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Studies of physio-chemical properties and accessibility of flaxseed incorporated in camel and buffalo milk nuggets

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Abstract
The milk products and byproducts may be contaminated intentionally/unintentionally at different level at the time of production, processing, and storage. The present study was aimed to estimate physio-chemical properties of camel and buffalo milk and to determine the optimum level of incorporation of flaxseed and evaluate physio-chemical properties of camel and buffalo milk nuggets. The overall compositions of buffalo and camel milk showed that the buffalo milk had higher concentrations of protein, fat and solid not fat (SNF) than camel milk. Formation of milk nuggets was done using coagulum developed by different ratio of camel and buffalo milk viz. (90:10, 80:20, 70:30, 60:40). Best result obtained were based on yield and consistency of milk coagulum by combination of 70% camel milk and 30% buffalo milk. The pH was significantly ($P<0.05$) decreased with increase in refrigerated storage and TBA values were also found to be increased significantly ($P<0.05$) with storage period for both type of nuggets. There was a highly significant ($P<0.05$) decrease in the DPPH and ABTS activity of both the nuggets for storage over a period of 12 days. The DPPH and ABTS% activity of treatment was higher than control. The proximate analysis for Dry Matter, Crude Protein, Ether extract, Crude fiber and Total ash showed a significant difference between control and treatment nuggets developed under the study.

Keywords: camel milk, buffalo milk, dry matter, flaxseed, protein

Introduction
Milk has a high nutritive value and supplies body building proteins, bone forming minerals, healthful vitamins and provides energy giving lactose and milk fat. Milk provides essential nutrients and is an important source of dietary energy, high-quality proteins, and fats. Milk can make a significant contribution to the required nutrient intakes for calcium, magnesium, selenium, riboflavin, vitamin B12.

Buffalo milk has a remarkably high fat content, which is on average twice as high as that of cow milk. The fat-to-protein ratio in buffalo milk is about 2:1. Compared with cattle milk, buffalo milk also has a higher casein-to-protein ratio. The high calcium content of casein facilitates cheese making. Buffalo milk contains less cholesterol compared to cow milk and more tocopherol. Due to high peroxidase activity, buffalo milk can be preserved naturally for a longer period. Buffalo milk contains more calcium and better calcium: phosphorous ratio and less sodium and potassium than in cow milk.

Camel milk has a similar composition to cow milk but is slightly saltier. Camel milk can be three times as rich in vitamin C as cow milk and represents a vital source of this vitamin for people living in arid and semi-arid areas, who often cannot obtain vitamin C from fruits and vegetables. Camel milk is also rich in unsaturated fatty acids and B vitamins. Milk from Bactrian camels has a higher percentage of fat than milk from dromedaries, but levels of proteins and lactose are similar. Normal camel milk has a very white color and is foamy (El – Agamy, 1983) [4]. The taste of camel milk is usually sweet, when camels are fed on green fodder, but sometimes salty, due to feeding on certain shrubs and herbs in the arid regions (El – Agamy, 1983 & 1994; Indra and Erdenebaatar, 1998) [4, 5, 6]. The one-humped camels (Camelus dromedarius) are well-known producers of milk which differs from bovine milk in the composition and structure of its protein content and thus has different functional and medicinal properties. Caseins (CNs) are the major proteins in camel milk, and α-, β- and κ- CN constitutes about 65, 21 and 3.47% respectively, of total caseins (Kappeler *et al*., 2003) [7].

Milk protein-based nugget is one such Ready-to-Cook type new product having scope for commercial exploitation. However, in case of nuggets preparation, protein texturization takes places in mechanical process in presences of heat and pressure, which sometimes improves the digestibility of the protein. Nuggets from milk protein may also give an alternative to utilize milk protein for food preparation and can be effectively used as replacer of meat or animal protein. Milk nugget is a cooked and ready to eat milk based functional product suitable as a snack food as well as an adjunct to the routine meals. It is a healthy vegetarian food with reasonably good shelf life under refrigerated and frozen storage conditions. Incorporation of Flaxseed as a source of nutraceuticals and functional food in the preparation of camel and buffalo milk nuggets would be more beneficial for the health-conscious people and the people demanding variety of healthy products.

Material and Methods

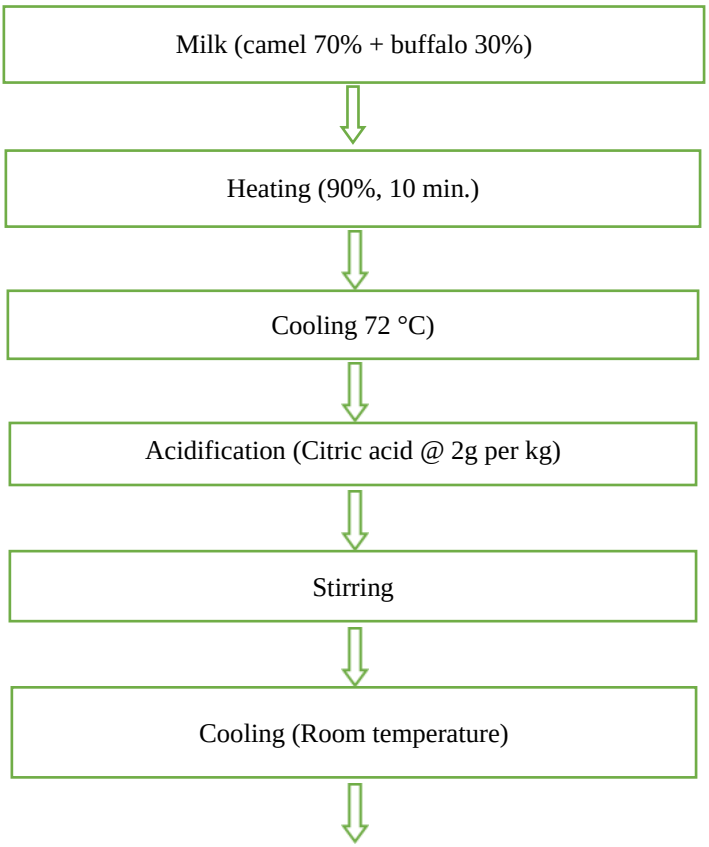
Formation of milk nuggets were done by using 70% camel milk and 30% buffalo milk coagulum with incorporation of flaxseed.

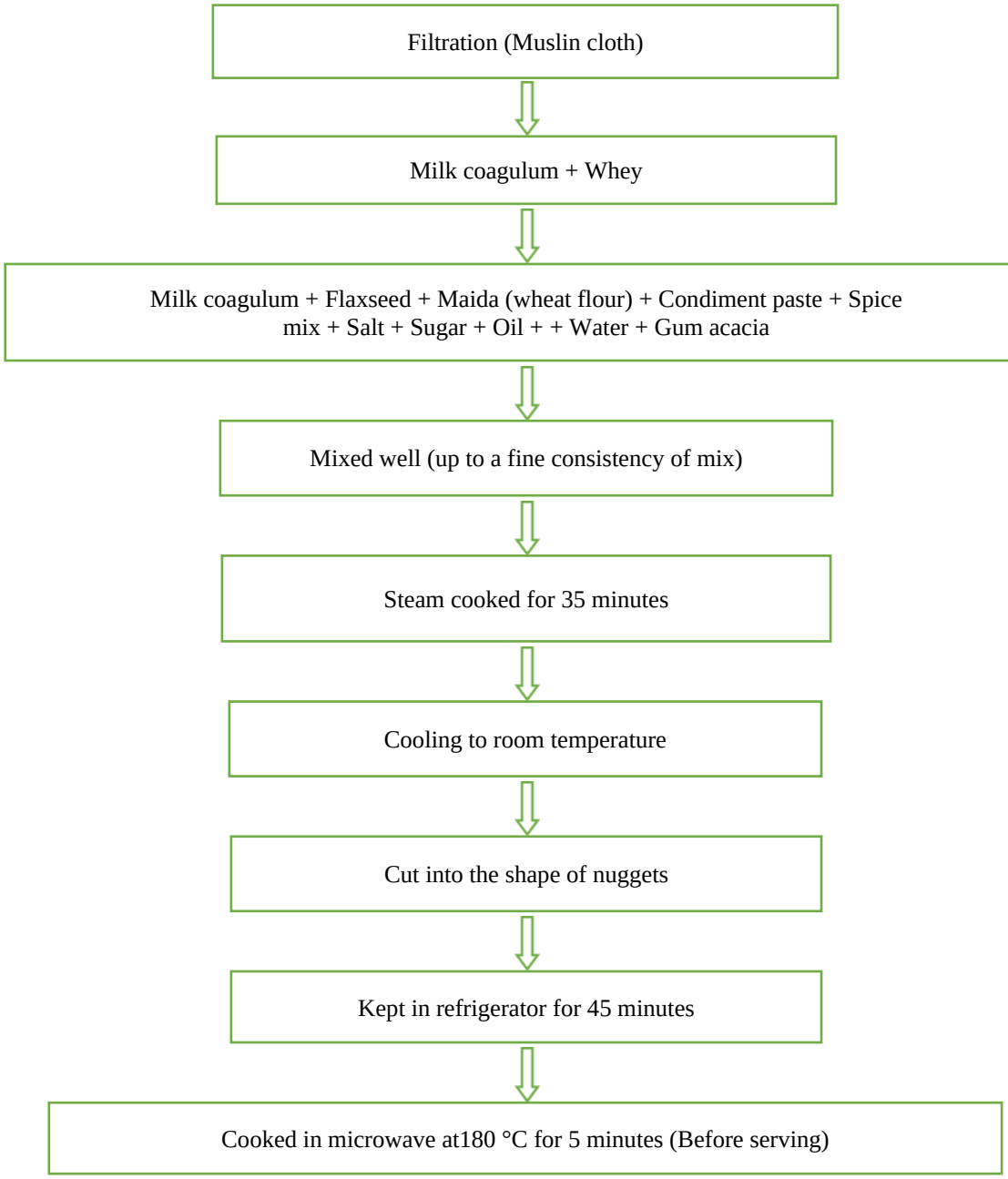
Table 1: Formulation of different combinations of flaxseed incorporated in camel and buffalo milk nuggets

S. No.	Ingredients	Control (T_0)	Treatment (T1)	Treatment (T2)	Treatment (T3)	Treatment (T4)
1.	Mil coagulum	84%	82%	80%	78%	76%
2.	Flaxseed	0%	2%	4%	6%	8%
3.	Wheat flour	4%	4%	4%	4%	4%
4.	Condiment paste	1.5%	1.5%	1.5%	1.5%	1.5%
5.	Spice mix	1.5%	1.5%	1.5%	1.5%	1.5%
6.	Salt	0.5%	0.5%	0.5%	0.5%	0.5%
7.	Sugar	0.5%	0.5%	0.5%	0.5%	0.5%
8.	Oil	1%	1%	1%	1%	1%
9.	Water	6.5%	6.5%	6.5%	6.5%	6.5%
10.	Gum acacia	0.5%	0.5%	0.5%	0.5%	0.5%
	Total	100	100	100	100	100

Formation of flaxseed incorporated camel and buffalo milk nuggets

Whey was drained from coagulum by using clean muslin cloth and the coagulum obtained was cooled at room temperature and then 4% flaxseed powder, Spice mix, Condiment mix and other ingredients in the required ratio was mixed as shown in above table 1 to form soft textured dough. After this the prepared soft textured dough was placed in aluminium mould, packed compactly, covered, and cooked in steam without pressure for 30 minutes. The internal temperature of cooked block was 72°C, measured using a probe type thermometer. The block was cooled to room temperature, chilled overnight at 4°C and cut into nuggets of 4 x 2 x 2 cm3. Flaxseed incorporated camel and buffalo milk nuggets were prepared as shown in flow chart.





Flow chart for the preparation of flaxseed incorporated camel and buffalo milk nuggets

Physiochemical parameters

Following Physiochemical parameters is measured during study.

A. pH determination
B. Cooking yield
C. TBARS value
D. ABTS+ radical-scavenging activity
E. DPPH radical-scavenging activity

A) pH determination

The pH of milk nuggets was measured using digital pH meter as suggested by (AOAC, 1995).

B) Cooking yield

The cooking yield of the product was calculated as under:

$$\text{Cooking yield (\%)} = \frac{\text{Weight of cooked nugget}}{\text{Weight of coagulum used}} \times 100$$

C) Thio-barbituric acid (TBARS value)

Lipid oxidization was monitored by measuring Thio-barbituric acid reactive substances during storage. TBARS were determined using extraction method described by Witte *et al.*, (1970) [9].

D) DPPH (2,2′-diphenyl-1-picrylhydrazyl) radical-scavenging activity

The ability to scavenge DPPH (2,2′-diphenyl-1-picrylhydrazyl) radical by added antioxidants in samples was estimated by following the method of Brand-Williams *et al.*, (1995) [3] with slight modification.

E) ABTS+ (2,2′-azinobis (3-ethylbenzthiazoline-6-sulphonic acid) radical- scavenging activity

The spectrophotometric analysis of ABTS+ radical-scavenging activity was determined according to method described by Salami *et al.*, (2009) [8].

Results and Discussion

Physio-chemical properties of camel and buffalo milk

All samples collected manually in sterile bottles once per day (usually in the morning), milk samples were analyzed for pH, SNF, fat, specific gravity, water content, protein, lactose etc. using Milkoscan at Camel milk research laboratory, ICAR-NRC, Bikaner.

The mean values of Physio-chemical properties of fresh buffalo and camel milk has been presented in Table 2.

Table 2: Physio-chemical properties of buffalo and camel milk

Physio-chemical Properties	Camel milk (Mean ± SE)	Buffalo milk (Mean ± SE)
Fat%	3.30 ± 0.12	7.64 ± 0.26
SNF%	6.78 ± 0.15	7.42 ± 0.10
Protein%	2.22 ± 0.06	2.93 ± 0.05
Lactose%	3.76 ± 0.07	3.75 ± 0.04
Salt%	0.77 ± 0.01	0.74 ± 0.00
Freezing Point (^{0}C)	-0.44 ± 0.01	-0.47 ± 0.00
Ph	6.47 ± 0.04	6.61 ± 0.02
Electrical Conductivity (mho)	5.55 ± 0.147	2.65 ± 0.03

Cooking yield of camel and buffalo milk nuggets incorporated with flaxseed

Table 3: cooking yield of milk nuggets

Parameters	Control	Treatment
Cooking yield (%)	92.54 ± 0.08	95.03 ± 0.18

Control -milk nuggets without flaxseed incorporation
Treatment - milk nuggets incorporated with flaxseed

pH measurement of camel and buffalo milk nuggets

The determination of pH of prepared milk nuggets was done under refrigerated storage condition (0, 3, 6, 9 and 12 days). The data of pH has been shown in table 4 (a) and has been presented in figure 1.

Table 4(a): pH (Mean ± SE) of camel and buffalo milk nuggets

Day	Control	Treatment	Overall
0 Day	5.92^{cA} ± 0.01	5.74^{dB}±0.06	5.83^{c} ± 0.040
3 Day	5.72^{bA} ± 0.01	5.68^{cB}±0.02	5.70^{b} ± 0.012
6 Day	5.70^{bA} ± 0.02	5.65^{bcB}±0.01	5.67^{b} ± 0.016
9 Day	5.61^{aA} ± 0.03	5.60^{abA}±0.02	5.60^{a} ± 0.022
12 Day	5.58^{aA} ± 0.01	5.53^{aA}±0.02	5.56^{a} ± 0.015
Overall	5.71^{A} ± 0.02	5.64^{B} ± 0.01	

Note – Means bearing different superscripts within a row (capital letter) and column (small letter) differ significantly
Control-Milk Nuggets without Flaxseed Incorporation
Treatment- Milk Nuggets Incorporated with Flaxseed

Table 4(b): Analysis of variance for pH of milk nuggets

Source of variation	D.F.	Mean Square	Level of sig.
Between treatment	1	0.070042	**
Between period	4	0.129144	**
Interaction between treatment & period	4	0.011387	N
Error	50	0.005032	

** = Significant at 1% (P<0.01)

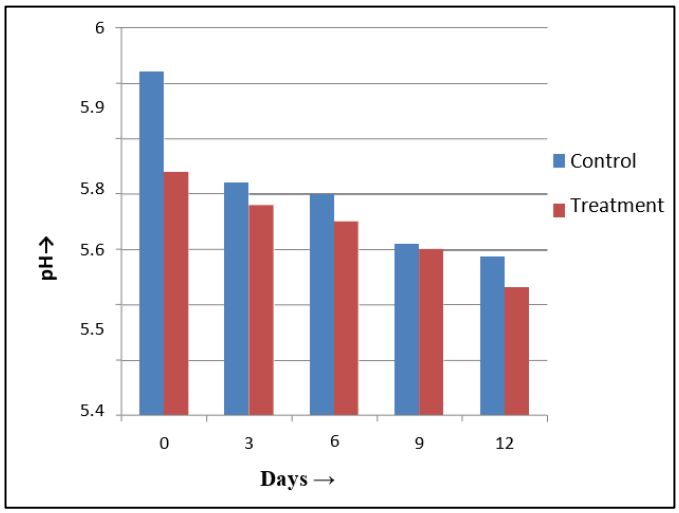


Fig 1: pH of milk nuggets

Proximate analysis of camel and buffalo milk nuggets

Proximate analysis of camel and buffalo milk nuggets was done according to method described by A.O.A.C. (2000) [1] (Official methods of analysis).

Table 5: proximate analysis (Mean ± SE) of milk nuggets

Constituent (%)	Control	Treatment
Moisture	65.02 ± 0.03	64.34 ± 0.02
Crude protein	27.69 ±0.01	28.84 ± 0.02
Crude fiber	2.78 ± 0.06	3.90 ± 0.03
Ether extract	1.90 ± 0.13	3.24 ± 0.13
Total ash	3.10 ± 0.05	3.14 ± 0.01

Control- Milk Nuggets without Flaxseed Incorporation
Treatment- Milk Nuggets Incorporated with Flaxseed

Abts Activity of Camel and Buffalo Milk Nuggets

The data related to ABTS activity (% inhibition) of milk nuggets has been shown in Table 6 and has been presented in figure 2.

Table 6(a): ABTS (Mean ± SE) activity of camel and buffalo milk nuggets

Day	Control	Treatment	Overall
0 Day	27.13^{cA} ± 0.47	53.20^{eB} ± 0.15	40.16^{e} ± 3.93
3 Day	21.88^{bA} ± 0.19	47.62^{dB} ± 0.20	34.75^{d} ± 3.8
6 Day	21.71^{bA} ± 0.29	39.77^{cB} ± 0.29	30.74^{c} ± 2.73
9 Day	21.13^{bA} ± 0.43	24.17^{bA} ±0.16	22.65^{b} ± 0.50
12 Day	18.84^{aA} ± 0.38	21.71^{aA} ± 0.29	20.27^{a} ± 0.48
Overall	22.14^{A} ± 0.52	37.29^{B} ± 2.32	

Note– Means bearing different superscripts within a row (capital letter) and column (small letter) differ significantly
Control- Milk Nuggets without Flaxseed Incorporation
Treatment- Milk Nuggets Incorporated with Flaxseed

Table 6(b): Analysis of variance for ABTS activity of camel and buffalo milk nuggets

Source	D.F.	Mean square	Level of sig.
Between treatment	1	3445.363	**
Between period	4	823.8033	**
Interaction between treatment & period	4	402.8341	**
Error	50	0.57114	

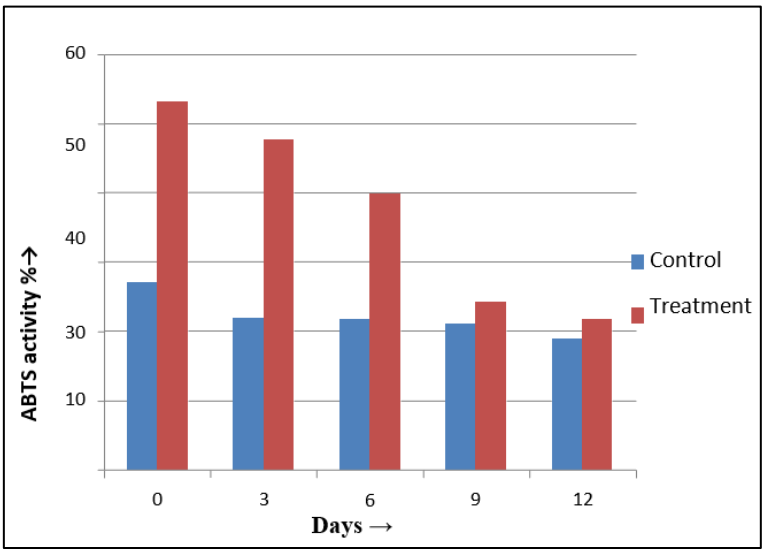


Fig 2: ABTS activity% of camel and buffalo milk nugget

Control- Milk Nuggets without Flaxseed Incorporation
Treatment- Milk Nuggets Incorporated with Flaxseed

DPPH Activity of Camel and Buffalo Milk Nuggets

The determination of the DPPH activity was done to test the antioxidant properties of flaxseed incorporated camel and buffalo milk nuggets ($T_{1)}$ as compared to control (T_0) or plain nuggets. The mean data related to DPPH activity of control and treatment group has been presented in Table 7 (a) and depicted in figure 3.

Table 7(a): DPPH (Mean ± SE) activity of camel and buffalo milk nuggets

Day	Control	Treatment	Overall
0 Day	$9.57^{dA} \pm 0.06$	$15.00^{eB} \pm 0.10$	$12.29^{e} \pm 0.869$
3 Day	$4.79^{cA} \pm 0.01$	$11.14^{dB} \pm 0.17$	$7.97^{d} \pm 0.961$
6 Day	$4.04^{bA} \pm 0.08$	$7.82^{cB} \pm 0.24$	$5.93^{c} \pm 0.583$
9 Day	$2.28^{aA} \pm 0.09$	$6.53^{bB} \pm 0.13$	$4.40^{b} \pm 0.645$
12 Day	$1.76^{aA} \pm 0.07$	$4.44^{aB} \pm 0.13$	$3.10^{a} \pm 0.411$
Overall	$4.49^{A} \pm 0.52$	$8.99^{B} \pm 0.69$	

Note – Means bearing different superscripts within a row (capital letter) and column (small letter) differ significantly

Control- Milk Nuggets without Flaxseed Incorporation
Treatment- Milk Nuggets Incorporated with Flaxseed

Table 7(b): Analysis of variance for DPPH activity of camel and buffalo milk nuggets

Source of variation	D.F.	Mean Square	Level of sig.
Between treatment	1	303.795	**
Between period	4	154.8799	**
Interaction between treatment & period	4	6.1225	**
Error	50	0.317294	

** = Significant at 1% (P<0.01)

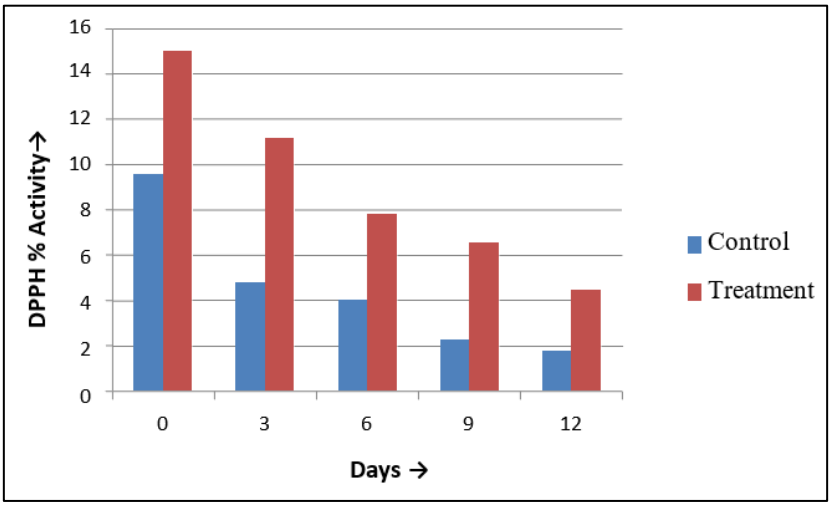


Fig 3: DPPH activity% of camel and buffalo milk nuggets

Control- Milk Nuggets without Flaxseed Incorporation
Treatment- Milk Nuggets Incorporated with Flaxseed

TBARS (2-Thiobarbituric Acid Reactive Substance) value of milk nuggets

The mean ± S.E values of TBARS values of camel and buffalo milk nuggets as influenced by incorporation of 4% flaxseed and storage periods has been presented in the Table 8 (a) and analysis of variance in Table 8 (b).

Table 8(a): TBARS Value (Mean ± SE) of milk nuggets

Day	Control	Treatment	Overall
0 Day	$0.39^{aA} \pm 0.002$	$0.43^{aB} \pm 0.003$	$0.415^{a} \pm 0.005$
3 Day	$0.44^{bA} \pm 0.002$	$0.46^{bB} \pm 0.003$	$0.455^{b} \pm 0.003$
6 Day	$0.78^{cA} \pm 0.002$	$0.70^{cB} \pm 0.004$	$0.746^{c} \pm 0.013$
9 Day	$0.95^{dA} \pm 0.002$	$0.91^{dB} \pm 0.003$	$0.931^{d} \pm 0.006$
12 Day	$1.05^{eA} \pm 0.003$	$1.10^{eB} \pm 0.009$	$1.079^{e} \pm 0.009$
Overall	$0.72^{A} \pm 0.048$	0.72A ± 0.041	

Note – Means bearing different superscripts within a row (capital letter) and column (small letter) differ significantly
Control- Milk Nuggets without Flaxseed Incorporation
Treatment- Milk Nuggets Incorporated with Flaxseed

Table 8(b): Analysis of variance for TBA Value

Source of variation	D.F.	Mean Square	Level of sig.
Between treatment	1	0.00008	N
Between period	4	1.010837	**
Interaction between treatment & period	4	0.010135	**
Error	50	0.000111	

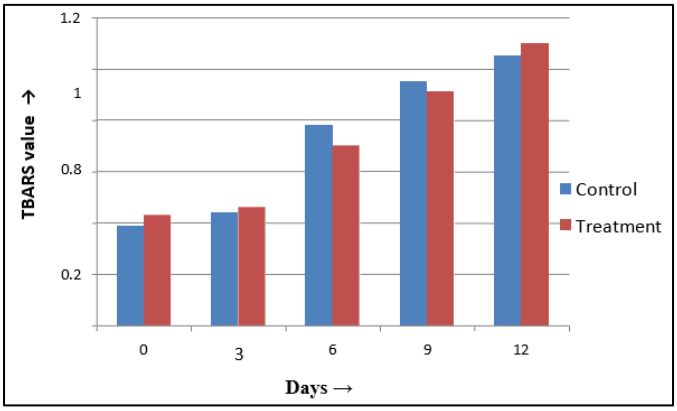


Fig 4: TBARS value of camel and buffalo milk nuggets

Control- Milk Nuggets without Flaxseed Incorporation
Treatment- Milk Nuggets Incorporated with Flaxseed

Main Conclusion and Research Prospects

Flax seed incorporated camel and buffalo milk nuggets with particularly good acceptability can be prepared with the use of 70% camel milk and 30% buffalo milk and other ingredients viz. refined wheat flour, spices, condiments, table salt, sugar and gum acacia. Flax seed incorporated milk nuggets is a new product with functional and nutraceutical properties and have potential to contribute micronutrient, natural antioxidants, unique fatty acid profile and high dietary fiber. The antioxidant capacity (based on DPPH and ABTS radical scavenging activity) was high for milk nuggets incorporated with 4% flaxseed. Based on Physio-chemical properties, the optimum level of flax seed incorporation was adjudged to be 4% without affecting Physio-chemical properties. Storage studies revealed that aerobic packaged products can be stored up to 12 days under refrigeration without any marked loss of Physio-chemical, microbiological, and sensory quality. Hence, it may conclude that flaxseed incorporated milk nuggets significant increase in nutritional properties and consumption of flaxseed as an adjunct in milk-based products will positively benefit the consumers.

Conflict of Interest

The author declares that there are no conflicts of interest

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