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Chufa Drink: Developing a New Plant-Based Beverages with Different Flavours

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CHUFA has well-known health and nutritional benefits. This study aimed to produce innovative chufa milk with fruit juices or other flavour materials fortified with whey protein concentrate (WPC). Six chufa milk beverages were prepared as follows: plain chufa milk (CM), chufa milk supplemented with orange juice (CO) or strawberry juice (CS), chufa milk flavoured with cocoa (CC), instant coffee (CF) or cinnamon extract (CN), in addition to buffalo milk fortified with WPC, which served as a control (CT). The results showed that CM beverage had higher fat, protein, sucrose contents and viscosity value than CT beverage, while the control had higher ash, lactose content and pH value than chufa milk beverages. The highest fat content was found in CC beverage. Furthermore, CC and CF beverages had higher protein content than the other flavoured chufa milk beverages, while CS beverage exhibited the highest viscosity value. The minerals content showed significant differences between the control and chufa milk beverages. The control beverage had the highest Ca content compared to the chufa milk beverages, while CC beverage contained higher K and Fe values than CT and the other chufa milk beverages. The highest Na and Mg contents were found in CF and CC beverages, while CF contained the highest P value. Chufa milk beverages flavoured with cocoa and coffee were preferred over all beverages, whereas CM gained the lowest sensory attributes.

Keywords: Chufa milk, Chufa beverages, Orange Juice, Strawberry juice, Cocoa, Instant coffee, Cinnamon extract, WPC.

1. Introduction

Plant-based milk analogues or alternatives are defined as aqueous extracts of diverse plants that mimic the physical and biochemical properties of milk (Jeske et al., 2017). These drinks market is growing exponentially for consumers who are looking for novel products, and they represent a safe and healthy choice for people suffering from lactose intolerance or those allergic to cow milk. Plant-based milk is considered a food product that represents a source of calories, nonallergic proteins, vitamins, minerals and dietary fibres, with reduced fat content, free from lactose and cholesterol (da Silva et al., 2022). Furthermore, these beverages have been shown numerous health benefits, and consequently recognized as functional foods (Moss et al., 2022). Chufa (also known as 'tiger nut', 'earth almond', 'underground walnut' and yellow nut sedge) is the tiny tuber of the perennial plant *Cyperus esculentus* L., cultivated in the Nile valley by ancient Egyptians, but it grows all over the world (Samuel et al., 2023). Studies have shown that tiger nut and its derivatives provide significant health benefits, including reducing blood LDL and triglycerides, increasing HDL, improving macular and cardiovascular health, and having vasodilating, antidiarrheal, anticancer, antibacterial, anti-melanogenic, anti-inflammatory, antidiabetic, anti-apoptotic and antioxidant effects (Zommara and Imaizumi, 2017b; Nwosu et al. 2022). The tubers are rich in bioactive components and essential dietary constituents, such as minerals, carbohydrates, proteins, vitamins, fibres, some digestive enzymes (catalase, lipase and amylase), and antioxidant components such as vitamin E (Hernández-Olivas et al., 2022). Tiger nut fat is rich in monounsaturated fatty acids. Chufa oil contains about 70% oleic acid, 9.5% linoleic acid and about 185 mg kg-1 vitamin E, isoflavones daidzein 12.4 µg g-1 and genistein 8.5 µg g-1 and 1680 mg kg-1 oil of phytosterols (Zommara and Imaizumi, 2017a, b). Therefore, it was suggested as the most suitable fat for human consumption (Yu et al., 2022).

Chufa tubers are sweet nutty tubers that can be eaten after soaking in water or consumed as drinks, grated and baked or dried forms (Nwosu et al., 2022). For instance, this tuber is used in Spain to prepare a refreshing beverage known as "horchata de chufa", which is usually consumed in summer (Yu et al., 2022). This milk-like beverage has a nutty, coconut-like and slightly sweet flavour. Tiger nut milk is consumed for its therapeutic benefits. It is used in China to treat mouth and gum ulcers, relieve severe

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stomach pain, and support regular menstruation and is used as a liver tonic and heart stimulant (Wagner et al., 2002; Rios et al., 2017).

Flavors are important factors affecting the acceptability of beverages by the consumers. Manufacture of chufa milk with fruit juices or flavour agents and supplementation with ingredients that have nutraceutical benefits may make this product more marketable. The utilization of fruit juices could endorse the nutritional and healthy image of chufa milk and can influence the sensory properties of the beverage by increasing the volatility of flavour and masking the undesirable flavor (Nongonierma et al., 2006; Temiz et al., 2018).

Whey protein products are widely used as food additives for their high biological and nutritional value due to their content of essential amino acids and unique functional properties. Additionally, whey proteins exhibit several therapeutic applications in the prevention of various diseases, and they play crucial roles in healthcare and pharmaceutical products (Mehra et al., 2021; Boscaini et al., 2023). Commercially, whey proteins are prepared from milk whey, a byproduct of cheese manufacturing. Whey protein concentrates with protein content ranging from 35-80% are available in the market.

In order to improve its sensory attributes and consumer acceptability, the present study aims to produce chufa milk beverages fortified with whey protein concentrate with different natural juices and flavours, including orange, strawberry, cocoa, instant coffee and cinnamon extract.

2. Materials and Methods

Fresh buffalo's milk (6% fat) was obtained from the healthy herd of the Faculty of Agric., Kafrelsheikh Univ., Egypt. Dried chufa tubers were purchased from a local market in Tanta city, Egypt. The tubers contained 7.1% moisture, 6.20% crude protein, 24.0% crude fat, 60.90% total carbohydrate and 1.18% ash. Whey protein concentrate (WPC, 80% protein) was supplied by Nampa, ID, USA. Commercial stabilizer (Unicream™ 120) was purchased from the United Food Industries Co., Egypt. Sodium benzoate was purchased from Bio Jet Company, Egypt. Granulated sugar, fresh orange and strawberry, pure cocoa powder, classic instant coffee, cinnamon powder, was obtained from a local market in Kafr El-Sheikh city, Egypt.

Making of chufa milk

Preparation of chufa milk was carried out according to the method of Sanful (2009). A total of 900 g of dried chufa tubers were sorted, washed under running tap water and soaked overnight to soften. Two liters of distilled water was added to the soaked tubers and blended several times. The mix was then strained through cheesecloth to separate the chufa milk from the mash. Chufa milk was mixed with 5% sugar, 5% WPC, 0.5% stabilizer (Unicream™) and 0.1% sodium benzoate (It has generally regarded as safe according to the FDA (CFR, 2021), then pasteurized (63 °C for 30 min), cooled and stored in a refrigerator (6 ± 1 °C) until use.

Preparation of fruit juice mix

Orange and strawberry were washed under running tap water. After removing the seeds and undesirable parts, the edible portion of the orange tissue was squeezed, and the strawberry was mixed using an electrical blender to obtain fruit juices. Orange and strawberry juices were mixed with 5% sugar, 5% WPC, 0.5% stabilizer and 0.1% sodium benzoate.

Preparation of cinnamon extract mix

Hot aqueous extract of 2% cinnamon powder was cooled and then mixed with 5% sugar, 5% WPC, 0.5% stabilizer and 0.1% sodium benzoate.

Preparation of chufa beverages

Chufa beverages (Fig. 1) were prepared by mixing the chufa milk (with the additives) with the juices or flavouring materials. Every treatment was divided into six portions and packaged into sterile glass bottles (100 mL) portions with three replicates per treatment as follows: chufa milk (CM) was prepared as previously described. Chufa-orange (CO) was prepared by mixing 50% CM with 50% orange juice mix. Chufa-strawberry (CS) was prepared by mixing 65% CM with 35% strawberry juice mix. Chufa-cocoa (CC) was prepared by mixing CM with 6% cocoa powder. Chufa-coffee (CF) was prepared by mixing CM with 0.9% classic instant coffee powder.

Fig. 1. Chufa milk beverages.

Chufa-cinnamon (CN) was prepared by mixing 67% CM with 33% cinnamon extract mix.

The amount of each juice or flavouring material used was recommended after preliminary experiments, which were conducted to organoleptically evaluate the best desirable percentage of each material from the consumer's point of view (data not shown).

Chufa milk and chufa beverages were compared with buffalo milk beverage (CT) prepared by mixing buffalo milk with 5% WPC, 5% sugar, 0.5% stabilizer and 0.1% sodium benzoate. The beverages were kept in a refrigerator until use.

Analysis of the beverages

Chemical composition

Determination of fat, protein and ash was carried out according to AOAC (2005) methods. The sucrose content (%) was determined according to the method

given by Finley and Fellers (1973). Lactose content was determined according to Barnett and Abd El-Twab (1957).

Physical properties

The pH values of the beverages were measured using a pH meter (Crison, Spain) after calibration with standard buffer solutions (pH 4.0 and 7.0). The apparent viscosity (expressed as cP) was determined using a digital Brookfield viscometer (LVDV–E, Brookfield Eng. Lab., Middleboro, MA, USA) and spindle No. 61 at a speed of 60 rpm, as described by Ghanimah (2018). Temperature of the samples was adjusted to 20°C before determination.

Minerals content

The minerals content [sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), phosphorus (P) and iron (Fe)] of the beverages was determined according to AOAC (2000), using an atomic absorption spectrophotometer (BB model Avanta Σ mar GBC, Australia).

Sensory properties

Sensory evaluation was performed by 20 panelists from the Department of Dairy Sci., Faculty of Agric., Kafrelsheikh Univ., according to Nelson and Trout (1981). The following scoring points were used for sensory properties: taste (10 points), colour (10 points), mouth feel (10 points), aroma (10 points) and overall acceptability (10 points).

Statistical analysis

It was carried out using the SPSS version (10) computer program (SPSS Inc. Chicago IL USA).

3. Results and Discussion

Chemical composition of the beverages

The data in Table (1) show the chemical composition of buffalo's milk beverage (CT) and chufa milk beverages. It can be observed that chufa milk beverage (CM) had higher ($p<0.05$) fat, protein and sucrose contents than CT. The control beverage had significantly higher ash and lactose contents than CM beverage. These results could be attributed to the chemical composition of chufa tubers. Previous studies have shown that chufa tubers contained 15.90-44.92% lipids, 20.1-41.7% starch, 1.5-9.3% protein, and 15.4-19.5% total sugar content with approximately 13% sucrose (Madsen et al., 2021). Chufa protein is considered of high quality because it contains essential amino acids that account 46.03% of total amino acids (Yu et al., 2022). This value largely exceeds that specified in the WHO/FAO model and is close to egg protein (Yu et al., 2022). Although lactose was expectedly not present in the chufa milk, the addition of whey protein concentrate (contained 10% lactose) is responsible for the low lactose content in chufa milk (0.72%). In addition, chufa-based extracts have been reported to have a high sucrose content, which naturally provides sweetness (Madsen et al., 2021).

On the other hand, the chemical composition of CM is higher than that obtained by Sobhy et al. (2022), who found that water-tiger nut milk contained 0.584, 2.43, and 0.263% for protein, fat and ash contents, respectively. El-Shenawy et al. (2019) reported that the average composition of tiger nut extract was 96.86%, 0.34%, 0.95%, 1.65% and 0.20% for moisture, protein, fat, carbohydrate and ash, respectively. Studies on Horchata de chufa (milk-like extract of chufa produced in Spain) showed that the chemical composition of this beverage varied. The range of oil content was 2.4-3.1, protein content was 0.6-1.4, and sugar content was 9.0-10.0 (Madsen et al., 2021). These variations could be attributed to the variety of chufa and the process conditions and procedures.

It is clear from Table 1 that adding different juices and flavouring agents changed the chemical composition of chufa milk. Compared to the chufa beverages, the chufa-cocoa beverage (CC) contained the highest ($p<0.05$) fat content, while the lowest value was recorded for chufa-orange beverage (CO). The highest ($p<0.05$) protein content was found in CC and CF beverages, while the differences among other chufa beverages were insignificant. It has been reported that cocoa powder contains 10-15% fat and 15-20% protein (Barišić et al., 2023). Ash content did not differ in chufa milk beverages by adding orange, strawberry and coffee, whereas the highest

Table 1. Chemical composition of control and chufa milk beverages.

Products*	Fat (%)	Protein (%)	Ash (%)	Sucrose (%)	Lactose (%)
CT	5.63±0.27^{c}	6.07±0.10^{b}	0.79±0.05^{a}	4.63±0.17^{e}	4.45±0.06^{a}
CM	6.84±0.10^{b}	7.68±0.19^{a}	0.59±0.02^{c}	17.3±0.23^{a}	0.72±0.07^{b}
CO	3.19±0.09^{e}	6.25±0.31^{b}	0.54±0.04^{c}	11.71±0.44^{d}	0.68±0.03^{b}
CS	4.83±0.07^{d}	6.79±0.21^{b}	0.53±0.03^{c}	15.88±0.42^{b}	0.64±0.02^{b}
CC	8.37±0.13^{a}	8.04±0.27^{a}	0.69±0.02^{b}	18.17±0.42^{a}	0.68±0.03^{b}
CF	6.77±0.10^{b}	7.92±0.42^{a}	0.61±0.02^{bc}	17.09±0.41^{a}	0.68±0.02^{b}
CN	4.51±0.07^{d}	6.49±0.16^{b}	0.37±0.05^{d}	14.73±0.41^{c}	0.65±0.02^{b}

*CT, control (buffalo milk beverage); CM, chufa milk beverage; CO, orange chufa milk beverage; CS, strawberry chufa milk beverage; CC, cocoa chufa milk beverage; CF, coffee chufa milk beverage; CN, cinnamon chufa milk beverage.

Data are mean ± SE for 3 replicates

Means within column with different superscript letters differed significantly ($p<0.05$).

content was noticed in CC and the lowest content in CN beverage. The sucrose content is sharply increased in chufa beverages compared with CT, while lactose content showed much lower values in chufa beverages than CT. Consequently, these beverages are very suitable for persons suffering from lactose intolerance syndromes.

Physical properties of the beverages

The results of the physical properties showed that the CT beverage had significantly higher pH value (6.54) than chufa beverages (Fig. 2). The CO beverage exhibited the lowest pH value (5.11) followed by CS (5.74), while no significant differences were found among CC, CF and CN beverages. This result is attributed to the high acidity of orange juice due to the presence of organic acids especially citric acid, which is the most abundant free organic acid in orange juice, in addition to malic acid, isocitric acid and ascorbic acid (Liu et al., 2023).

After 7 days of storage, the pH values of chufa beverages significantly decreased, while no marked change was observed in CT beverage (Fig. 2). These results may be attributed to using of patch pasteurization process at lab scale that may be not sufficient to preserve chufa milk, which have high microbiological load and consequently short shelf life (Yu et al., 2022).

Viscosity is an important rheological property and quality attribute that directly influences sensory acceptability and describes the mouth feel of the beverages. Fig. 3 shows the apparent viscosity values of CT and chufa milk beverages. Clearly, CM beverage had significantly higher (p<0.05) apparent viscosity value (40.82 cP) than CT (22.78 cP). This result could be related to the higher protein, fat and sucrose contents in CM than in CT (Table 1). The viscosity depends on the interactions between the dispersion phase and dispersed particles (El-Khair, 2009). Viscosity of the milk mainly depends on the concentration and state of the protein and fat (Ghanimah and Mehanna, 2016). A direct nonlinear effect of the concentration of soluble solids (such as sucrose) and insoluble solids on the apparent viscosity of fluid foods has been reported (Bourne, 2002). Furthermore, chufa tubers contain starch which has good water absorption, binding activity and swelling power, thus increasing the beverage viscosity (Yu et al., 2022).

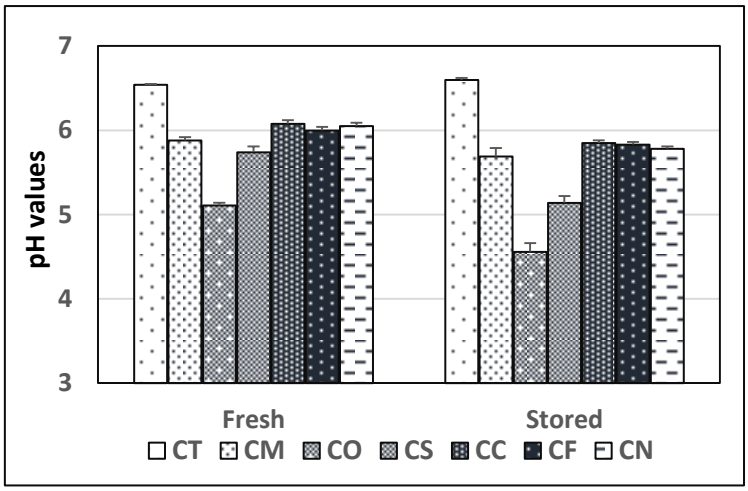

Fig. 2. pH values of fresh and stored control and chufa beverages.

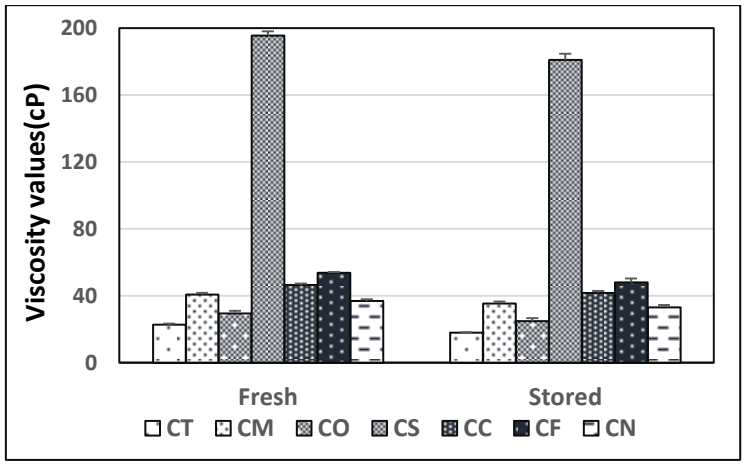

Fig. 3. Viscosity values (cP) of fresh and stored control and chufa beverages.

Regarding the chufa beverages, Fig. 3 illustrates that CS beverage exhibited much higher apparent viscosity value (195.61 cP) than the other chufa beverages, followed by CF (53.83 cP) and CC (46.67 cP), whereas CO exhibited the lowest (p<0.05) value (29.56). These results could be attributed to the pectin and polysaccharide content in strawberry juice, as well as the soluble and insoluble components in coffee and cocoa, which have significant effect on the viscosity of these beverages (Wang et al., 2019; Barišić et al., 2023).

The viscosity values significantly decreased after 7 days of storage (Fig. 3). Furthermore, the viscosity values of stored beverages showed a trend similar to that recorded for fresh samples. Comparing with chufa beverages, the highest viscosity value was recorded in stored CS beverage (181.11 cP), while stored CO beverage showed the lowest value (24.99 cP). This decrease in viscosity during cold storage could be attributed to the phase-separation arising between the coarse starch granules and liquid phase, which causes the destabilization of chufa beverages, or sedimentation of the dispersed particles (Madsen et al., 2022). The decrease in the viscosity in stored chufa milk enriched with fruit juices may be due to endogenous pectinolytic enzymes activity and microbial growth (Bermejo-Prada et al., 2015).

Minerals content

The minerals contents in CT and chufa beverages are given in Table 2. Clearly, all the measured minerals (Na, K, Ca, Mg, P and Fe) varied significantly among the beverages. Chufa milk beverage (CM) had significantly higher K, Mg, and Fe contents than CT beverage, while the control had significantly higher Ca and P contents than CM beverage. It is well known that milk and dairy products have high Ca and P contents (Miller et al., 2000). The richness of chufa tubers with K, Mg and Fe (Ogunlade et al., 2015) was responsible for such increase in CM beverages. It has been reported that dried tiger nut tubers contained 4.25, 0.37 and 0.08 g/kg K, Ca and Fe, respectively (Sobhy et al., 2022). Ogunlade et al. (2015) reported that the Na-K ratio in tiger nut was less than 1, indicating its suitability in the formulation of diets for patients suffering from hypertension disease.

Table 2. Minerals content (mg/100g) of control and chufa milk beverages

Products*	Na	K	Ca	Mg	P	Fe
CT	44.21±4.02^{a}	145.86±4.18^{e}	156.91±2.79^{a}	24.48±1.83^{b}	108.29±1.72^{b}	0.74±0.23^{d}
CM	36.88±2.86^{a}	227.86±4.67^{c}	8.58±0.47^{d}	30.48±0.55^{a}	88.62±3.92^{c}	2.12±0.23^{c}
CO	17.30±1.30^{c}	195.20±4.90^{d}	25.30±2.30^{b}	18.80±1.30^{c}	45.10±4.80^{e}	0.80±0.10^{d}
CS	24.69±1.87^{b}	208.34±5.16^{d}	12.90±2.04^{cd}	24.42±2.34^{b}	65.76±4.71^{d}	1.11±0.10^{d}
CC	37.22±1.88^{a}	282.83±5.03^{a}	15.89±1.20^{c}	32.17±1.99^{a}	91.01±2.51^{c}	3.13±0.10^{a}
CF	37.59±1.16^{a}	242.86±4.58^{b}	8.94±0.22^{d}	32.51±1.85^{a}	119.36±1.11^{a}	2.37±0.20^{bc}
CN	27.41±1.19^{b}	179.49±1.81^{f}	9.42±0.37^{d}	27.53±1.66^{ab}	73.51±3.03^{d}	2.72±0.09^{ab}

*Refer to Table (1), materials and methods for details

Data are Mean ±SE for 3 replicates

Means with different superscripts letters differed significantly (p<0.05).

Compared to chufa milk beverages, CO beverage recorded the lowest Na content. The highest K content was found in CC beverage, while CN beverage showed the lowest K content. Additionally, CO beverage possessed the highest Ca content and the lowest Mg content compared to the flavoured chufa beverages. The highest (p<0.05) P content was found in CF beverage, while CC beverage had higher Fe content than the other beverages. It has been reported that cocoa could be a good source of macro- and microelements such as K, Mg, P and Fe (Barišić et al., 2023).

Sensory properties of the beverages

The results of the sensory evaluation of the control and chufa milk beverages are shown in Table 3. The sensory properties were significantly different among the beverages. The control beverage showed higher (p<0.05) sensory scores than CM beverage. The use of juices and flavour agents significantly improved the sensory attributes of chufa milk. Compared to chufa milk beverages, chufa-cocoa (CC) and chufa-coffee (CF) beverages received the highest (p<0.05) taste and overall acceptability scores, while chufa-orange beverage ranked the lowest taste, aroma and overall acceptability. Cocoa-based drinks have superior sensory characteristics due to their colour, aroma and flavour richness (Barišić et al., 2023). Furthermore, cocoa has been found to improve cardiovascular health, modulate the metabolism of carbohydrates and lipids and improve the secretion of insulin (Ramos et al., 2017).

Conclusions

This study revealed that chufa milk is a promising product due to its nutritional and health value. Chufa milk had higher protein, fat and much lower lactose than buffalo milk. Consequently, this beverage is suitable for persons suffering from lactose intolerance and milk allergy. Chufa milk had higher K, Mg and Fe than buffalo milk. Fortification of chufa milk with whey protein concentrate and utilization of fruit juices or flavour materials improved the nutritional value and sensory properties of chufa milk. Chufa milk made with cocoa or coffee were the most acceptable beverage, while plain chufa milk gained the lowest sensory scores.

Table 3. Sensory evaluation of control and chufa milk beverages.

Products*	Taste (10)	Colour (10)	Mouth feel (10)	Aroma (10)	Overall Acceptability (10)
CT	8.20±0.51^{b}	8.00±0.21^{b}	8.10±0.23^{ab}	7.80±0.25^{de}	8.50±0.37^{bc}
CM	7.00±0.33^{c}	6.30±0.21^{c}	6.60±0.34^{c}	7.20±0.25^{e}	7.10±0.18^{d}
CO	7.90±0.28^{bc}	8.10±0.31^{b}	7.90±0.31^{b}	7.90±0.23^{cd}	8.00±0.21^{c}
CS	8.10±0.28^{b}	8.60±0.22^{ab}	8.30±0.26^{ab}	8.50±0.22^{bc}	8.60±0.22^{bc}
CC	9.20±0.25^{a}	9.20±0.33^{a}	8.80±0.20^{a}	9.80±0.13^{a}	9.60±0.16^{a}
CF	8.80±0.29^{ab}	8.90±0.18^{a}	8.90±0.23^{a}	8.70±0.21^{b}	9.20±0.20^{ab}
CN	8.00±0.21^{b}	7.90±0.23^{b}	8.10±0.27^{ab}	8.90±0.23^{b}	8.50±0.37^{bc}

*Refer to Table (1), materials and methods for details

Data are Mean ±SE for 3 replicates

Means with different superscripts letters differed significantly (p<0.05).

References

AOAC (2000) Official method of analysis, 17th ed. Association of Official Analytical Chemists, Gaithersburg, USA

AOAC (2005) Official method of analysis, 18th ed. Association of Officiating Analytical Chemists, Washington, DC

Barišić V, Icyer N, Akyil S, Toker O, Flanjak I and Aćkar D (2023) Cocoa based beverages – composition, nutritional value, processing, quality problems and new perspectives. Trends Food Sci Technol 132: 65–75. https://doi.org/10.1016/j.tifs.2022.12.011

Barnett, A. and Abd El-Twab, G. (1957) Rapid method for the determination of lactose in milk and cheese. J. Sci. Food Agric. 8:437–441.

Bermejo-Prada, A., Segovia-Bravo, K., Guignon, B. and Otero, L. (2015) Effect of hyperbaric storage at room temperature on pectin methylesterase activity and serum viscosity of strawberry juice. Innov. Food Sci. Emerg. Technol.30:170–176. https://doi.org/10.1016/j.ifset.2015.06.004.

Boscaini, S., Skuse, P., Nilaweera, K., Cryan, J. and Cotter, P. (2023) The 'Whey' to good health: Whey protein and its beneficial effect on metabolism, gut microbiota and mental health. Trends Food Sci. Technol.133:1–14. https://doi.org/10.1016/j.tifs.2022.12.009

Bourne M (2002) Food texture and viscosity: concept and measurement. Second Edition. Academic Press. London.

CFR—Code of Federal Regulations Title 21. [(accessed on 14 November 2021)]; Available online: https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearch.cfm?fr=184.1733.

da Silva L, Velasco J and Fakhouri F (2022) Use of rice on the development of plant-based milk with antioxidant properties: From raw material to residue. LWT - Food Sci. Technol. 173 114271 https://doi.org/10.1016/j.lwt.2022.114271.

El-Khair A (2009) Optimization of a new version of chocolate milk for endurance performance and post-exercise recovery. J. Applied Sci. Res. 5:482–489.

El-Shenawy M, Fouad M, Hassan L, Seleet F and Abd El-Aziz M (2019) A probiotic beverage made from tiger-nut extract and milk permeate. Pak. J. Biol. Sci. 22:180-187. DOI: 10.3923/pjbs.2019.180-187

Finley J and Fellers D (1973) Sucrose determination by a modified anthrone method. application with sweetened wheat-soy blend and corn-soy-milk. Cereal Chem. 50: 210–215.

Ghanimah M (2018) Functional and technological aspects of whey powder and whey protein products. Int. J. Dairy Technol. 71:454-459. https://doi.org/10.1111/1471-0307.12436.

Ghanimah M and Mehanna N (2016) A survey on the composition and some properties of market UHT milk during storage. Egyptian J. Dairy Sci. 44:17-26.

Hernández-Olivas E, Asensio-Grau A, Calvo-Lerma J, García-Hern´andez J, Heredia A and Andr´es A (2022) Content and bioaccessibility of bioactive compounds with potential benefits for macular health in tiger nut products. Food Biosci. 49: 101879 https://doi.org/10.1016/j.fbio.2022.101879.

Jeske S, Zannini E and Arendt E (2017) Evaluation of physicochemial and glycaemic properties of commercial plant-based milk substitutes. Plant Foods Hum Nutr 72:26-33. DOI 10.1007/s11130-016-0583-0.

Liu X, Frederick G, Gmitter JR, Grosser J and Wang Y (2023) Effects of rootstocks on the flavor quality of huanglongbing-affected sweet orange juices using targeted flavoromics strategy. RSC Adv. 13:5590-5599. DOI: 10.1039/D2RA08182B

Madsen M, Thulesen E, Mohammadifar M and Bang-Berthelsen C (2021) Chufa drink: potential in developing a new plant-based fermented dessert. Foods 10: 3010. https://doi.org/10.3390/foods10123010.

Mehra R, Kumar H, Kumar N, Ranvir S et al. (2021) Whey proteins processing and emergent derivatives: An insight perspective from constituents, bioactivities,

functionalities to therapeutic applications. J. Functional Foods 87:104760. https://doi.org/10.1016/j.jff.2021.104760.

Miller G, Jarvis J and Mcbean L (2000) Handbook of dairy foods and nutrition. Second Edition. CRC Press LLC. Boca Raton.

Moss R, Barker S, Falkeisen A, Gorman M, Knowles S and McSweeney M (2022) An investigation into consumer perception and attitudes towards plant-based alternatives to milk. Food Res. Int. 59:111648. https://doi.org/10.1016/j.foodres.2022.111648.

Nelson J and Trout G (1981) Judging of dairy products, 4th ed.; INC Westport; Academic Press: Cambridge, MA, USA, p. 345–567.

Nongonierma A, Springett J, Quere Le, Cayot P and Voilley A (2006) Flavour release at gas/matrix interfaces of stirred yoghurt models. Int. Dairy J. 16:102–110. https://doi.org/10.1016/j.idairyj.2005.01.010.

Nwosu L, Edo G and Özgör E (2022) The phytochemical, proximate, pharmacological, GC-MS analysis of Cyperus esculentus (Tiger nut): a fully validated approach in health, food and nutrition. Food Biosci. 46: 101551. https://doi.org/10.1016/j.fbio.2022.101551.

Ogunlade I, Bilikis A and Olanrewaju A (2015) Chemical compositions, antioxidant capacity of tigernut (Cyperus esculentus) and potential health benefits. Eur. Scie. J. 11:217–224.

Ramos S, Martin M and Goya L (2017) Effects of cocoa antioxidants in type 2 diabetes mellitus. Antioxidants 6:84. https://doi.org/10.3390/antiox6040084.

Rios M, Tinitana F, JarrínV, Donoso N and Romero-Benavides J(2017) "Horchata" drink in Southern Ecuador: medicinal plants and people's wellbeing. J. Ethnobiol. Ethnomed. 13:18. https://doi.org/10.1186/s13002-017-0145-z.

Samuel S, Animashaun O, Omolola O Adekanmi O and Emmanue F (2023) Process optimization of extrusion process variables for improving the quality and extrudate characteristics of wheat-tiger nut pasta. Applied Food Res. https://doi.org/10.1016/j.afres.2023.100333.

Sanful R (2009) Production and sensory evaluation of tiger nut beverages. Pak. J. Nut. 8:688–690.

Sobhy H, El-Nawawy M, Hegazi N, El-Dieb S, Abd El-Razik F and Elkashef H (2022) Tiger nut tuber milk: using dairy byproducts and probiotic bacteria. Acta Sci. Pol. Technol. Aliment. 21:271–280. https://doi.org/10.17306/J.AFS.2022.1008

Temiz H, Tarakcı Z, Yarilgac T and Dağ B (2018) Some physicochemical properties and mineral contents of stirred yoghurts containing different fruit marmalades. Int. J. Dairy Technol. 71:264–268. https://doi.org/10.1111/1471-0307.12420.

Wagner K, Derkits S, Herr M, Schuh W and Elmadfa I(2002) Antioxidative potential of melanoidins isolated from a roasted glucose–glycine model. Food Chemistry 78:375–382. https://doi.org/10.1016/S0308-8146(02)00200-5.

Wang H, Wang C and Guo M (2019) Effects of addition of strawberry juice pre- or postfermentation on physiochemical and sensory properties of fermented goat milk. J. Dairy Sci. 102:4978-4988. https://doi.org/10.3168/jds.2018-15750

Yu Y, Lu X, Zhang T, Zhao C, Guan S, Pu Y et al. (2022) Tiger nut (*Cyperus esculentus* L.): nutrition, processing, function and applications. Foods 11: 601. https://doi.org/10.3390/foods11040601.

Zommara M and Imaizumi K (2017a) In vitro antioxidative activity of chufa tubers (Cyperus esculentus L.) extracts in liposome peroxidation system. J. Sus. Agric. Sci. 43:69-76.

Zommara M and Imaizumi K (2017b) Antiatherogenic effect of Tiger nut tubers (Cyperus esculentus L.) supplemented diet in apolipoprotein E knockout mice. J. Sus. Agric. Sci. 43:197-204.

مشروب حب العزيز: تطوير مشروبات نباتية جديدة بنكهات مختلفة

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حب العزيز (chufa) له فوائد صحية وغذائية معروفة. تهدف هذه الدراسة إلى إنتاج مشروبات لبن حب العزيز مبتكرة مع عصائر الفاكهة أو مواد نكهة أخرى مدعمة بمركز بروتين شرش اللبن (WPC). تم تحضير ست مشروبات من لبن الحب العزيز على النحو التالي: لبن الحب العزيز السادة (CM)، لبن الحب العزيز المدعم بعصير البرتقال (CO) أو عصير الفراولة (CS)، لبن الحب العزيز بنكهة الكاكاو (CC)، القهوة الفورية (CF) أو مستخلص القرفة (CN)، بالإضافة إلى لبن جاموسي مدعم بـ WPC، والذي اعتبر عينه المقارنة (CT). أظهرت النتائج أن مشروب CM احتوى على نسبه أعلى من الدهن والبروتين والسكروز وقيمه لزوجه ظاهريه أعلى من مشروب المقارنة، في حين أن مشروب المقارنة احتوي على نسبه أعلى من الرماد واللاكتوز وقيمة الأس الهيدروجيني من مشروبات لبن حب العزيز. تميز مشروب CC بأعلى نسبه من الدهن. علاوة على ذلك، تميزت مشروبات CC وCF باحتوائها على نسبة بروتين أعلى من مشروبات لبن الحب العزيز الأخرى، كما تميز مشروب CS بقيمه لزوجة ظاهريه عالية مقارنه ببقيه المشروبات. أظهر محتوى المعادن اختلافات معنويه ($p<0.05$) بين مشروبات لبن الحب العزيز ومشروب المقارنة. احتوي مشروب المقارنة على نسبة اعلى من الكالسيوم مقارنة بمشروبات لبن الحب العزيز، بينما احتوي مشروب CC على نسبه K وFe أعلى من مشروب المقارنة (CT) ومشروبات لبن حب العزيز الأخرى. وجد ان اعلى نسبه من Na وMg كانت في مشروبات CF وCC، بينما احتوى CF على أعلى محتوى من P من المشروبات الأخرى. تميزت مشروبات لبن الحب العزيز بنكهة الكاكاو والقهوة بأفضل درجات تقييم حسي مقارنه ببقيه المشروبات، في حين اكتسب CM أقل درجات تقييم حسي.