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EVALUATION OF NOVEL PLANT-BASED MILK PRODUCED FROM MELON KERNEL

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ABSTRACT

In this study, the possible use of melon kernel (*Cucumis melo* L.) as a source for the production of a daily milk alternative was evaluated. For this purpose, the study evaluated the proximate composition, physicochemical properties, and sensory properties of the milk from the kultik kernel. Overall, proximate composition consists of %88.84 moisture, %1.08 ash, %0.96 protein, %5.50 fat, and %3.63 carbohydrate content. The low protein content of the milk limits its usage as an ingredient in the production of fermented dairy products. Physicochemical properties showed that kultik kernel milk is rich in nutritional value. The rheological behaviour of the milk was non-Newtonian with a pseudoplastic character. Similar flow characteristics to dairy milk enable the milk sample to be produced in existing equipment and processes, allowing large-scale industrial production. In addition, the sensory scores of the milk sample showed that new formulas for the milk sample should be developed in further studies.

Keywords: Kultik, kernel, dairy, milk, alternative.

KAVUN ÇEKİRDEĞİNDEN ÜRETİLEN YENİ BİTKİSEL SÜTÜN DEĞERLENDİRİLMESİ

ÖZET

Bu çalışmada kavun çekirdeğinin (*Cucumis melo* L.) günlük süt üretiminde alternatif kaynak olarak kullanım imkanı değerlendirilmiştir. Bu amaçla çalışmada kultik çekirdeğinden elde edilen sütün bileşimi, fizikokimyasal özellikleri ve duyusal özellikleri değerlendirilmiştir. Genel olarak, bileşiminin %88.84 nem, %1.08 kül, %0.96 protein, %5.50 yağ ve %3.63 karbonhidrat olduğu belirlenmiştir. Düşük protein içeriği, alternatif süt ürününün fermente ürünlerin üretiminde kullanım imkanlarını sınırlandırmaktadır. Ancak fizikokimyasal içeriği incelendiğinde sütün besin içeriğinin yüksek olduğu belirlenmiştir. Sütün reolojik davranışı Newtonyen olmayan ve psödoplastik karakter göstermiştir. İnek sütüne benzer akışkanlık özellikleri göstermesinden dolayı kavun çekirdeği sütünün mevcut ekipman ve proseslerde büyük ölçekli olarak üretiminin uygun olduğu bulunmuştur. Ayrıca duyusal analiz sonuçları süt örneğinin ileriki çalışmalarda yeni formülasyon denemeleri yapılarak geliştirilmesi gerektiğini göstermiştir.

Anahtar Kelimeler: Kultik, çekirdek, süt ürünleri, süt, alternatif.

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1. Introduction

Awareness of a healthy diet has changed consumers' preferences. Food products that are rich in bioactive compounds are more widely preferred to consume [1]. Vegetative foods have a high amount of nutritional value. Thus, costumer who have a disability and cannot consume lactose prefer to use vegetarian foods. It leads a vegan food market size to increase year by year [2, 5]. The development of non-dairy functional food products, that are prepared by adding/ replacing/ fortifying with fruits, cereals, and vegetables, offers opportunities for manufacturers who tend to invest in vegan food market for alternative food products, such as meat substitutes, egg-like foods, plant-based milks, etc. The fastest-sprawling vegan food product on the market is plant-based milks [3, 22, 29].

Plant-based milks are produced by the extraction of plant sources from water. Soy milk is the most preferred plant-based milk product in the world. To date, various plant sources, including hazelnut, peanut, almond, soy, rice, etc., have been used in the production [2]. The production process consists of various stages. These are soaking, grinding, separation, hydrolysis, blanching, thermal processing, homogenization, and formulation [4, 12]. The main advances of plant-based milks over dairy milk are lactose- and cholesterol-free. In addition to these advantages, plant-based milks are rich in bioactive components, including minerals, phenolic substances, and fatty acids. The biggest disadvantages of plant-based milk over dairy milk are the low content of protein, vitamins, and minerals, and bad sensory perception [5, 11]. Therefore, even though plant-based milks can be produced from different plant sources, further studies are required to develop the possible usage of plant-based milks as an alternative to dairy milk.

The nutritional qualities of plant-based milks show differences depending on the plant source, ingredients, and processing method [5]. Even though plant-based milks have some disadvantages, they can be overcome in the change of ingredients and processing. The formulation that has been reported in previous studies includes a combination of different ingredients, including the milks from different plant sources [5, 20, 29] and a mixture of plant-based milks with different foodstuffs such as chocolate and flavor agents [8]. In this study, it was aimed to evaluate the proximate composition and physicochemical properties of a novel plant-based milk from kultik kernel and to evaluate the kernel as an alternative ingredient to dairy milk for those who have disability to consume dairy milk, and to show its capacity to produce functional food products. For this purpose, the proximate composition (ash, oil, protein, moisture, and carbohydrate contents), physicochemical properties (whiteness index, DPPH antioxidant activity, total phenolic content, and apparent viscosity), and sensory properties (color, appearance, taste, and acceptability) of the sample were identified.

2. Materials and Methods

2.1. Materials

2.1.1. Sample Preparation:

Sample preparation was performed according to the study of Alozie and Udofia [3]. Kultik kernels that were harvested in 2023, were sorted to remove the spoilt and foreign materials. They were washed, and then dried for four days at 25^0C in the dark. One kilogram of the kernel was soaked in deionized water for six hours at 1:3 (w/v) kernel to water ratio; thereafter, the mess was milled in a kitchen blender (Fisher Scientific, Model 8010 ES) using maximum speed for five minutes. The resultant slurry was strained through a filter paper (Whatman, Cat no 1004; diameter 110; pore size 20-25 μ). The vegetable milk sample, kultik kernel milk, was homogenized and pasteurized at 60^0C for fifteen minutes. The milk extract was bottled in sterilized screw capped glass bottle and stored at 4^0C.

2.2. Psychochemical Properties Analysis:

The psychochemical properties; that include ash, moisture, fat, brix and titratable acidity; of plant-based milk sample were evaluated using standard methods described in the study of Kookal and Thimmaiah [19]. The protein content of the sample was derived from nitrogen content. To calculate true protein content, no specific nitrogen conversion factor was found; thus, the standard conversion factor of 6.25 was used. The color was measured with a colorimeter, and the results were expressed as the chromatic space L, a, and b values as defined by the International Commission on Lighting (CIE) in 1976. L value represents the color's clarity; a value is for the sample location between red and green, while b value is for the location between yellow and blue [13]. The whiteness index was calculated using the following formula:

$$\text{WI} = 100 - \sqrt{[(100 - L)^2 + a^2 + b^2]}$$

2.3. Total Phenolic Content (TPC):

The TPC of the sample was determined according to the study of Ertan et al. [25]. Folin-Ciocalteu reagent (Merck, Germany) was mixed with water (1:10) to prepare folin- ciocalteu solution (FC solution). The FC solution was added to 1 mL of standard or sample diluted at a suitable rate, and then the mixture was incubated for 3 minutes. 4 mL of sodium carbonate solution (7.5%; Sigma, USA) were added into the mix. After incubation for 2 hours at room temperature in dark, the absorbance values of the samples were measured at a wavelength of 760 nm against distilled water using UV-Vis spectroscopy (Shimadzu, UV-1800). To draw a calibration chart, gallic acid was prepared with different concentrations, resulting in a calibration curve of $y=0.0046x+0.1256$, $R^2>0.99$. The phenolic content of

the samples calculated according to the chart and expressed as mg gallic acid equivalent (GAE) per L of melon milk sample.

2.4. Antioxidant activity

DPPH antioxidant activity was measured for a milk sample according to the method described by Zhu et al. [26]. 0.1 mL, diluted at a suitable rate using methanol, of the sample was mixed with 3.9 mL of DPPH solution ($4x10^{-3}$g of DPPH in 50 mL methanol). The mixture waited in the dark for 30 min. The absorbance values of the samples were measured at a wavelength of 517 nm. The standard curve of trolox was conducted with various concentrations, resulting in the calibration curve of $y=0.0042x+0.0146$ ($R^2>0.99$).

2.5. Apparent viscosity assay

The viscosity of melon milk sample was determined using Anton Paar MCR 301 (Anton Paar Gmbh, Graz, Austria) at 25 ^{0}C (298.15 K) at a storage time of 1 day. The apparent viscosity of the sample was measured according to Ibrahim et al. [27]. The parallel cone (PP 25) was equipped. The gap was set to 0.3 mm. A controlled ramped share rate was performed to determine the rheological properties of the samples. The share rate steadily increased from 0 to 100 s^{-1} in 10 min. The average of all the measured data was accepted as the viscosity. All rheological data were collected and calculated by Anton Paar Labor- software version. All rheological measurements were performed in triplicate.

2.6. Sensory evaluation

Twenty semi-trained panelists joined the sensory evaluation of a vegetative milk sample from kultik kernel. The panelists include 10 women and 10 men, aged between 20 and 35, and they are students or staff of Munzur University. After 1 day of production, the kernel milk waited in the refrigerator, and the sample was presented to panelists for evaluation [28]. The ratings were displayed on a 9- point hedonic ranking scale with the following score expressions: 1 = highly dislike, 2 = dislike very much, 3 = rather dislike, 4 = dislike a little, 5 = neither like nor dislike, 6 = quite like, 7 = rather like, 8 = like a lot, and 9 = like very much [28]. The parameters utilized in the sensory evaluation were appearance, texture, taste quality, and overall acceptance. The values gained from the panelists were assessed from the averages scores of the panelist's values in duplicate for each sample. Randomized three-digit numbers (for example, 101, 205) were assigned to each sample of about 25 mL. All samples were served at 4^0C.

2.7. Statistical analysis

SPSS 29 was used to evaluate the results. The results displayed in the tables were the mean value of triplicate measurements according to a randomized block design. In addition, the mean value for each sensory attribute was calculated from twenty judgments.

3. Results and Discussions

3.1. Proximate composition of Kultik kernel milk

There is a need to find a solution particularly for people suffering from specific clinical conditions, including allergies or intolerances to cow's milk proteins and carbohydrates. Plant-based milks are accepted as a good alternative to dairy milk and are often sold close to dairy milks in stores. They are deemed healthier and more sustainable products than dairy milk [18, 29]. The result of this study gives information as to the milk produced from kultik kernel, which is considered food waste but is rich in nutritional content.

Table 1. Proximate composition of kultik kernel milk.

Proximate Composition	Kultik Kernel Milk
Moisture Content, %	88.84 ± 0.05
Ash Content, %	1.08 ± 0.03
Protein Content, %	0.96 ± 0.03
Crude Fat, %	5.50 ± 0.11
Carbohydrate, %	3.63 ± 0.20

Mean value ± standard error (n=3). Results are mean values of triplicate measurements.

The proximate composition of the milk sample is displayed in Table 1. The concentration of proximate composition in plant-based milks is influenced by moisture content. The moisture level obtained for the sample milk was similar to values stated for soymilk (88.12%), almond milk (86.11%) [3], and milk of melon seed harvested in Ibadan, Nigeria (88.0%) [23]. However, lower moisture content was reported in the studies, that used a 1:6 ratio (w/v) in production, for the plant-based milks from cashew nut (82.66%) [7] and tiger nut (79.29%) [1]. The ratio of water to plant sources can affect the moisture content of plant-based milks [23]. The ash value indicates the level of mineral content in foodstuffs [7]. Even though the ash content of kultik kernel milk was lower than values reported for Nigerian melon seed milk (1.62%) [23] and almond milk (3.04%) [3], but it was higher than values reported for soymilk (0.84%), coconut milk (0.71%) [21], cashew nut milk (0.90%) [7], and dairy milk (0.70%) [3, 7, 21, 23]. Thus, the higher ash content of kultik kernel milk in comparison to dairy milk shows the milk sample as a good alternative to cow milk. The protein content of the milk sample was

higher than the protein contents of the milks from other plant sources, including almond, cashew, oat, sunflower seed, pumpkin seed, and coconut [5, 12], but it was lower than that of other melon seed varieties [23]. Thus, kultik kernel milk, as an alternative to dairy milk, is more suitable than other plant-based milks for the production of fermented dairy products. Fat is the major energy source in foods. The amount of fat in kultik kernel milk (5.50%) was higher than the minimum requirement level for plant-based milks by Codex Alimentarius [3]. It is also higher than the oil content of other plant-based milks, including soymilk (3.20%), almond milk (3.40%) [3], Nigerian melon seed milk (3.09%) [23], coconut milk (3.3%), and oat milk (2.1%) [12]. The milk sample is sufficient as an energy source and thus can produce a protein sparing effect [23].

3.2. Physicochemical properties of Kultik kernel milk

The physicochemical properties of the milk sample are shown in Table 2. Total titratable acidity (T.T.A.) of the milk was 0.14%, which is higher than T.T.A. values of milks produced from other plant sources (cashew nut milk and soy milk) having lower pH value [7, 20] while it is lower than T.T.A values of milks produced from soy and tiger nut having higher pH value [10, 24]. The inverse relationship between pH value and T.T.A in milk and milk products is related to glucose concentration, which increases proton (H^+) concentration while lowering lactic acid production [9]. An acidic pH has an effect on susceptibility at ambient temperature. Susceptibility is the matter in stabilizing dairy products throughout pasteurization and storage at convenient conditions [7]. A high acidic pH of kultik kernel milk (5.65) indicates that the milk sample is suitable for immediate consumption. The shelf life can be extended by the addition of sugar or flavour that decreases the acidity of milk products [7, 8]. Thus, a further study is needed to investigate the effect of the additions on extending the shelf life of kultik kernel milk.

Dairy milk contains natural sugar such as lactose and glucose. It makes difficult especially for those having lactose-intolerance. Those people can consume plant-based milks that have no glucose content [2, 29]. The total sugar contents of plant-based milks vary according to many factors, including the type of plant source, extraction conditions, and the ratio of water to plant material [9]. The total sugar content of the milk sample was an average of 2.23 ^{o}Brix. It is lower than the total sugar contents of other plant-based milks, including cashew nut (3.00 ^{o}Brix) [7], tiger nut (5.10 ^{o}Brix) [4], soy (18.70 ^{o}Brix), and coconut (3.10 ^{o}Brix) [20, 24]. Even though low sugar content is preferred for health, it leads to lower sensory scores and overall acceptance [7].

The colorimetric properties of the milk sample were expressed as a function of the Whitening Index (WI), which is determined by calculating the chromatic space L, a, and b values. Every plant-based milk has a unique WI value [13]. WI values of plant-based milks show diversity according to the

plant source, and the WI value of the kultik kernel milk sample was 22.75, being lower than the WI value of hemp's milk (34.97); but being higher than almond's milk (21.46) and oat's milk (9.48) [13].

Plant-based milks have unique antioxidant and phenolic contents that are mainly related to plant sources [13]. Total phenolic content in the sample was 7.85 mg GAE/L, which is higher than TPC in almond, soy, oat, and quinoa milks [11, 13, 18]. The DPPH antioxidant activity in the sample was also higher than that of other plant-based milks, including hazelnut and pumpkin seed [5]. However, TPC and DPPH of the sample were lower than cow's milk [17]. Therefore, kultik kernel milk can be assessed as a fortified beverage milk alternative to dairy milk on the market.

Table 2. Physicochemical properties of kultik kernel milk.

Physicochemical Properties	Kultik Kernel Milk
Sugar (^{0}Brix)	2.23 ± 0.05
pH	5.65 ± 0.03
Titratable as % of lactic acid	0.14 ± 0.02
Viscosity (cP)	11.82 ± 0.72
TPC (mg GAE L^{-1})	7.85 ± 0.72
DPPH (mg Trolox L^{-1})	1.1 ± 0.03
L	22.79 ± 0.72
a	-0.14 ± 0.07
b	2.45 ± 0.26
WI	22.75 ± 0.73

Mean value ± standard error (n=3). Results are mean values of triplicate measurements.

Apparent viscosity is an important parameter in assessing plant-based milks. The lower the viscosity of a fluid, the lower the heat loss throughout the flow, reducing the costs of power and the production process [15]. The apparent viscosity of kultik kernel milk is lower than that of oat milk, rice milk, and cow's milk [6, 14, 16], indicating the production of the milk can be made at a lower price among plant-based milk varieties. The viscosity of plant-based milks mainly depends on the amount of water used throughout the extraction process [3]. Moreover, the character, similar to that of dairy milk, enables the application of production for the milk sample in existing equipment and processes, allowing large-scale production of the sample in the market [7]. There was a non-linear relationship between the share rate and the share stress, and as the share rate increased, the apparent viscosity of the sample decreased, demonstrating the rheological behavior of non-Newtonian fluids with pseudoplastic character. This result confirms the findings of previous studies that reported the same behavior for other plant-based milks, including Brazil nut, Macadamia, and Bengal rice [14, 15].

There is a need to find a solution, particularly for people suffering from specific clinical conditions, including allergies or intolerances to cow's milk proteins and carbohydrates. Plant-based milks are accepted as a good alternative to dairy milk and are often sold close to dairy milks in stores. They are deemed healthier and more sustainable products than dairy milk [18]. The result of this study gives information as to the milk produced from kultik kernel, which is considered food waste and has caused serious environmental problems.

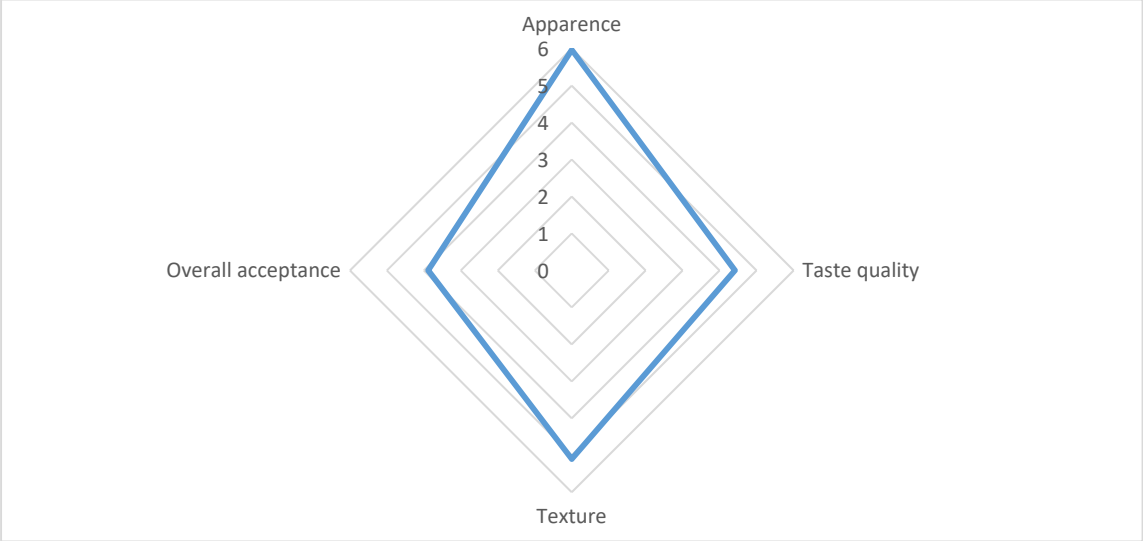

Figure 1. Sensory evaluation of kultik kernel milk.

3.3. Sensory evaluation

The sensory evaluation of the milk sample is demonstrated in Figure 1. The highest score among sensory attributes was appearance, which was 5.97±0.53. The taste quality and texture of the sample were 4.41±1.16 and 5.1±1.01 respectively. Overall acceptance was quite low (3.88±0.80). The addition of sugar and flavour can enhance the sensory characteristics of plant-based milks [7].

4. Conclusion

This study proves that kultik kernel milk is rich in nutritional content and has sufficient proximate content and physicochemical properties that partially make the milk possible as an alternative to dairy milk. Proximate composition showed the milk sample may not be suitable for production of fermented dairy products due to its low protein content. The flow character of the milk was the same as that of dairy milk, providing an opportunity to use current equipment and processes in large-scale production for the vegetative market. All in all, the result, which has yet to have a place on the market

with a local production, can attract the attention of manufacturers who want a position in the vegan food market. It is therefore suggested that the milk from Kultik kernel was encouraged to decrease the cost of dairy milk, especially in rural areas, and to enable those suffering from lactose-intolerance problems to receive the necessary nutrition for their lives.

Declarations

Ethical Approval Not applicable

Competing interests The author declare no competing interests.

Authors' contributions Not applicable

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Availability of data and materials Data will be made available on reasonable request.

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