specific gravity in Table (3) explained that there were no significantly different among all milk samples. This result could be attributed to uniform dispersion of solutes. Corn milk had specific gravity 1.027 g/cm^3, these result was in agreement with those of Ajala *et al.* (2013), who found that corn milk (Freshly harvested) in Nigeria had specific gravity 1.03. Also specific gravity of coconut milk was 1.033 g/cm^3, these result were higher than the values reported for coconut milk in Nigeria and Thailand (1.010 and 1.008 g/cm^3, respectively) by Ladokun and Oni (2014); Khuenpet *et al.* (2016). Meanwhile cantaloupe seed milk had specific gravity 1.024. The values of these results were lower than Omole and Ighodaro (2012) who stated that melon seeds (*Citrullus vulgaris*) milk in Nigeria had specific gravity 1.032.

Sedimentation involves the formation of a (usually dense) layer of protein-rich material at the base in the pack. Sedimentation will be accelerated for larger particles and for larger density differences between the particles and the continuous phase. Particles with a higher density than the continuous phase will sediment over time under the force of gravity (Anema, 2019).

Sedimentation stability values was the highest in coconut and dry bean milk (not sedimentation), followed by sorghum seeds milk sample. The milk of sesame and cantaloupe seed had the lowest sedimentation stability(Table 3).

Definitely, the sensory quality is very important for the food and beverage products. According to the results in Table (4), the alternative milk were sensory evaluated for color, taste, flavor, mouth feel, texture and similarity of milk. In general, there were significantly different ($p < 0.05$) among all alternative milk. The milk of coconut had the highest values in all sensory attributes; which were 9.3, 9.1, 9.0, 9.1, 8.9 and 9.2 for color, taste, flavor, mouth feel, texture and similarity of milk, respectively. Likewise dry bean milk recorded the lowest value for all sensory attributes. Meanwhile Rehman *et al.* (2004) stated that, coconut natural milk better than cow milk in flavor; this might be due to the preference of coconut flavor which was felt pleasant and attractive to the judges.

Table 4. Sensory evaluation of alternative milk samples from tested raw material

Alternative milk samples	Color, 10	Taste, 10	Flavor, 10	Mouth feel, 10	Texture, 10	Similarity of milk, 10
Coconut	9.3^{a}	9.1^{a}	9.0^{a}	9.1^{a}	8.9^{a}	9.2^{a}
Potato	8.8^{abc}	7.0^{cd}	7.7^{cd}	7.4^{bc}	7.7^{bcd}	7.2^{de}
White corn	7.8^{d}	7.5^{bcd}	7.7^{cd}	7.5^{bc}	7.6^{cd}	7.9^{bc}
Tiger nut	8.2^{cd}	7.9^{b}	7.9^{bc}	7.4^{bc}	7.7^{bcd}	7.0^{de}
Sorghum	8.5^{bc}	7.7^{bc}	7.9^{bc}	7.5^{bc}	7.7^{bcd}	7.6^{cd}
Dry bean	6.9^{e}	6.8^{d}	7.1^{d}	6.9^{c}	7.2^{d}	6.8^{e}
Sesame	9.1^{ab}	7.6^{bc}	7.8^{bcd}	7.8^{b}	8.1^{bc}	8.4^{b}
Cantaloupe	8.7^{abc}	8.7^{a}	8.5^{ab}	8.7^{a}	8.4^{ab}	8.5^{b}

In a column, means having the same superscript letters are not significantly different at 5% level.

On the other hand, sesame and cantaloupe seeds milk had good sensor judging value for color, taste, flavor, mouth feel, texture and similarity of milk. Anjaya *et al.* (1996) reported that, the consistency (mouth feel) of this milk varies considerably depending on quantity of water added during the process. The statistical analysis demonstrates significant differences between samples concerning similarity of milk. The highest values for similarity of milk were in coconut milk followed by cantaloupe seeds milk which was nearly to sesame seeds milk. Likewise dry bean milk recorded the lowest values for similarity of milk compared other samples.

Color is an important consideration in food products, because color and general appearance are generally the first impressions consumers have about a specific product (Perez-Alvarez and Fernandez-Lopez, 2000). Figure (1) and Table (5) showed that, the color characteristics of alternative milk measured directly with a Hunter Lab. Data revealed that color varied among all samples for lightness (L∗), redness (a∗), and yellowness (b∗)-values. The value (L*) is the color parameter that measures the extent of light, thus L*-value when 0 would indicate black and when 100 would indicate white (Siddiq *et al.*, 2009). Coconut milk had high L* (91.20) followed by sesame seeds milk (87.06). Chantrapornchai *et al.* (1999) studied the color of oil-in-water emulsions and found that lightness was higher when increasing the fat content. It is because fat can raise the dispersion and reflectance of light (Chanamai and McClements, 2001). The lowest L∗ -value (44.31) was showed in dry bean milk. The decrease in L*-value indicated darkening of the milk (Aidoo *et al.*, 2010).

Table (5) illustrated that, the values of a*-value which indicated the redness (+a*-value) and greenness (-a*-value) generally higher in tiger nut milk (0.04). The milk of potato had the lowest redness (-3.62) compared to other alternative milk samples. Kahyaoglu and Kaya (2006) reported that redness (a*-value) reduction can lead to increase in whiteness. Tristimulus colourimetry in color is a valuable tool for discriminating changes in color due to both Milard reaction and anthocyanin degradation (Farrag *et al.*, 2017).

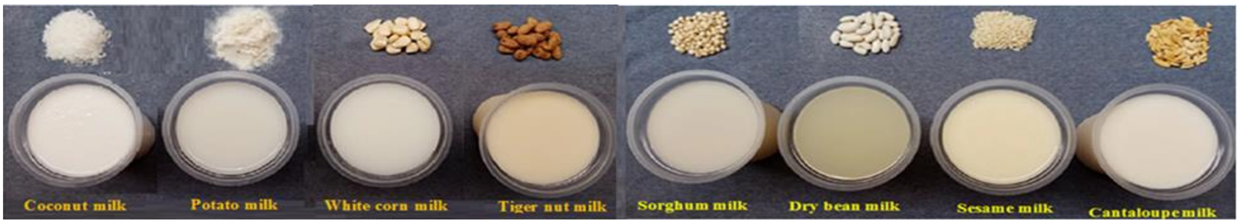

Figure 1. Comparison of different alternative milk samples from eight plant based raw materials

Table 5. Color characteristics of alternative milk samples

Alternative milk samples	L*	a*	b*	ΔE	H	C	BI
Coconut	91.20	-1.10	3.51	91.27	72.59	3.68	5.38
Potato	85.79	-3.62	-5.07	86.02	54.47	6.23	-15.62
White corn	66.10	-2.32	-3.31	66.22	54.97	4.04	-13.19
Tiger nut	69.89	0.04	-22.61	73.46	89.89	22.61	-48.84
Sorghum	67.07	-3.28	-25.41	71.79	82.64	25.62	-61.65
Dry bean	44.31	-3.50	-2.22	44.50	32.38	4.14	-18.98
Sesame	87.06	-0.14	11.94	87.88	89.32	11.94	26.03
Cantaloupe	84.67	-0.73	12.30	85.56	86.60	12.32	26.75

L* = lightness (0 ≤ L ≤ 100); a*(+) = redness; a*(-) = greenness; b*(+) = yellowness; b*(-) = blueness, ΔE: Delta E, H*: Hue, C*: Chroma and BI: Browning index.

On the other hand, the milk of cantaloupe seeds had high b*-value (12.30) value followed by sesame seeds milk (11.94). This could have been attributed to the pigment component in the seed coat (Nti, 2009) and enzymatic reactions. Azhari *et al.* (2014) reveled that *Seinat (Cucumis melo var. tibish)* seed oil had 29.31 b*-value, this indicates the presence of yellow pigments like carotenoid compounds. On the other hand Rababah *et al.* (2017) stated that (+ b*-value) in sesame samples ranged from 12.2 to 20.8. This yellow color, which includes carotenoids, is beneficial, since it stimulates the appearance without the use of primary colorants, such as carotenes and annattos, commonly used in the oil and fat industry (Oomah *et al.*, 2000). Coconut milk recorded 91.20 (L*-value), -1.10(a*-value) and 3.51 (b*-value). These results nearly were in agreement with Khuenpet *et al.* (2016) who mentioned that coconut milk in Thailand had 78.21 L*-value, -0.40 a*-value and 3.68 b*-value.

Data in table (5) also showed that, ΔE ranged between 44.50 in dry bean milk and 91.27 in coconut milk. Hue is expressed as an angle where 0° represents red, 90° represents yellow, 180° represents green and 270° represents blue (Siddiq *et al.*, 2009). The milk of tiger nut recorded 89.89 followed by 89.32 in sesame milk for hue, that indicating a yellowish color. Murevanhema and Jideani (2015) mentioned that, the increase in hue indicated that during hydration, more color components were solubilized.

From Table (5) results showed that, saturation index (Chroma) was increased in milk samples, while Hunter hue angle increased in the same samples. Chroma (C) is the quality that distinguishes a pure hue from a gray shade and describes hue saturation or purity; its axis extends from the values (lightness) axis toward the pure hue (Sahin and Sumnu, 2006).Chroma ranged between 3.68 in coconut milk to 25.62 in sorghum seed milk. Browning index increased in the sesame and cantaloupe seed milk (26.03 and 26.75, respectively) compared to other samples.

CONCLUSION

From the above study, it was concluded that, coconut, cantaloupe seeds, sesame seeds and tiger nut milk had the best sensory properties and nutritional value. Meanwhile dry bean milk had the lowest sensory properties but higher in protein and minerals. So, in future study, these samples will be combined at different levels to produce new alternative milk with high nutritional value and acceptable sensory properties.

REFERENCES

A.O.A.C. (2010). Official Methods of Analysis. Association of Official Analytical Chemists. 19th ed. Washington, D.C., USA.

Ahmadian-Kouchaksaraei, Z.; Varidi, M.; Varidi, M.J. and Pourazarang, H. (2014). Influence of processing conditions on the physicochemical and sensory properties of sesame milk: A novel nutritional beverage. LWT-Food Science and Technology, 57(1): 299-305.

Aidoo, H.; Sakyi-Dawson, E.; Tano-Debrah, K. and Saalia, F.K. (2010). Development and characterization of dehydrated peanut–cowpea milk powder for use as a dairy milk substitute in chocolate manufacture. Food Research International, 43(1): 79-85.

Ajala, L.; Ologunde, M.O. and Adetuyi, F.O. (2013). Physicochemical and sensory qualities of spiced soy-corn milk. African Journal of Biotechnology, 12 (17): 2262-2265.

Akubor, P.I. and Ogbadu, R.L. (2003). Effects of processing methods on the quality and acceptability of melon milk. Plant Foods for Human Nutrition, 58(1): 1-6.

Akubor, P.I.; Achi, O.K. and Offonry, S.U. (2002). Influence of storage on chemical, microbial and consumer acceptability of a milk-like product made from melon seeds. Plant Foods for Human Nutrition, 57(2): 191-196.

Anema, S.G. (2019). Age Gelation, Sedimentation, and Creaming in UHT Milk: a Review. Comprehensive Reviews in Food Science and Food Safety, 18(1): 140-166.

Anjaya, C.C.N.; Arlina, M.M. and Adawiyah, D.R. (1996). Effects of extraction, antioxidant, bleaching agent on the shelf life of coconut milk packed in retort pouch. Buletin Teknologi dan Industri Pangan (Indonesia), 7(2): 54- 62.

Asante, F.A.; Ellis, W.O.; Oduro, Ibok N. and Saalia, F.K. (2014). Effect of soaking and cooking methods on extraction of solids and acceptability of tiger nut (*Cyperus esculentus* L.) milk. Journal of Agricultural Studies, 2 (2): 76-86.

Awonorin, S.O. and Udeozor, L.O. (2014). Chemical properties of tiger nut-soymilk extract. Journal of Environmental Science, Toxicology and Food Technology, 8(3): 87-98.

Azhari, S.; Xu1, Y.S.; Jiang, Q.X. and Xia, W.S. (2014). Physicochemical properties and chemical composition of Seinat (*Cucumis melo* var. *tibish*) seed oil and its antioxidant activity. Grasasy Aceites, 65(1): 1-9. https://cyberleninka.org/ article/n/ 1291011/ viewer.

Bastıoğlu, A.Z.; Tomruk, D.; Koç, M. and Ertekin, F.K. (2016). Spray dried melon seed milk powder: physical, rheological and sensory properties. Journal of Food Science and Technology, 53(5): 2396-2404.

Belewu, M.A. and Belewu, K.Y. (2007). Comparative physicochemical evaluation of tiger-nut, soybean and coconut milk sources. International Journal of Agriculture and Biology, 9(5): 785-787.

Belewu, M.A.; Abdulsalam, K.O.; Belewu, K. and Belewu, N. (2013). Rice Coconut Yoghurt: preparation, nutritional and sensory qualities. Asian Journal of Agriculture and Rural Development, 3(12): 924-928.

Bricker, B. (1991). MSTATC: A micro computer program from the design management and analysis of agronomic research experiments. Michigan State University, USA.

Bridges, M. (2018). Moo-ove over, cow's milk: the rise of plant-based dairy alternatives. Practical Gastroenterology, 20-27.

Bristone, C.; Badau, M. H.; Igwebuike, J.U. and Igwebe, A.O. (2015). Production of yoghurt from mixtures of cow milk, milk extract from soybean and tigernut. World Journal of Dairy and Food Sciences, 10(2): 159-169.

Chanamai, R. and McClements, D.J. (2001). Prediction of emulsion color from droplet characteristics: dilute mono disperse oil-in-water emulsions. Food Hydrocolloids, 15(1): 83-91.

Chantrapornchai, W.; Clydesdale, F. and McClements, D.J. (1999). Theoretical and experimental study of spectral reflectance and color of concentrated oil-in-water emulsions. Journal of colloid and interface science, 218(1): 324-330.

Chima, A.O.; Abuajah, C.I. and Utuk, R.A. (2013). Tiger nut milk: a nutritious under-utilized food ingredient. Food Biology, 2(2): 14-17.

Chope, G.A.; Terry, L.A. and White, P.J. (2006). Effect of controlled atmosphere storage on abscisic acid concentration and other biochemical attributes of onion bulbs. Postharvest Biology and Technology, 39(3): 233–242.

David, F. (1986). Human Nutritional Dietary Food Encyclopaedia. Pp. 35–36. *Cited from*: Udeozor, L.O. (2012). Tigernut-soy milk drink: preparation, proximate composition and sensory qualities. International Journal of Food and Nutrition Science, 1(4):18-26.

Duncan's, D.B. (1955). Multiple range and multiple F tests. Biometrics, 11(1):1-42.

Edwards, M.; Creanor, S.L.; Foye, R.H. and Gilmour, W.H. (1999). Buffering capacities of soft drinks: the potential influence on dental erosion. Journal of Oral Rehabilitation, 26(12): 923–927.

Farrag, A.F.; Bayoumi, H.M.; Ibrahim, W.A.; El-Sheikh, M.M. and Eissa, H.A. (2017). Characteristics of white soft cheese fortified with hibiscus soft drink as antimicrobial and hypertension treatment. Science, 12: 122-129.

Gomez, K.A. and Gomez, A.A. (1984). Statistical procedures for agricultural research. An International Rice Research Institute Book John Wiley and Sons.INC., New York. USA.

Grobler, S.R.; Jenkins, G.N. and Kotze, D. (1985).The effects of the composition and method of drinking of soft drinks on plaque pH. British Dental Journal, 158: 293–296.

Heyman, M.B. (2006). Lactose intolerance in infants, children, and adolescents. Pediatrics, 118(3): 1279–1286.

Hunt, C.; Burn, P. and Adamczuk, Z.C. (1987). Proximal composition and fat type of three popular take-away meals. International Journal of Food Science and Technology, 22(6): 669-675.

Hunter, R.S. (1975). Scales for measurements of color differences. The Measurement for Appearance. John Wiley and Sons, New York, 133- 140.

Ihekoronye, A.I. and Ngoddy, P.O. (1985). Integrated food science and technology for the tropics. Macmillan, London, UK.

Ito, T.; Sasaki, K. and Yoshida, Y. (1997). Changes in respiration rate, saccharide and organic acid content during the development and ripening of mango fruit (*Mangifera indica* L. 'Irwin') cultured in a plastic house. Journal of the Japanese Society for Horticultural Science, 66(3-4): 629-635.

James, S.C. (1995). Analytical chemistry of food. Chapman and Hill Printers. London. Pp. 23.

Kader, A.A. (1999). Fruit maturity, ripening and quality relationships. Acta Horticulturae, 485: 203–208.

Kader, A.A. (2008). Flavor quality of fruits and vegetables. Journal of the Science of Food and Agriculture, 88: 1863–1868.

Kahyaoglu, T. and Kaya, S. (2006). Modeling of moisture, color and texture changes in sesame seeds during the conventional roasting. Journal of Food Engineering, 75(2): 167-177.

Khuenpet, K.; Jittanit, W.; Hongha, N. and Pairojkul, S. (2016). UHT skim coconut milk production and its quality. In SHS Web of Conferences, EDP Sciences, Vol. 23: p 03002.

Ladokun, O. and Oni, S. (2014). Fermented milk products from different milk types. Food and Nutrition Sciences, 5(13): 1228-1233.

Magwaza, L.S. and Opara, U.L. (2015). Analytical methods for determination of sugars and sweetness of horticultural products—A review. Scientia Horticulturae, 184: 179–192.

Manzoor, M.F. (2017). Effect of cooking temperature on some quality characteristic of almond milk. International Journal of Agricultural and Life Sciences, 3 (1): 131-135.

Murevanhema, Y.Y. and Jideani, V.A. (2015). Production and characterization of milk production from Bambara ground nut (*Vigna subterranean*) Varieties. Journal of Food Processing and Preservation, 39(6):1485-1498.

Niveadhitha, S. and Ramasamy, D. (2018). Study on Physicochemical Properties of Milk Beverage. International Journal of Current Microbiology and Applied Sciences, 7(5): 2421-2428.

Nti, C.A. (2009). Effects of bambara groundnut (*Vigna subterranea*) variety and processing on the quality and consumer appeal for its products. International Journal of Food Science and Technology, 44(11): 2234-2242.

Omole, J.O. and Ighodaro, O.M. (2012). Proximate composition and quality attributes of milk substitute from melon seeds (*Citrulus vulgaris schrad*). Report and Opinion, 4(9): 75- 78.

Onivogui, G.; Zhang, H.; Mlyuka, E.; Diaby, M. and Song, Y. (2014). Chemical composition, nutritional properties and antioxidant activity of monkey apple (Anisophyllea laurina R. Br. ex Sabine). Journal of Food and Nutrition Research, 2(6): 281-287.

Oomah, B.D.; Ladet, S.; Godfrey, D.V.; Liang, J.; Girard, B. (2000). Characteristics of raspberry (*Rubus idaeus* L.) seed oil. Food Chemistry, 69(2): 187–193.

Padghan, P.V.; Patil, S.; Jaybhaye, R.V.; Katore, V.D. and Deshmukh, N. (2015). Studies on cost of production of sweet corn milk and its blended milk products. Journal of Ready to Eat Food, 2(2): 51-55.

Palou, E.; López-Malo, A.; Barbosa-Cánovas, G.V.; Welti-Chanes, J. and Swanson, B.G. (1999). Polyphenol oxidase activity and color of blanched and high hydrostatic pressure treated banana puree. Journal of Food Science, 64(1): 42-45.

Patil, U.; Benjakul, S.; Prodpran, T.; Senphan, T. and Cheetangdee, N. (2017). A comparative study of the physicochemical properties and emulsion stability of coconut milk at different maturity stages. Italian Journal of Food Science, 29(1): 145-157.

Paul, A.A.; Kumar, S.; Kumar, V. and Sharma, R. (2020). Milk Analog: Plant based alternatives to conventional milk, production, potential and health concerns. Critical Reviews in Food Science and Nutrition, 60(18): 3005-3023.

Pereira, F.M.V.; de Souza Carvalho, A.; Cabeca, L.F. and Colnago, L.A. (2013). Classification of intact fresh plums according to sweetness using time-domain nuclear magnetic resonance and chemometrics. Microchemical Journal, 108: 14–17.

Perez-Alvarez J.A. and Fernandez-Lopez J. (2000). Aspectos fisicos, quımicos, psicologicos, fisiol ´ ogicosy ultraestructurales del color de la carne´ . *Cited from:* Sánchez-Zapata, E.; Fernández-López, J. and Angel Pérez-Alvarez, J. (2012). Tigernut (*Cyperus esculentus*) commercialization: health aspects, composition, properties, and food applications. Comprehensive Reviews in Food Science and Food Safety, 11(4):366-377.

Quasem, J.m.R.; Mazahreh, A. and Abu-Alruz, K. H. (2009). Development of vegetable based milk from decorticated sesame (*Sesamum indicum*). American Journal of Applied Sciences, 6(5): 888-896.

Rababah, T.; Al-U'datt, M.; Al-Mahasneh, M.; Odeh, A.; Ajouly, T. and Feng, H. (2017). Effect of processing and storage at different temperatures on the physicochemical and minerals content of sesame seeds and tehina. Bulgarian Journal of Agricultural Science, 23(5): 851-859.

Rehman, S.; Mushtaq, A.M.; Yameen, A.; Almas, K. and Muntaha, S. (2004). Sensory and nutritional evaluation of coconut-natural milk blend. Pakistan Journal of Life and Social Sciences, 2(2): 104-108.

Sahin, S. and Sumnu, S.G. (2006). Color. In: Physical Properties of Foods, Technology and Engineering, pp. 167–173, Springer Science and Business Media, LLC, New York.

Sanni, A.I.; Onilude, A.A. and Adeleke, E.O. (1999). Preparation and characteristics of lactic acid fermented cowpea milk. Zeitschrift für Lebensmitteluntersuchung und-Forschung A, 208(3): 225-229.

Sapers, G.M. and Douglas Jr, F.W. (1987). Measurement of enzymatic browning at cut surfaces and in juice of raw apple and pear fruits. Journal of Food Science, 52(5): 1258-1285.

Siddiq, M.; Nasir, M.; Ravi, R.; Butt, M.S.; Dolan, K.D. and Harte, J.B. (2009). Effect of defatted maize germ flour addition on the physical and sensory quality of wheat bread. LWT-Food Science and Technology, 42(2): 464-470.

Strickland, E. (2009). Eating for Autism: The 10-step Nutrition Plan to Help Treat Your Child's Autism, Asperger's, Or ADHD. Da Capo Lifelong Books.

Tadeo, J.L.; Ortiz, J.M.; Estelles, A. (1987). Sugar changes in clementine and orange fruit during ripening. Journal of Horticultural Science, 62(4): 531-537.

Tunde-Akintunde, T.Y. and Souley, A. (2009). Effect of processing methods on quality of soy milk. Pakistan Journal of Nutrition, 8(8):1156-1158.

Udeozor, L.O. (2012). Tigernut-soy milk drink: preparation, proximate composition and sensory qualities. International Journal of Food and Nutrition Science, 1(4):18-26.

Ukwuru, M.U.; Ibeneme, C.L. and Agbo, G.I. (2011). New product development from tigernut (Cyperus esculentus) and their sensory, proximate and microbiological evaluation. Pakistan Journal of Nutrition, 10(2):101-105.

Ukwuru, M.U.; Omachona, L.J. and Onokah, N. (2008). Production and quality assessment of tigernut (*Cyperus esculentus*) imitation milk during storage. Journal of food science and technology, 45(2):180-182.

Watts, B.M.; Ylimaki, G.L.; Jeffery, L.E. and Elias, L.G. (1989). Sensory methods for food evaluation. The International Development Research Center, Ottawa, 160p.

Williams, T.J.; James, I.J.; Abdulateef, M.R.; Onabegun, L.O.; Jinadu, S.O.; Falade, Y.O.; Solola, F.T.; Adewumi, O.O. and Oke, O.E. (2012). Composition and specific gravity of milk of West African Dwarf sheep as affected by stage of lactation and parity. Nigerian Journal of Animal Production, 39(2): 49-56.

اللبن النباتى البديل الغير حيوانى للأشخاص الذين يعانون من حساسية اللاكتوز والكازين

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تهدف هذه الدراسة إلى تجهيز لبن نباتى بديل صحي وطيب المذاق للأشخاص الذين يعانون من حساسية اللاكتوز والكازين.تم إعداد اللبن البديل بإستخدام جوز الهند المبشور ومطحون البطاطس وحبوب الذرة البيضاء والذرة الرفيعة وحب العزيز وبذور الفاصوليا والسمسم والكنتالوب. إجريت الاختبارات الكيميائية والفيزيائية والحسية واللون والمعادن فى اللبن البديل. أوضحت النتائج وجود فروق معنوية لجميع عينات اللبن في التركيب الكميائى (على اساس الوزن الجاف). أعلى نسبة بروتين كانت في لبن بذور الكنتالوب وأقلها في لبن الذرة البيضاء. وكان لبن جوز الهند أعلى فى نسبة الدهون يليه لبن السمسم ولبن بذور الكنتالوب. وأعلى نسبة رماد سجلت فى لبن الفاصوليا الجافة و أقل قيمة فى لبن الذرة البيضاء. اما لبن جوز الهند فهوأعلى قيمة في نسبة المواد الصلبة الكلية، لبن بذور الكنتالوب كان الأعلى فى الفوسفوروالمغنيسيوم والحديد. ولبن بذور السمسم سجل أعلى قيمة فى البوتاسيوم والنحاس والزنك والمنجنيز والسيلينيوم. سجل الـ pH أعلى قيمة في لبن حب العزيز و أقل قيمة في لبن الذرة البيضاء. اما المواد الصلبة الكلية الذائبة سجلت أعلى نسبة في لبن حب العزيز وأقل نسبة في لبن بذور الكنتالوب. ثبات الراسب فى اللبن البديل كان عالى في لبن جوز الهند والفاصوليا الجافة.لا توجد فروق معنوية فى الوزن النوعي للبن النباتى البديل. لبن جوز الهند كان الأعلى في جميع الصفات الحسية، لبن الفاصوليا سجل اقل قيم لجميع الصفات الحسية . لبن جوز الهند سجل أعلى قيمة فى اللمعان L* يليه لبن بذور السمسم. ودرجة الاحمرار a* كانت أعلى في لبن حب العزيز. لبن بذور الكنتالوب سجل أعلى قيمة للاصفرار b* يليه لبن بذور السمسم.