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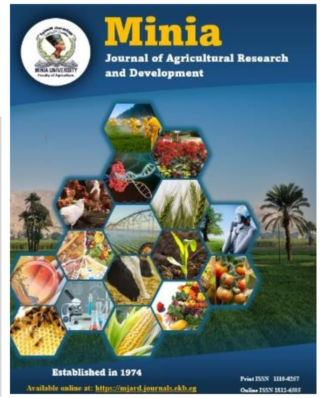

Evaluation of Chemical Composition, Digestibility, Antioxidant Activity, and Sensory Characteristics of Soft Cheese Made with Kidney Bean Milk

Mahmoud H. Abdel Kareem, Ali Metwalli, Salma M. Galal and Raghda M.S. Moawad*

Dairy Science Department, Faculty of Agriculture, Minia University, Minia 61519, Egypt

ABSTRACT

This work aimed to produce soft cheese using different ratios of *Phaseolus vulgaris* kidney bean milk (KBM) and cow milk and evaluating their Chemical, in-vitro digestibility, antioxidant, and organoleptic characteristics.

Cheeses were prepared using cow milk with varying levels of KBM (T1 control, T2 5%, T3 10%, T4 15%, T5 20%, T6 30%, T7 40% and T8 50%). The preliminary sensory evaluation excluded treatments from T6 to T8, Then the selected treatment was analyzed for physicochemical properties, digestibility, and antioxidant properties; sensory evaluation was also conducted.

The addition of KBM resulted in a significant increase in cheese acidity, and protein, antioxidant scavenging capacity while fat, water holding capacity and cheese yield were decreased. Among the tested samples, T5 exhibited the highest antioxidant properties. However, increasing the kidney bean milk levels (KBM) was linked to a decrease in consumer acceptability.

In conclusion, processing soft cheese by substituting 10% KBM was the most acceptable treatment and achieved satisfactory results in chemical, digestibility, and antioxidant properties, which introduced an innovative soft cheese that includes a plant origin that may be probable for vegetarian consumers. While a 10% kidney bean milk substitution may not be sufficient for complete lactose intolerance management, cheese typically contains low lactose levels and is unlikely to trigger lactose intolerance.

Keywords: : kidney bean milk, soft cheese, sensory evaluation, plant-origin milk

INTRODUCTION

Introducing novel products to processing becomes a necessity, milk replacers occupy a great position due to their low cost and the increasing health and nutrition awareness of the consumer., especially those who follow a particular lifestyle like vegetarianism, flexitarianism, and veganism(Shah *et al.*, 2014). Plant-based or cell-based substitutes are rapidly expanding because more consumers are deciding to cut back on or

* **Corresponding author: Raghda M.S. Moawad**
E-mail address: raghda.moawad@mu.edu.eg

give dairy products and meat for health reasons, environmental sustainability, and/or ethical aspects(Mefleh *et al*., 2022).

Kidney bean is a leguminous vine plant grown worldwide for its edible dry seed (Campos-Vega *et al*., 2013). It is an important participant in protein, carbohydrates, vitamins, and minerals in human nutrition(Rehman *et al*., 2001), especially among those who have low income. kidney beans also contain phytochemicals such as flavonoids, tannins, phytates and total phenols *(Laparra et al*., 2009). These components have recently more conscious of their capability to inhibit ageing disorders (Campos-Vega *et al*., 2013). *Phaseolus vulgaris L.* is rich in alpha-amylase inhibitors and has been used for reducing glycemia and calorie absorption by preventing or delaying the digestion of complex carbohydrates (Wang *et al*., 2020). On the opposite side, the nutritionally deprived, are disadvantaged forming complexes with metal ions thus inhibiting mineral absorption (Laparra *et al*., 2009). Tannins and phenolic substances also form complexes with carbohydrates and protein under certain conditions of concentration and pH (Akillioglu & Karakaya, 2010), and thus decrease starch and protein digestibility(Nosworthy *et al*., 2018). As a result, they are often considered as anti-nutrients. To inhibit these antinutrients cooking method for kidney beans includes boiling for 1 to 3 h based on the variety, size and age of the beans(Nakitto *et al*., 2015). However, due to the hard-to-cook phenomenon, the long cooking hours involve high energy consumption. Traditional processing methods such as soaking and de-hulling followed by thermal treatment can be used to reduce the cooking time and potentially eliminate most of the undesirable attributes (Nakitto *et al*., 2015). Moreover, legume-based milk is gaining in popularity as an alternative to bovine milk, mainly because consumers consider it to be cholesterol-free, low in fat, and have bioactive peptides with antioxidant and health-promoting properties(Sethi *et al*., 2016). kidney beans have antimicrobial, antioxidant and anti-inflammatory activities (Pina-Pérez & Ferrús Pérez, 2018). Moreover, a high intake of legumes is correlated with a low risk of metabolic syndrome (Trinidad *et al*., 2010).

Kidney bean milk had 1.92–2.32% protein, it had (25.66–27.78%) α-linolenic acid and 18.95–23.08% palmitic acid(Aydar *et al.*, 2023). However, Meghrabi & Yamani, (2023) reported that white kidney beans milk contains 12.19 % total solids, 3.71% protein, 0.79 % fat, 6.41% carbohydrate 1.19 % ash, 0.8-% fiber, and 87.78-% for moisture, respectively, and 6.64 and 0.21 % for pH and acidity. Many attempts involved kidney bean milk or kidney bean derivates in the dairy industry, *Sarker et al*., (2020) informed that Protein isolates from dark red beans (*Phaseolus vulgaris*, L)., inhibits the growth of oxidizing substances in yoghurt at an application rate of 3 gm/L during storage at room temperature for 72 hrs. Chaturvedi & Chakraborty, (2022) studied the effect of extraction conditions of legume-based synbiotic beverages from kidney beans (*Phaseolus vulgaris L.)* and mung beans (*Vigna radiata L.*) using response surface methodology (RSM). The variables considered were $NaHCO_3$ concentration, time, and temperature. The optimized condition for red kidney bean beverage (RKB) suggested that employing extraction at 89˚C for 12.3 min using 0.01% $NaHCO_3$ would lead to the maximum prebiotic content, beverage yield, and total phenol content along with reduced antinutrients. After the fermentation with probiotic bacteria, *Lactobacillus casei*, the antinutrients in RKB, i.e., phytate, tannin, and saponin, were reduced by 29%, 58%, and 28%. Fermentation process by *Aspergillus oryzae*, *Pleurotus ostreatus* and *Rhizopus oligosporus* for seed flour Kidney beans (*Phaselous vulgaris*) Black beans (*Phaselous vulgaris*) resulted in protein, dietary fiber in kidney beans, low lipids, dietary fiber in black beans, elevation in essential amino acids (EAA) , free amino acids (FAA) , total phenolic contents (TPC), isoflavones, mineral content, protein digestibility, mineral bioavailability, acyl coenzyme A oxidase (AoxA) , water holding capacity (WHC), emulsifying properties, reduction in bulk density and tannins(Garrido-Galand *et al*., 2021).

The great demand for more healthy dairy products is increasing more and more, traditional soft cheese was manufactured by salting before adding rennet, and integrating kidney bean milk in soft cheese manufacturing as a milk replacer may introduce a solution to the shortage of milk production, reduce the amount of lactose in the resultant product, fortification cow milk with a vegetable source enhance nutritional value thus may be considered an innovative type of soft cheese and might be categorized as functional dairy products, thereby the extent of work aimed to process innovative soft cheese by integrating a non-dairy base (kidney bean milk) and investigating the chemical, antioxidant and organoleptic characteristics of fresh soft cheese produced from different ratios of common bean.

MATERIAL AND METHODS:

A fresh cow was obtained from a local farm in Minia governorate. Kidney bean (*Phaseolus vulgaris L.)* was purchased from a local market in Beni Sueif governorate.

Preparation of kidney bean milk (KBM)

KBM was prepared as follows, Kidney bean seeds were cleaned by removing dirt and damaged seeds, and the clean seeds were soaked overnight in distilled water in ratio 1:10 at ambient temperature. The soaked kidney bean seeds were drained, rinsed in distilled water, dehulled by hand and grounded in a blender for 3 min at 550W with water. The water was added to make common bean slurry in a ratio of 1:10 on a weight basis. After blinding the resultant was filtered by cheesecloth, the insoluble matter was discarded, and the soluble matter called bean milk was collected. Kidney bean milk was heated at 80°C for 10 min and cooled at 4 °C (Anino *et al*., 2019) with some modifications (water was not boiled it was at room temperature, and the heat treatment that was conducted was only at 80°C for 10 min instead of 100 °C for 20 min).

Manufacturing of Cheese:

The cheese was prepared as follows: cow milk was pasteurized at 72°C for 15 sec, cooled at 4 °C, after that, it was heated to 37°C to add rennet, while Kidney bean milk was heated at 80°C for 10 min and cooled at 4 °C. Treatments were designed as mixing ratios of cow and common bean, as indicated:

T1: 0 beans milk + 100% cow milk (control)

T2: 5% kidney bean milk+95% cow milk

T3: 10% kidney bean milk+90% cow milk

T4: 15% kidney bean milk+85% cow milk

T5: 20% kidney bean milk+80% cow milk

T6: 30% kidney bean milk+70% cow milk

T7: 40% kidney bean milk+60% cow milk

T8: 50% kidney bean milk+50% cow milk

All cheese samples were adjusted to a pH degree that resembles the control (6.61). The rennet was added for all treatments at level 1.5 ml/kg of milk at 37°C after adding 0.02% $CaCl_2$. After complete coagulation, the curd was transferred into metal form for wheying-off for 24 hours. The curds were then salted at 2% and kept in a domestic refrigerator at 7-10°C and analyzed when fresh (Abou-Donia, 2008).

Manufacturing was carried out at the laboratory of dairy science department in the Faculty of Agriculture, Minia University.

Sensory evaluation: a preliminary sensory evaluation by staff members at the Department of Dairy Science. Sensory evaluation was conducted to choose the acceptable treatments which were then analyzed for chemical and antioxidant parameters (Pappas *et al*., 1996).

Chemical composition

pH was measured in milk and cheese by using an E 512 type pH meter (Switzer land). Titratable acidity and pH were measured by the method described by (Marshall, 1992). Fat content in milk and cheese was determined using the special Gerber's tubes, ash, TS, SNF, and Specific density were estimated according to AOAC (2016). Total nitrogen (TN) and water-soluble nitrogen (WSN) contents were determined using Kjeldahl & semi-micro Kjeldahl methods as described in AOAC (2016), respectively. Carbohydrates are calculated by equation (SNF- (protein+ ash)

Determination of Water holding capacity:

The susceptibility of the curd to water holding capacity was determined using the method of (Harte *et al*., 2003) with minor modifications. In 50 ml conical plastic tubes (falcon type) 45 g of sample (*Y*) were centrifuged at 3000 g for 20 min at 4° C (using Hraeus Christ GMBH centrifuge, H. Jurgens & Co. Bremen). The clear supernatant (*W*) was poured off, weighed and the water holding capacity (WHC, g100g) was calculated as: WHC = (Y - W)/Y × 100

Salt determination:

Salt was determined according to Simov (1980).

Free Radical Scavenging Activity

The free radical scavenging was determined according to McCune & Johns, (2002). The reaction mixture (3.0 ml) consists of 1.0 ml of DPPH in methanol (0.3 mM), 1.0 ml of the extract and 1.0 ml of methanol. It is incubated for 10 min in dark, and then the absorbance is measured at 517 nm. In this assay, the positive controls can be ascorbic acid. The percentage of inhibition can be calculated using the formula: Inhibition (%) = (A0 – A1 / A0) × 100 Where; A0 is the absorbance of control and A1 is the absorbance of Test samples.

In-Vitro Protein Digestibility (IVPD)

Protein (pepsin) digestibility was determined using the procedure described by Aboubacar *et al*., (2001) and Ayo *et al*., (2007). Flour samples (200mg) were weighed and mixed with 35 ml of porcine pepsin (Sigma –P.700, activity 890 U/ mg of protein, Sigma chemical co. Sl Lousis, Mo) solution (1.5g of pepsin in 0.1M KH2 PH4, PH 2- 0). Samples were digested for 2 h at 370 C in a shaking water bath. Digestion was stopped by the addition of 2 ml of 0.72M TCA. Samples were centrifuged (4, 900xg, 400 C) for 20 min, and the supernatant was discarded. The residues were washed and centrifuged twice with 20ml of buffer (0.l M KH2 P04, PH 7.0). Undigested nitrogen was determined using Kjeldahl method. Digestibility was calculated as % digestibility = (N in sample - Undigested N)/ N in sample x 100.

Statistical analysis: -

Every assessment was performed at least three times. Means and standard errors were calculated. Data were analyzed by one-way ANOVA analysis by CoStat software.

RESULTS AND DISCUSSION:

Preliminary sensory evaluation for cheese samples excluded treatments from T6, T7 and T8 from further experiments due to their low acceptability.

Table (1) indicates the chemical composition of both cow (CM) and kidney bean milk (KBM), total solids were higher in cow milk than in KBM, where SNF was higher in KBM due to the low-fat percentage in its composition, KBM composed more protein concentration than found in CM, whereas a lower ash content was recorded by KBM 0.44. Specific density was slightly higher in KBM. Up till now, there have not been any standard criteria or Codex Alimentarius commission for plant-based milk alternatives that defined nutrients in each type except for a few beverages like an aqueous coconut product (Meghrabi & Yamani, 2023; Shimelis & Rakshit, 2007).

Table (1) Chemical composition of cow and kidney bean milk,

parameter %	Cow milk (CM)	kidney bean milk (KBM)
TS	13.30	12.67
SNF	8.80	12.47
Moisture	86.70	87.33
Acidity	0.14	0.78
pH	6.61	5.21
Fat	4.5	0.2
Protein	3.42	7.65
Carbohydrates	4.74	4.38
Ash	0.61	0.44
Specific density	1.0336	1.0340

A study by Jayamanohar *et al*., (2019) investigated the characteristics of kidney bean milk that emerged from three varieties of kidney bean, they concluded that crude protein in milk from different varieties ranged from 17.7±0.2 to 26.0±1.7%. The protein milk content reported in the current study which was only 7.65% may be related to the variety of *Phaseolus vulgaris L.* and the method of extraction of milk. Aydar *et al*., (2023) reported a lower protein percentage for kidney bean milk extracted from varieties cultivated in Turkey that were 1.92–2.32%. Meghrabi & Yamani, (2023) reported that white kidney beans milk has 12.19 % TS which is approximately like those obtained in the current study 12.67, 3.71% protein, 0.79 % fat, 6.41% carbohydrate 1.19 % ash, 0.8% fiber, and 87.78% for moisture, respectively, and 6.64 and 0.21 % for pH and acidity. Jayamanohar *et al*., (2019) reported that ash content ranged between 1.9 to 2.00, whereas in the current study was 0.44%. In all three varieties, the milk fat content ranged between 3.4 to 4.4 %, this percentages were higher than those reported for the dry seeds in the same study and in our study. That may refer to the heating process conducted by Jayamanohar *et al*., (2019) helps to release fats from plant tissues (Awang, 2016).

Based on our knowledge this is the first trial to process cheese from KBM, although cheese remains a vehicle for those interested in turning to a vegan diet. The plant-based cheese alternatives (PBCAs) industry cannot mimic cheese meltability and elasticity, and most marketable PBCAs have some chalk, paste, and plastic-like texture. Because of the higher molecular weight of plant proteins and different functional properties rather than milk, thus emerged different features in cheese texture. So, producers intend to make spreadable and creamy textures, like ricotta, cottage cheese, and feta, which have strong flavors to mask the beany flavor(Yanni *et al*., 2023). So, the current study depends on the partial substitution of animal-origin milk by plant-based milk in cheese making, we suggested that hypothesis as a proper choice to obtain satisfactory and acceptable characteristics in the produced cheese.

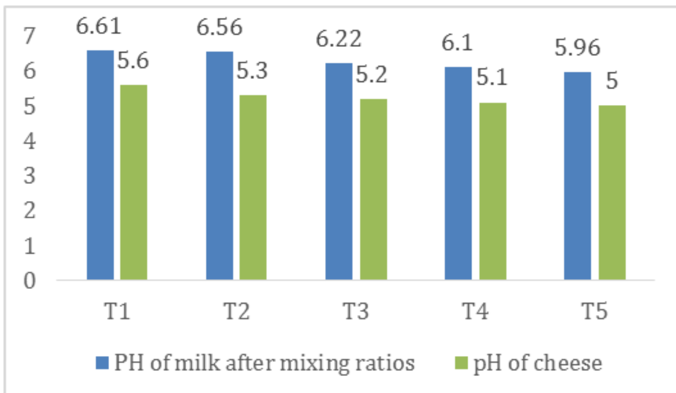

Fig (1) pH changes after addition of different ratios from KBM.

Fig (1) represents changes affected by addition of different ratios from KBM, it was 6.61, 6.56, 622,6.10 and 5.96 as the rate of KBM was 0,5,10,15 and 20% respectively, the addition of KBM caused decreasing in pH values that corresponded with results in Table 1 that indicated pH of KBM was 5.21 versus 6.61 for CM. Meghrabi & Yamani, (2023) reported that white kidney bean milk has a higher PH value of 6.64. Moreover, Chaturvedi & Chakraborty, (2022) reported that red kidney bean beverage had a pH degree of 6.35 ± 0.01 the difference may refer to the selected variety. The same performance was also observed in cheese that was 5.6,5.3, 5.2, 5.1, 5 in the replacement ratio of 0, 5, 10, 15 and 20%, Hussein *et al*., (2016) claimed that pH of 'warankashi' cheese produced from blends of soy and cow milk ranged between 4.21 – 5.10 .

Although higher KBM resulted in a great slope in curd properties as water holding capacity is decreased statically in T2, T3, T4 and T5 compared to control Table (2). Previous studies suggested that moist-heated kidney beans appeared to increase water-holding capacities of 2.54-2.87 g H_2O/g sample and starch/protein digestibility whereas dry-heated ones showed improved flavor profile and increased oil-holding capacities of 1.04-1.14 g oil/g sample (Choe *et al*., 2022). An obvious reduction in cheese yield that was only 14.33±0.33 in T5 compared with 21.00±0.57% in control, T2 and T3 appeared to be very close in concerning yield of cheese however they differ significantly to control group, the reduction may be explained by lower TS and fat in KBM Chaturvedi & Chakraborty, (2022) claimed that the extraction method affected the yield of red kidney bean beverages, ranging from 78 to 90%.

Table (2) Characteristics of cheese manufactured by different ratios of kidney bean milk.

Treatment	Acidity	Water holding capacity	Cheese yield %
T1	0.253±0.1[a]	78.00±2.6 [a]	21.00±0.57 [a]
T2	0.550±0.1[a]	73.00±2.0 [b]	18.57±0.81 [b]
T3	0.550±0.1[a]	58.33±2.08[c]	18.17±0.44 [bc]
T4	0.572±0.1[a]	52.33±2.51[d]	16.30±0.89[cd]
T5	0.583±0.1[b]	50.67±2.08[d]	14.33±0.33[d]

Results are expressed as means ± SD, P ≤ 0.05, different letter in the same column means significant variation. T1: 0% kidney bean milk (control) T2: 5% kidney bean milk T3: 10% kidney bean milk, T4: 15% kidney bean milk and T5: 20% kidney bean milk.

Table (3) Chemical composition of cheese manufactured by different ratios of kidney bean milk.

T	Ts %	Moisture%	Protein%	Fat %	Salt in moisture %	Ash%	Fat/ DM	Protein /DM
T1	42.76±2.307 [a]	57.24±2.307[a]	15.55±0.555[a]	21.25±0.500 [a]	1.92±0.032[a]	3.081±0.082[a]	49.6[a]	36.3[a]
T2	40.44±1.399[b]	59.56±1.399[b]	16.49±1.000[b]	18.00±0.817[b]	1.91±0.051 [a]	3.064±0.132[a]	44.5[b]	40.7 [b]
T3	40.26±0.206[b]	59.74±0.206[b]	16.64±0.405[bc]	17.75±0.960[b]	1.91±0.036 [a]	2.978±0.073[ab]	44.0[b]	41.3 [c]
T4	39.12±0.418[b]	60.88±0.418[b]	17.37±0.115[bc]	16.00±0.817[c]	1.90±0.021 [a]	2.852±0.044[b]	40.8[c]	44.4 [d]
T5	38.49±0.638[b]	61.51±0.638[b]	19.04±0.960[c]	13.75±0.957[d]	1.85±0.047 [a]	2.820±0.131[b]	35.7[d]	49.5 [e]

Results are expressed as means ± SD, P ≤ 0.05, different letter in the same column means significant variation. T1: 0% kidney bean milk (control) T2: 5% kidney bean milk T3: 10% kidney bean milk, T4: 15% kidney bean milk and T5: 20% kidney bean milk.

Results in Table (3) showed that incorporating an extra ratio of KBM attributed to a rise in protein content, it was 15.55±0.555 in control and 16.49±1.000, 16.64±0.405, 17.37±0.115 and19.04±0.960 at 5,10,15 and 20% of substitution, respectively. All treatments increased significantly compared to control. Fat content was decreased significantly at p<0.05 in all treatments by the addition of KBM compared to the control that reflected the low percent of fat in KBM (Table 1) Total solids were slightly decreased by KBM addition up to 10% (T3), however it was significantly decreased at T2, T3, T4 and T5, these are in agreement with results in Table 1 that discussed alleviating TS content in KBM compared with cow milk. There were not any differences at p<0.05 in salt % as it was added at the end of the manufacturing process, ash appeared the same trend observed in salt. A significant decrease in fat/DM and a significant increase in protein /DM made by more KBM addition. Chaturvedi & Chakraborty, (2022) reported that produced red kidney bean beverage chemically composed of 14.4 ± 0.30, 85.6± 0.06, 8.05 ± 0.11, 2.40 ± 0.03 and 0.20 ± 0.01 for %TS, moisture, protein, fat and acidity respectively.

In line with the current study, cow milk was replaced with soymilk at ratios of 25, 50 and 75 % (v/v), the moisture content increased significantly at <0.05from 45.12 to 58.30 % by increasing soymilk protein increased from 13.90 % to 18.50 % and fat-reduced significantly at p<0.05 from 28.10 to 11.30% and acidity ranged from 1.34 – 1.47 %, whoever an increasing in ash content was reported (Hussein *et al*., 2016).

Table (4) water-soluble nitrogen, digestibility and antioxidant biomarker of cheese manufactured by different ratios of kidney bean milk.

Treatment	%SN	%TN	SN/TN	Protein Digestibility	DPPH
T1	0.40±0.074^{a}	2.44±0.08^{a}	0.163^{a}	97.23±0.208^{a}	19.86±1.096^{a}
T2	0.39±0.091^{a}	2.58±0.156^{b}	0.151^{b}	89.33±0.351^{b}	22.56±0.640^{b}
T3	0.38±0.149^{a}	2.60±0.063^{bc}	0.146^{c}	88.73±0.666^{b}	25.43±0.101^{c}
T4	0.33±0.008^{a}	2.72±0.008^{bc}	0.121^{d}	88.67±0.651^{b}	26.82±0.317^{d}
T5	0.29±0.014^{a}	2.98±0.150^{c}	0.097^{e}	88.27±0.929^{b}	29.54±1.095^{e}

Results are expressed as means ± SD, P ≤ 0.05, different letter in the same column means significant variation. T1: 0% kidney bean milk (control) T2: 5% kidney bean milk T3: 10% kidney bean milk, T4: 15% kidney bean milk and T5: 20% kidney bean milk.

As shown in Table 4 soluble nitrogen decreased by increasing replacement ratio by KBM, treatments are not statically differed at P ≤ 0.05. Total nitrogen was increased by increasing exchange ratio, all treatments expressed a significant difference at P ≤ 0.05 compared to T1(control). Soluble nitrogen to total nitrogen ratio is reduced by increasing KBM utilized in cheese processing, treatments are statically differed at P ≤ 0.05.

Öner & Saridağ,(2018) reported that SN in fresh cheese was 1.79±0.02, furthermore, Georgescu *et al*., (2019) explained that TN and SN in fresh white cheese were 2.08±0.02 and 2.94±0.035, respectively. Lower values were reported by Furtado& Partridge, (1988) for TN and SN which were 2.93±0.06 and 0.27±0.02 seem to be closer to those obtained in the present study. Saad *et al*., (2016) confirmed that soluble nitrogen in milk protein concentrate was 0.609 and it was 0.221 in soy protein concentrate, utilized in cheese sauce manufacturing, which emphasizes lower values in the case of KBM utilization in cheese processing compared to control.

Protein digestibility is alleviated by the addition of KBM, this may be related to the presence of antinutrients in KBM that can inhibit protein digestibility. Anino *et al.*, (2019) studied protein digestibility in three varieties of kidney bean seed, Red haricot, Yellow kidney and Pinto 74.7±1.4, 81.9±1.6 and 78.2±1.8 whatever milk from the same varieties including higher values that were 86.7±3.3, 82.9±0.1and 81.0±3.3, respectively, slightly higher values in the current study that can be explained by blending KBM with CM that have high protein digestibility.

Reducing scavenging capacity by using DPPH was listed in Table (4), it appeared that KBM addition made a significant increase compared with control, the results were highly significant in the portions of 10,15 and 20% KBM versus control (T1), there were 25.43±0.101, 26.82±0.317 and 29.54±1.095 vs 19.86±1.096, Addition of 5% KBM emerged a statical difference at $P \leq 0.05$. Following our results antiradical activity (ARA) was estimated using DPPH for 9 types of kidney bean results was ranged between 4.74 to 17.41 and for bean millstreams varied from 5.72 to 20.96. Total antioxidant capacity in KBM was 50%–186% determined by DPPH free radical scavenging method (Aydar *et al*., 2023). Furthermore, the fermentation of kidney bean beverage by *Lactobacillus* and *Bifidobacterium sp* enhanced the antioxidant properties which were determined by elevating DPPH radical scavenging activity by 2–6%, the authors recommended germination and fermentation processes to maximize the nutritional value of kidney bean beverages (Cichońska *et al*., 2023). The antioxidant feature of KBM which is expressed as reducing scavenging capacity may be introduced as an added value for the soft cheese produced by kidney bean milk.

Table (5) Sensory evaluation of cheese manufactured by different ratios of kidney bean milk.

Treatment	Appearance	Aroma	Taste	Mouth feel	color	Overall acceptability	Total score
T1	6.500± 0.5345[a]	6.500± 0.5345[a]	6.625± 0.518[a]	6.625± 0.5175[a]	6.750± 0.4629[a]	6.500± 0.5345[a]	6.583± 0.1021[a]
T2	6.375± 0.5175[a]	6. 250± 0.7071[a]	6.250± 1.165[a]	6.375± 0.961 [a]	6.500± 0.5341[ab]	6.375± 0.916[a]	6.354± 0.0941[a]
T3	6.375± 0.5175[a]	6.250± 0.4629[a]	6.125± 0.835[a]	6.250± 0.8864 [a]	6.375± 0.5175[ab]	6.250± 0.707[a]	6.271± 0.9410[a]
T4	5.125± 0.6409[b]	5.125± 0.6409[b]	4.875± 1.126[b]	5.500± 1.195 [a]	5.875± 0.3538[b]	5.250± 0.4629[b]	5.292± 0.3506[b]
T5	4.125± 0.9910[c]	4.000± 1.069[c]	3.000± 0.756[c]	4.125± 1.458[b]	4.875± 1.458[c]	4.500± 1.069[b]	4.104± 0.6296[c]

Results are expressed as means ± SD, $P \leq 0.05$, different letter in the same column means significant variation. T1: 0% kidney bean milk (control), T2: 5% kidney bean milk, T3: 10% kidney bean milk, T4: 15% kidney bean milk and T5: 20% kidney bean milk.

From Table (5) T2 and T3 seemed to have a slight difference compared to control in considering appearance, aroma and taste however they did not have statical differences $p<0.05$ for mouthfeel, color and overall acceptability. T3 did not show a statistical difference at $p<0.05$ in all studied aspects of sensory evaluation. T5 appeared highly significant difference at $p<0.05$ compared to control in items of appearance, aroma, and taste 4.125±0.9910, 4.000±1.069 and 3.000±0.756 vs 6.500±0.5345, 6.500±0.5345 and 6.625±0.518. It was obvious that the addition of KBM up to 15% gives resemble characteristics to control mouth feel and color (Table 5). From Table 5, it is showed that the total score of appearance, aroma, taste, mouth feel, color, and overall acceptability for T3 was very close to T1 (control group) there was not a significant difference between them however, T5 was the lowest acceptable treatment with a total score of 4.104±0.6296 which highly statically differed at $p<0.05$ compared to control followed by T4 5.292±0.3506 which was also extremely differed compared to control. Panellists reported rich flavor in KBM treatments unless the decrease in fat percentage in cheese. Emulsifying properties of legume proteins are well-established (Ladjal Ettoumi *et al*., 2016). Moreover, Meghrabi & Yamani, (2023) reported that white kidney bean milk was slightly less acceptable than the commercial soymilk in terms of overall acceptability. And recommended it as a low-fat alternative milk with improvement in the production steps or adding flavor to increase consumer acceptability. Furthermore, Aydar *et al*., (2023) claimed that the overall acceptability of KBM ranged between 2.9 and 4.1 out of 10 and recommended KBM as a milk replacer with rich bio-accessible antioxidant capacity and fatty acid profile despite the detection of intense beany by sensory analysis. A study involving three beverages manufactured from red kidney bean by three different extraction methods ($NaCHO_3$ concentration, time and temperature) showed overall acceptability of 6.73 ± 0.46, 6.72 ± 0.55 and 6.51 ± 0.59 (Chaturvedi & Chakraborty, 2022). Addition of soymilk in cheese preparation at ratios of 25,50 and 75 % resulted in wealth in texture(Hussein *et al*., 2016).

Plant-based products (e.g., legumes) represent only 3.32% of consumption as a protein source, whether it is a sustainable protein source (Bonnet *et al*., 2020). The current work that a trial to substitute KBM for cow milk partially is by sustainable trend and reduces the utilization of foods from animal sources.

CONCLUSION

Utilization of milk replacers is a necessity to face shortages in milk production, especially in cheese processing which consumes large amounts of milk. Addition of KBM at the ratio of 10% in soft cheese manufacturing is attributed to an increase in protein content and antioxidant properties with acceptable organoleptic characteristics, more studies should investigate the effectiveness of KBM on starter growth.

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الملخص العربي

تقييم التركيب الكيميائي وقابلية الهضم ونشاط مضادات الأكسدة والخصائص الحسية للجبن الطري المصنوع من لبن الفاصوليا

محمود حسن عبد الكريم [1]، علي متولي[1]، سلمى محمد جلال[1] ، رغدة مختار سيد معوض [1]

[1]قسم علوم الالبان- كلية الزراعة - جامعة المنيا – المنيا – مصر .

تهدف هذه الدراسة إلى إنتاج الجبن الطري باستخدام نسب مختلفة من لبن الفاصوليا (KBM) واللبن البقري وتقييم الخصائص الكيميائية والقابلية الهضم معمليا ومضادات الأكسدة وكذلك الخصائص الحسية.

تم تصنيع الجبن باستخدام اللبن البقري بتركيزات مختلفة من T1 0%، T2 5%، T3 10%، T4 15%، T5 20%، T6 30%، T7 40%، T 8 50%. يتم استخدام 1T كمجموعة ضابطة (كنترول). استبعد التقييم الحسي الأولي المعاملات من 6T إلى 8T، تم تحليل الخصائص الفيزيائية والكيميائية، والهضم، وخصائص مضادات الأكسدة، كما تم إجراء التقييم الحسي.

أدت إضافة KBM إلى زيادة ملحوظة في حموضة الجبن والبروتين ومضادات الأكسدة بينما انخفض كلا من الدهن ووقت التجبن والقدرة على الاحتفاظ بالماء وتصافي الجبن. أظهر 5T أعلى خصائص مضادة للأكسدة. ومع ذلك، فإن زيادة مستويات لبن الفاصوليا (KBM) ارتبطت بانخفاض القبول لدى المستهلك.

في الختام، إن معاملة الجبن الطري باستبدال 10% KBM كانت المعاملة الأكثر قبولاً وحققت نتائج مرضية في الخصائص الكيميائية والهضم ومضادات الأكسدة، وهذا يقدم جبن طري مبتكر من أصل نباتي قد يكون مناسبا للمستهلكين النباتيين. في حين أن استبدال لبن الفاصوليا بنسبة 10% قد لا يكون كافيًا للتحكم الكامل في عدم تحمل اللاكتوز، والجبن يحتوي عادةً على مستويات منخفضة من اللاكتوز ومن غير المرجح أن يؤدي إلى عدم تحمل اللاكتوز.