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Investigating the Effects of Strawberry Puree on the Quality Attributes of Goat and Sheep Milk Puddings

Mai, G. Mohamed, Helal, A.M.[(1)], Awad, S.A.[(2)], Yacoub, S.S.[(1)]

(1) Food, Dairy Science &Techno. Dept., Fac. of Agric., Damanhour Univ., Egypt.
(2) Dairy Science & Techno. Dept., Fac. of Agric., Alex. Univ., Egypt.

ABSTRACT

The current research was conducted to study the impact of supplementation pudding based on goat or sheep milk with different levels of strawberry puree (1.5%, 3%, and 5%) on the physicochemical, rheological, and organoleptic properties of products. The results showed that the milk type and the addition of strawberry puree had a significant effect on the physicochemical composition of the pudding samples. Flavored goat and sheep pudding exhibited significantly higher ($p \leq 0.05$) carbohydrates, ash, fiber, and antioxidant content compared to their plain counterparts. While dry matter, fat, and protein were the opposite. Goat pudding flavored with 5% strawberry puree had the highest antioxidant (61.24 mg/100g); in addition, sheep pudding flavored with 5% strawberry puree had the highest fiber content (100.26±0.06 mg/100g), while those with 1.5% and 3% strawberry puree displayed increased antioxidant and fiber content compared to controls. Incorporating strawberry puree resulted in a statistically significant decrease ($p \leq 0.05$) in the texture parameters of flavored goat and sheep milk pudding samples compared to the control. Sensory evaluation revealed that strawberry puree addition significantly improved ($p \leq 0.05$) the attributes of both goat and sheep pudding samples, resulting in higher consumer acceptability. Moreover, among all pudding samples, the sheep milk pudding samples flavored with 5% strawberry puree received the highest scores, primarily for their color, odor, taste, and texture.

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Adding strawberry puree maintains the quality of the puree during cold storage at 5°C for 14 days. In conclusion, strawberry puree fortification enhanced the physicochemical, rheological, and sensory characteristics of both goat and sheep milk pudding.

Key words: Antioxidants, Fiber, Rheological parameters, Sensory Properties

INTRODUCTION

Modern cuisine focuses on items that may provide a pleasing flavor at the expense of natural products, utilizing healthier alternatives not only in terms of technology, but also in terms of natural product exploitation. Typically, consumers are unwilling to adopt functional foods that taste worse than traditional meals (Tuorila and Cardello, 2002; Hilliam, 2003; Verbeke, 2006). For this reason, one of the first phases in functional food creation is to investigate changes in the product's sensory qualities as a result of the inclusion of a novel ingredient, as well as customer reactions to these changes. All food items are designed to withstand both customer needs and market demands. Recently, the food industry has made attempts to manufacture items with functional features, as modern customers aim to maximize the beneficial effects of the food they consume on a daily basis. According to research, popular dessert recipe changes include milk substitutions owing to an increase in protein allergies and enzyme shortages (Spada *et al.,* 2015), prebiotic polysaccharide enrichment (Gałkowska *et al.,* 2020), hydrocolloid alternatives (Witczak *et al.,* 2020), and reduced sugar and fat content (Nejatian *et al.,* 2029).Functional components in meals are viewed as a growing tendency in sustainable food production, particularly the use of natural raw materials (Putnik and Kovacˇevic´ 2021). Advanced consumer understanding of foods with possible health advantages leads to the creation of new products with health-promoting components (Donno, and Turrini, 2020).

Pudding is widely enjoyed by people of all ages, from young children to the elderly, making it one of the most favored processed foods

because of its chewy texture, digestibility, and ease of preparation. It's no surprise that pudding is frequently served as a dessert or a delightful snack commonly referred to as desserts. Milk puddings are gelled dairy product, made mostly with milk, thickeners (starch and carrageenan), and sugar (Elmore *et al.,* 1999). Puddings are generally made with cow's milk as the major component, which enriches the dessert with proteins, vitamins, and minerals. Both creamy texture and soft taste are defining sensory features, and components such as eggs, butter, and cocoa powder have a significant impact on both (Sun *et al.,* 2006). The puddings are usually produced by boiling gelatin, milk, sugar, and water (Misnaiyah *et al.,* 2018).

Goat and sheep milk are gaining popularity as substitutes for bovine milk-based products, primarily because of their nutritional value and the less intensive farming practices needed to raise these animals (Polowsky *et al.,* 2017).Goat milk is rich in a diverse array of macro and micronutrients. Its low allergy levels make it a preferred option for infants with cow milk allergies, rendering it a viable alternative to other types of milk. A variety of goat milk-based products, such as yogurt, ice cream, fermented milk, and cheese, are readily accessible in the market. These products undergo efficient processing techniques and are recognized for their numerous health benefits upon consumption. However, the consumption of goat milk is comparatively restricted in many countries, primarily due to limited awareness regarding its nutritional composition and the significance of its various byproducts, especially when compared to cow, buffalo, camel, and sheep milk (Nayik *et al.,* 2022). Moreover, another milk type is sheep milk has health benefits and is a rich source of bioactive compounds that promote overall wellness. Sheep's milk is useful because it contains a high concentration of fatty acids, immunoglobulins, proteins, hormones, vitamins, and minerals. Milk contains several biopeptides with antibacterial, antiviral, anti-inflammatory effects, and anticancer potential. (Flis and Molik 2021).

Strawberry is the leading prospective horticultural commodity since its output is increasing, strawberry cultivation is widespread in many governorates of Egypt, including Qalyubia, Beheira, Ismailia, Sharqia, as well as the Nubaria region. Egypt produced about 539.48

thousand tons of strawberries in 2019. Therefore, about 20 thousand tons of fresh strawberries are exported abroad (Fayed, 2021). Strawberry is a popular fruit in Egypt due to its peculiar taste, particularly among children. Strawberries are a nutrient-dense fresh fruit, but their use is limited and they quickly deteriorate due to their high water content. As a result, innovation in strawberry processing is necessary to broaden the spectrum of strawberry-processed goods with a longer shelf life, such as juice, jam, desserts, candies, instant pudding, and other recipes**.** Consuming various fruits can also help to meet nutritional needs, one of which is strawberry which is high in provitamins A and C, calcium, phosphorus, iron, sodium, potassium, and magnesium, as well as elagic acid, which is an antitoxic, anti-free radical, and anti-carcinogenic compound that is beneficial to body health (Astuti *et al.,* 2015).

The demand for goat and sheep milk is on the rise in the global market, the distinct "goaty-sheepy" flavor commonly associated with these types of milk can pose limitations on consumer acceptance and consumption (Kaffarnik *et al.,* 2014a,b). Fruit purees provide an attractive alternative for improving taste, and odor, and hiding unpleasant flavors in dairy products. Based on the above description, the purpose of this study is to assess the nutritional content, antioxidant activity, and rheological and organoleptic properties of strawberry-based pudding made from goat or sheep milk. This study is anticipated to provide a reference for the public to be able to digest nutritious meals from vegetables and fruit in order to meet the nutritional requirements of vitamins, minerals, and substances that are beneficial to bodily health.

MATERIALS AND METHODS

Materials:

Fresh goat and sheep milk was provided from a local farm in Marsa Matrouh Governorate, Egypt. Strawberries (*Fragaria* × *ananassa*) were purchased from the local market in El-Beheira Governorate, Egypt, Disodium phosphate, was obtained from Egy-dairy, Egypt, k-carrageenan, USA, sugar (sucrose) and corn starch were purchased from a local market in Alexandria Governorate, Egypt.

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Methods:

Preparation of strawberry puree:

Strawberry (*Fragaria* × *ananassa*) fruits were washed under running water to remove dust and cleaned with an aseptic knife. Fruit pulp was blended using an electric blender after processed by scalding at 85°C for 15 min., packed in suitable jars and kept frozen until use. According to the manufacturer, the strawberry puree comprised of 100% fruit pulp.

Pudding preparation:

Table (1) shows the formulations of pudding based on goat or sheep milk flavored with strawberry puree (SP). The pudding preparation was estimated by the procedure given by Nunes *et al.* (2003). Suspensions were formed by combining the fresh goat or sheep milk with the dry components (sugar, k-carrageenan and starch) and stirring for 5 min at room temperature. The suspensions were heated to 90°C for 15 min. The manufacturing process involved the gradual addition of strawberry puree at 90°C, just 2 min before its completion. The control treatment followed the same procedures but without the addition of strawberry. The milk pudding was cooled to room temperature, poured into plastic cups, and stored in a refrigerator before analysis. Samples were analyzed after 1, 7, and 14 days. Physico-chemical, rheological, and sensory tests were conducted.

Table 1: The formula for goat and sheep milk pudding fortified with strawberry puree

Ingredients (g)	Treatments *			
	Control	T_1	T_2	T_3
Goat or sheep milk	1000	1000	1000	1000
Corn starch	35	35	35	35
Disodium phosphate	0.5	0.5	0.5	0.5
Sucrose	80	80	80	80
k-carrageenan	0.2	0.2	0.2	0.2
Strawberry puree (SP)	-	15	30	50

* Treatments: Control; T_1; T_2 and T_3 consist of goat or sheep milk pudding samples supplemented with (0%, 1.5%, 3% and 5%) strawberry puree, respectively.

Physicochemical composition:

Samples of goat's and sheep's milk, as well as pudding, were analyzed for physicochemical composition, including total solids, fat, total nitrogen (protein), ash, and fiber, as well as pH values (measured using a HANNA HI9321 microprocessor) and titratable acidity, in accordance with AOAC (2012) guidelines. Furthermore, total carbohydrates were computed by difference for all samples examined, as published by Guzman *et al.*(1999). Antioxidant activity was determined using the method described by Li *et al.* (2009).

Texture characterization:

The pudding's texture parameters were assessed using the Texture Profile Analysis (TPA) method, using a TA-XT express texture analyzer from Stable Micro Systems Ltd., based in godalming, UK, equipped with a TA/1000 cylindrical probe. The penetration speed was set to 1 mm/s, with a target distance of 5 mm and a trigger of 15 g. Firmness, consistency, and cohesiveness values for all samples were measured at intervals of 1, 7, and 14 days.

Organoleptic properties:

Color, odor, taste, body and texture, and overall acceptability of pudding from goat's and sheep's milk supplemented with strawberry were evaluated by staff members of Faculty of Agriculture, Damanhour University. The results were recorded on a score sheet described by Kebary and Hussein (1999).

Statistical analysis:

Measurements were performed in triplicate for each sample and mean values and standard deviations were reported. Statistical analyses were carried out using CoStat software, version 6.400 (CoHort software, Monterey, CA, USA). Three-way analysis of variance (ANOVA) and the least significant difference (LSD) test were used to establish the significance of differences among the treatments. Significant differences were defined at $p \leq 0.05$.

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RESULTS AND DISCUSSION

Physicochemical properties of goat and sheep pudding flavored with strawberry puree:

The approximate chemical composition of raw materials used in this study (goat milk, sheep milk, and strawberry fruits) is shown in Table (2).

Table (2): Approximate chemical composition of raw material used in pudding making

Raw materials	Total solids %	Protein %	Fat %	Carbohydrates %	Ash %	Fiber %	pH-value
Goat milk	12.72	3.59	4.13	4.22	0.83	-	6.49
Sheep milk	17.13	5.27	6.56	4.39	0.91	-	6.64
Strawberry	9.19	0.67	0.29	5.68	0.42	2.13	3.45

This research investigated the effects of incorporating strawberry puree (SP) into both goat and sheep pudding on their physicochemical attributes. The examination encompassed several parameters, such as dry matter, fat, protein, ash, crude fiber, carbohydrate contents, pH, acidity, and total antioxidant activity. The outcomes are detailed in Table 3.. The results revealed that the sheep pudding flavored with strawberry puree exhibited significantly ($p \leq 0.05$) higher levels of dry matter, protein, and fat as compared to the goat pudding flavored with strawberry puree, while the opposite happened in carbohydrates as calculated based on dry matter. This outcome is mainly based on the differences between the two types of milk as a main component of the pudding. As affected by the chemical composition of strawberry puree, as shown in Table (2), in flavored puree, the addition of strawberry puree (SP) at a higher ratio led to a decreased content of total solids. Conversely, the content of protein and fat decreased with increasing SP concentrations in both flavored goat pudding and flavored sheep pudding. These observations were made on a dry-matter basis. On the other hand, regarding the high content of carbohydrate in the strawberry puree with respect to the goat or sheep

milk, the varying concentrations of SP significantly influenced the total carbohydrate content. Pudding containing 5% SP in flavored goat and sheep pudding demonstrated the highest carbohydrate content (63.65±0.27% and 56.25±0.26%, respectively) compared to the control groups ($p \leq 0.05$).

Storage duration also exerted a significant effect on the pudding composition. Dry matter, fat, protein, and carbohydrate contents increased with extended storage time. The effect of the milk type and the addition of strawberry puree was also noticed during the storage period, and therefore, the highest dry matter values were noticed in the case of plain sheep pudding after 14 days of storage (25.05±0.24%), while the lowest values were noticed in the case of pudding based on goat milk flavored with 5% strawberry puree (T3) at the 1st day of storage (20.93±0.22%).

Ash content, a component that emerges from extracted materials in the absence of nitrogen, can influence the composition of organic matter (Utama *et al.*, 2019). Additionally, ash content serves as a metric to ascertain the collective mineral content present in food items (Susanti *et al.*, 2020). Notably, the ash content was not significantly affected, neither within the different milk types nor the strawberry puree percentage. Furthermore, the ash content remained relatively unaffected by storage duration. China *et al.* (2019) suggest that the ash content of food products is significantly impacted by the cooking method employed. Moreover, they note a correlation between ash content and the mineral composition of these food items.

Regarding the pH value and acidity, the sheep pudding treatments showed a higher pH value and lower acidity than the goat pudding treatments. These findings likely reflect compositional variations between the milk sources used in pudding production. Furthermore, the addition of strawberry puree led to an increase in acidity and a decrease in pH values. Therefore, the highest pH value and lowest acidity were found in the control sheep pudding (6.69±0.03 and 0.16±0.05%), and as expected, the lowest pH and the highest acidity were found in goat pudding flavored with 5% strawberry puree (6.27±0.01 and 0.35±0.02%). Regarding the heat treatment in the pudding manufacture process and the

cold storage environment; there was stability in the acidity of the pudding samples during the storage period; however, the differences between the two types of milk and the effect of strawberry puree addition on the acidity were still noticeable during the storage period. As shown in Table 3, the highest acidity was 0.38±0.03% and found in goat pudding flavored with 5% strawberry puree (T3), while the lowest acidity after 14 days of storage was 0.21±0.03% and found in the control sheep pudding.

During refrigerated storage (14 days), the pH of control and flavored pudding samples was monitored **(**Table 3**).** A noticeable stability in pH was observed in all samples throughout the storage period. Sheep milk pudding exhibited consistently higher pH values throughout storage compared to those made with goat milk. This difference was statistically significant ($p \leq 0.05$) on day 1 and persisted until the end of the storage period (day 14). Similar behavior of the effect of adding strawberry puree was also observed during the storage, as the highest pH value after 14 days of storage was found in the control sheep pudding (6.61±0.02) while the lowest was found in goat pudding flavored with 5% strawberry puree (6.25±0.01).

Milk pudding is rich in essential nutrients like protein, but it lacks dietary fiber content. Therefore, enhancing the pudding with dietary fiber is crucial for elevating its nutritional profile and expanding the range of dairy offerings, particularly those beneficial for human health. According to milk type, no differences were found among pudding samples based on goat milk and sheep milk. Strawberries, being a plentiful source of dietary fiber, the addition of SP with various levels led to a significant increase ($p \leq 0.05$) in the fiber content of pudding samples based on goat and/or sheep milk. As a comparison to the control, fiber content ranged from 0.01 to 100.26 mg/100 g, as shown in (Table 3).

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Table (3): Effect of different levels of strawberry puree on the physicochemical properties of pudding based on goat and sheep milk during cooled storage for 14 days.

Properties (%)	Storage time (days)	Treatments*							
		Goat milk				Sheep milk			
		Control	T_1	T_2	T_3	Control	T_1	T_2	T_3
Dry matter (DM)	1	$21.52\pm0.11^{B.a,C}$	$21.35\pm0.15^{B,a,C}$	$21.14\pm0.19^{B,b,C}$	$20.93\pm0.22^{B,c,C}$	$25.01\pm0.22^{A,a,C}$	$24.95\pm0.24^{A,a,C}$	$24.69\pm0.2^{A,b,C}$	$24.39\pm0.19^{A,c,C}$
	7	$21.73\pm0.13^{B.a,B}$	$21.55\pm0.12^{B.a,B}$	$21.4\pm0.17^{B,b,B}$	$21.18\pm0.23^{B,c,B}$	$25.25\pm0.18^{A,a,B}$	$25.13\pm0.26^{A,a,B}$	$24.97\pm0.23^{A,b,B}$	$24.6\pm0.22^{A,c,B}$
	14	$22.07\pm0.19^{B.a,A}$	$21.97\pm0.17^{B.a,A}$	$21.89\pm0.18^{B,b,A}$	$21.65\pm0.25^{B,c,A}$	$25.71\pm0.21^{A,a,A}$	$25.57\pm0.2^{A,a,A}$	$25.34\pm0.22^{A,b,A}$	$25.05\pm0.24^{A,c,A}$
Fat/dm	1	$17.3\pm0.08^{B.a,C}$	$17.15\pm0.05^{B,b,C}$	$17.1\pm0.06^{B,b,C}$	$17\pm0.08^{B,c,C}$	$23.5\pm0.05^{A,a,C}$	$23.38\pm0.07^{A,b,C}$	$23.29\pm0.08^{A,b,C}$	$23.2\pm0.05^{A,c,C}$
	7	$17.47\pm0.07^{B.a,B}$	$17.3\pm0.06^{B,b,B}$	$17.31\pm0.04^{B,b,B}$	$17.2\pm0.07^{B,c,B}$	$23.73\pm0.06^{A,a,B}$	$23.55\pm0.07^{A,b,B}$	$23.55\pm0.05^{A,b,B}$	$23.4\pm0.04^{A,c,B}$
	14	$17.74\pm0.06^{B.a,A}$	$17.65\pm0.05^{B,b,A}$	$17.7\pm0.07^{B,b,A}$	$17.58\pm0.06^{B,c,A}$	$24.16\pm0.06^{A,a,A}$	$23.96\pm0.06^{A,b,A}$	$23.9\pm0.06^{A,b,A}$	$23.83\pm0.03^{A,c,A}$
Protein/dm	1	$14.95\pm0.07^{B.a,C}$	$14.94\pm0.06^{B,b,C}$	$14.89\pm0.08^{B,b,C}$	$14.85\pm0.06^{B,c,C}$	$18.85\pm0.08^{A,a,C}$	$18.83\pm0.04^{A,b,C}$	$18.75\pm0.06^{A,b,C}$	$18.65\pm0.05^{A,c,C}$
	7	$15.1\pm0.05^{B.a,B}$	$15.07\pm0.06^{B,b,B}$	$15.07\pm0.06^{B,b,B}$	$15.03\pm0.04^{B,c,B}$	$19.03\pm0.06^{A,a,B}$	$18.97\pm0.07^{A,b,B}$	$18.96\pm0.05^{A,b,B}$	$18.81\pm0.03^{A,c,B}$
	14	$15.77\pm0.07^{B.a,A}$	$15.37\pm0.05^{B,b,A}$	$15.42\pm0.04^{B,b,A}$	$15.36\pm0.07^{B,c,A}$	$19.38\pm0.06^{A,a,A}$	$19.3\pm0.06^{A,b,A}$	$19.25\pm0.05^{A,b,A}$	$19.15\pm0.06^{A,c,A}$
Ash/dm	1	$3.46\pm0.03^{A,a,A}$	$3.48\pm0.06^{A,a,A}$	$3.48\pm0.08^{A,a,A}$	$3.5\pm0.07^{A,a,A}$	$3.26\pm0.04^{A,a,A}$	$3.26\pm0.06^{A,a,A}$	$3.27\pm0.03^{A,a,A}$	$3.29\pm0.04^{A,a,A}$
	7	$3.49\pm0.05^{A,a,A}$	$3.51\pm0.03^{A,a,A}$	$3.52\pm0.06^{A,a,A}$	$3.54\pm0.06^{A,a,A}$	$3.29\pm0.05^{A,a,A}$	$3.28\pm0.03^{A,a,A}$	$3.31\pm0.05^{A,a,A}$	$3.31\pm0.02^{A,a,A}$
	14	$3.55\pm0.06^{A,a,A}$	$3.58\pm0.07^{A,a,A}$	$3.6\pm0.08^{A,a,A}$	$3.62\pm0.06^{A,a,A}$	$3.35\pm0.06^{A,a,A}$	$3.34\pm0.06^{A,a,A}$	$3.37\pm0.06^{A,a,A}$	$3.36\pm0.06^{A,a,A}$

* Treatments: Control; T_1; T_2 and T_3 consist of goat or sheep milk pudding samples supplemented with (0%, 1.5%, 3% and 5%) strawberry puree, respectively.
Results are the mean of three different determinations _ standard deviation, and letters of significant effects of factors (the type of milk, fruit concentration, storage time), respectively. Means that are followed by the same letter in the row and the same capital letter in the column did not differ significantly ($p \leq 0.05$).

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Continue (Table 3): Effect of different levels of strawberry puree on the physicochemical properties of pudding based on goat and sheep milk during cooled storage for 14 days.

Properties	Storage time (days)	Treatments*							
		Goat milk				Sheep milk			
		Control	T_1	T_2	T_3	Control	T_1	T_2	T_3
Total carbohydrates/ dm	1	$63.25\pm0.25^{A,b}$	$63.3\pm0.22^{A,b,C}$	$63.44\pm0.26^{A,a,}$	$63.65\pm0.27^{A,a,}$	$55.59\pm0.23^{B,b,C}$	$55.84\pm0.3^{B,b,C}$	$56.06\pm0.26^{B,a,}$	$56.25\pm0.26^{B,a,C}$
	7	$63.87\pm0.29^{A,b}$	$63.89\pm0.27^{A,b,B}$	$64.22\pm0.24^{A,a,}$	$64.4\pm0.23^{A,a,B}$	$56.12\pm0.24^{B,b,B}$	$56.24\pm0.31^{B,b,}$	$56.7\pm0.25^{B,a,B}$	$56.73\pm0.3^{B,a,B}$
	14	$64.88\pm0.28^{A,b}$	$65.14\pm0.28^{A,b,A}$	$65.69\pm0.25^{A,a,}$	$65.84\pm0.28^{A,a,}$	$57.15\pm0.05^{B,b,A}$	$57.23\pm0.31^{B,b,}$	$57.54\pm0.3^{B,a,A}$	$57.77\pm0.25^{B,a,A}$
Fibers (mg/100g)	1	$0.03\pm0.01^{A.d,}$	$28.27\pm0.07^{A,c,C}$	$55.2\pm0.05^{A,b,C}$	$84.45\pm0.07^{A,a,}$	$0.01\pm0.01^{A,d,C}$	$25.81\pm0.06^{A,c,}$	$51.07\pm0.04^{A,b,}$	$100.26\pm0.06^{A,a,}$
	7	$0.05\pm0.03^{A.d,}$	35.76 ± 0.06	$55.11\pm0.07^{A,b,}$	95.51 ± 0.08	$0.03\pm0.01^{A,d,B}$	28.96 ± 0.07	$55.71\pm0.06^{A,b,}$	$107.27\pm0.07^{A,a,}$
	14	$0.05\pm0.04^{A.d,}$	$36.11\pm0.05^{A,c,A}$	$64.93\pm0.08^{A,b,}$	$96.12\pm0.04^{A,a,}$	$0.02\pm0.01^{A,d,A}$	$36.11\pm0.04^{A,c,}$	$65.44\pm0.05^{A,b,}$	$111.05\pm0.06^{A,a,}$
pH-Values	1	$6.37\pm0.02^{B,a,}$	$6.34\pm0.01^{B,b,A}$	$6.32\pm0.02^{B,b,A}$	$6.27\pm0.01^{B,c,A}$	$6.69\pm0.03^{A,a,A}$	$6.54\pm0.02^{A,b,A}$	$6.46\pm0.05^{A,b,A}$	$6.44\pm0.02^{A,b,A}$
	7	$6.35\pm0.02^{B,a,}$	$6.33\pm0.01^{B,b,A}$	$6.31\pm0.01^{B,b,A}$	$6.27\pm0.01^{B,c,A}$	$6.64\pm0.03^{A,a,A}$	$6.49\pm0.03^{A,b,A}$	$6.42\pm0.01^{A,b,A}$	$6.35\pm0.05^{A,b,A}$
	14	$6.34\pm0.01^{B,a,}$	$6.31\pm0.02^{B,b,A}$	$6.30\pm0.02^{B,b,A}$	$6.25\pm0.01^{B,c,A}$	$6.61\pm0.02^{A,a,A}$	$6.46\pm0.01^{A,b,A}$	$6.37\pm0.05^{A,b,A}$	$6.35\pm0.04^{A,b,A}$
Acidity (%)	1	$0.27\pm0.03^{A,b,}$	$0.31\pm0.02^{A,ab,A}$	$0.33\pm0.03^{A,a,A}$	$0.35\pm0.02^{A,a,A}$	$0.16\pm0.05^{B,b,B}$	$0.22\pm0.03^{B,ab,}$	$0.26\pm0.05^{B,a,A}$	$0.29\pm0.03^{B,a,A}$
	7	$0.28\pm0.02^{A,b,}$	$0.32\pm0.02^{A,ab,A}$	$0.35\pm0.02^{A,a,A}$	$0.36\pm0.03^{A,a,A}$	$0.18\pm0.02^{B,b,B}$	$0.23\pm0.03^{B,ab,}$	$0.28\pm0.01^{B,a,A}$	$0.31\pm0.02^{B,a,A}$
	14	$0.30\pm0.03^{A,b,}$	$0.33\pm0.03^{A,ab,A}$	$0.36\pm0.02^{A,a,A}$	$0.38\pm0.03^{A,a,A}$	$0.21\pm0.03^{B,b,B}$	$0.26\pm0.05^{B,ab,}$	$0.31\pm0.02^{B,a,A}$	$0.34\pm0.02^{B,a,A}$

* Treatments: Control; T_1; T_2 and T_3 consist of goat or sheep milk pudding samples supplemented with (0%, 1.5%, 3% and 5%) strawberry puree, respectively.

Results are the mean of three different determinations _ standard deviation, and letters of significant effects of factors (the type of milk, fruit puree ratio, storage period), respectively. Means that are followed by the same letter in the row and the same capital letter in the column did not differ significantly ($p \leq 0.05$).

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The inclusion of SP in pudding based on goat or sheep milks significantly improved their antioxidant contents ($p \leq 0.05$) as compared with the control. Typically, strawberries contain antioxidant compounds such as anthocyanins and ellagitannins, which are effective in detoxifying the body from carcinogens (Widyastuti and Desfita, 2020). The results of the total antioxidant activity of pudding samples are shown in Fig. 1. The highest concentration of total antioxidant content was found in goat milk-based pudding. In fact, the addition of 5% of SP (T3) led to a significant increase in total antioxidants with an amount of 61.24 and 45.55 mg/100g, in comparison with the pudding control samples (15.29 and 16.25 mg/100g for pudding based on goat and sheep milk, respectively. The increase in total antioxidants in the pudding samples is due to their enrichment with SP.

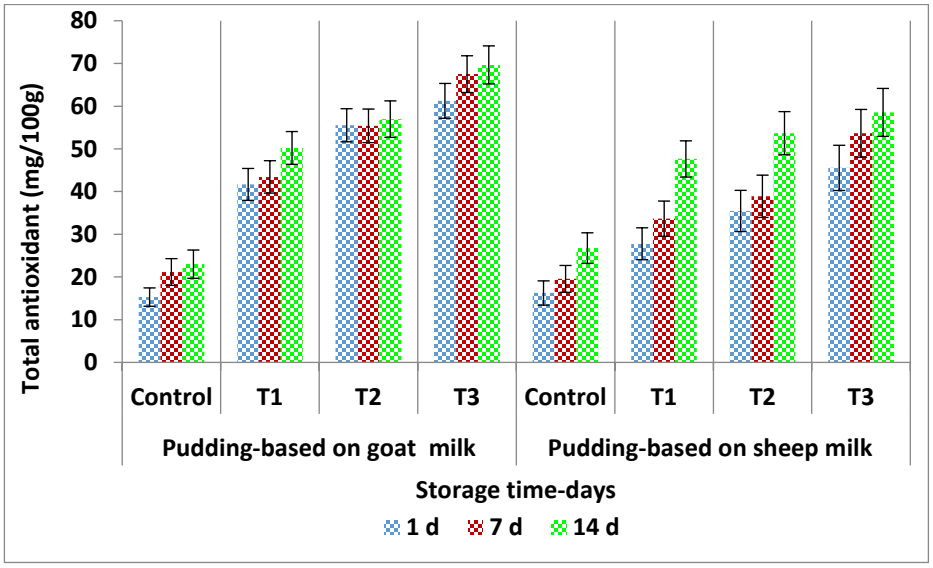

Fig.(1): Effect of different ratios of strawberry puree on total antioxidant content (mg/100g) of pudding based on goat and sheep milk during cooled storage for 14 days.

* Treatments: Control; T_1; T_2 and T_3 consist of goat or sheep milk pudding samples supplemented with (0%, 1.5%, 3% and 5%) strawberry puree, respectively.

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Texture profile analysis of pudding- based goat and sheep milk:

Pudding is formed through gel formation, a process wherein polymer chains (comprising polysaccharides and proteins) associate or crosslink, resulting in a three-dimensional network. This network forms a sturdy structure that entraps or immobilizes water, thereby enhancing flow resistance (Saha & Bhattacharya, 2010). Texture analysis serves as a technique for food quality control (Awad, 2011). Fig. 2 (a, b, and c) show the texture profile analysis of the goat and sheep milk pudding samples, detailing their firmness, cohesiveness, and adhesiveness, The incorporation of strawberry puree into the goat and sheep milk pudding led to a significant decrease ($p \leq 0.05$) in the texture parameters of the flavored pudding samples as compared to the control. All pudding samples exhibit a semi-liquid, creamy structure in terms of texture. The texture was uniformly smooth, without any clumps. This particular consistency is deemed suitable for children aged 10–16 months, characterized as being flowy, slightly thick, and requiring a thickening agent if intended for adult consumption. Individuals with dysphagia have effectively utilized semi-liquid textures in food (Wu *et al.,* 2021).

Firmness is associated with the product's structural strength during compression and represents the highest force exerted during the initial compression bite (Radoˇcaj *et al.,* 2012). According to the data in Fig.2(a), significant differences were found in the texture parameters of puddings based on goat and sheep milk. The greatest firmness was observed in T_3-pudding based goat milk (691.04 N), while the lowest was in control-pudding based sheep milk (149.84 N). Both milk puddings prepared with strawberry puree most probably show lower firmness values because of their higher moisture content compared to the control. Increased moisture availability reduces the amylose network's ability to firm up the starch gel.

Consistency is defined as the strength of the internal bonds within the food matrix and the amount of force required to deform them prior to rupture (Chandra & Shamasundar, 2015). As shown in Fig.2(b), the pudding treatments have a very tender texture, the consistency values vary from 4925.63 to 916.86 for control pudding- based sheep milk and

T_3-based goat milk, respectively. Consistency reflects the product's capacity to bind (Rahman & Al-Mahrouqi, 2009).

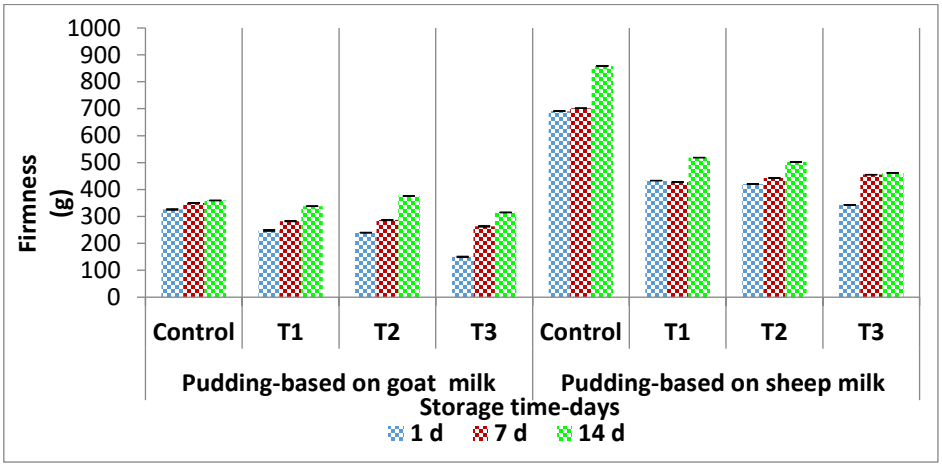

Fig.2(a): Effect of different ratios of strawberry puree on the texture profile analysis (firmness) of pudding based on goat and sheep milk during cooled storage for 14 days.

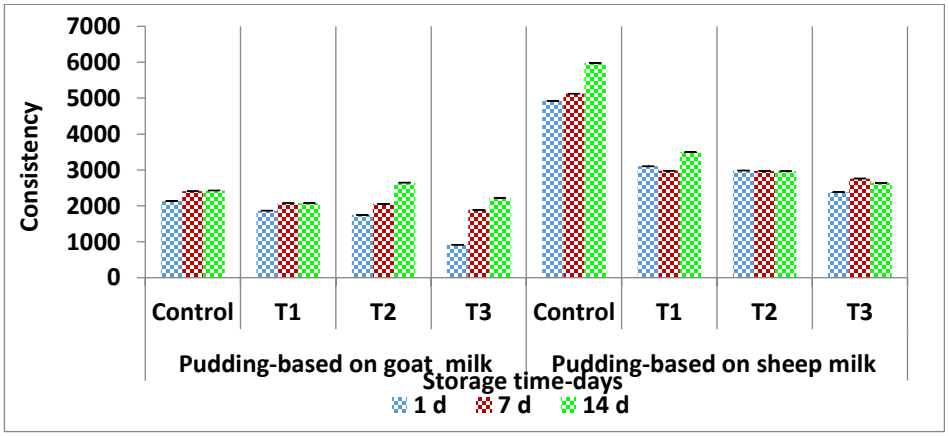

Fig.2(b): Effect of different ratios of strawberry puree on the texture profile analysis (consistency) of pudding based on goat and sheep milk during cooled storage for 14 days.

* Treatments: Control; T_1; T_2 and T_3 consist of goat or sheep milk pudding samples supplemented with (0%, 1.5%, 3% and 5%) strawberry puree, respectively.

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Adhesiveness is described as the work required to dislodge food sticking to the mouth, typically the palate, during the regular process of swallowing (Bourne, 2002). The pudding treatments show that those prepared with strawberry puree form a less adhesiveness structure with significant differences observed as compared to control samples, Fig.2(c). Cooled storage for 14 days led to a significant increase ($p \leq 0.05$) in texture parameter values of all pudding samples.

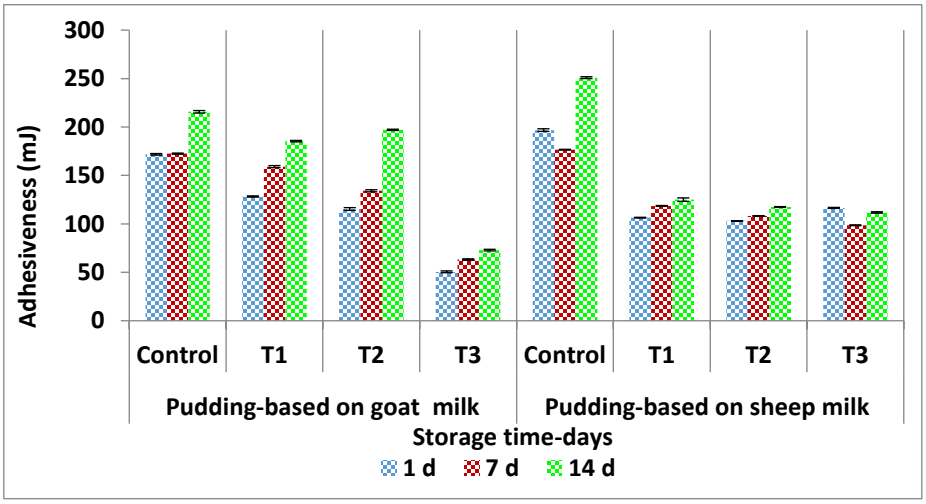

Fig.2(c): Effect of different ratios of strawberry puree on the texture profile analysis (adhesiveness) of pudding based on goat and sheep milk during cooled storage for 14 days.

* Treatments: Control; T_1; T_2; and T_3 consist of goat or sheep milk pudding samples supplemented with (0%, 1.5%, 3% and 5%) strawberry puree, respectively.

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Sensory evaluation of strawberry-flavored goat and sheep milk puddings:

The sensory evolution scores of goat and sheep milk pudding samples are shown in Table 4. According to fruit puree ratio, the incorporation of strawberry puree into the goat and sheep milk pudding formulations improved the sensory attributes and led to a significant increase ($p \leq 0.05$) in all sensorial scores as compared to the control. In order to milk type pudding based on sheep milk observed the higher sensorial scores than pudding based goat milk, and significant differences were found. Fontecha *et al.*(2000 & 2005) reported that goat milk has a stronger flavor than sheep milk. This might be due to the liberation of short-chain fatty acids during rough handling, which give off a goaty smell.

The overall acceptability represents the average score of all food attributes assessed in the organoleptic analysis, including taste, texture, color, and odor (Merry Marzeline & Adi, 2017). The T_3-pudding (5% strawberry puree) samples were most preferred within pudding based on goat milk. Moreover, panelists' preference towards sheep milk pudding samples (5% strawberry puree), its' achieved the highest scores and was mostly appreciated in terms of color, odor, taste, and texture among all pudding samples based on goat and sheep milk**.** The obtained results are in agreement with the findings of Arysanti *et al.* (2019), increasing the amount of fruit added to the pudding results in a greater color change and enhances the pudding's acceptance. Generally, the scores of sensory attributes were decreased during cooled storage for 14 days in all pudding samples.

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Table (4): The effect of different ratios of strawberry puree on the sensory attributes of pudding based on goat and sheep milk during cooled storage for 14 days.

Properties	Storage time (days)	Treatments *							
		Goat milk				Sheep milk			
		Control	T_1	T_2	T_3	Control	T_1	T_2	T_3
Color (10)	1	$8.1\pm0.88^{B,c,A}$	$8.2\pm0.79^{B,bc,A}$	$8.5\pm1.08^{B,ab,A}$	$9\pm0.94^{B,a,A}$	$9.0\pm0.47^{A,c,A}$	$9.1\pm0.74^{A,bc,A}$	$9.3\pm0.82^{A,ab,A}$	$9.5\pm0.53^{A,a,A}$
	7	$8\pm0.67^{B,c,AB}$	$8.1\pm0.32^{B,bc,AB}$	$8.5\pm0.53^{B,ab,AB}$	$8.8\pm0.79^{B,a,AB}$	$8.7\pm0.48^{A,c,AB}$	$9.0\pm0.66^{A,bc,A}$	$9.3\pm0.48^{A,ab,AB}$	$9.3\pm0.48^{A,a,AB}$
	14	$7.8\pm0.63^{B,c,B}$	$8.1\pm0.57^{B,bc,B}$	$8.2\pm0.92^{B,ab,B}$	$8.6\pm0.51^{B,a,B}$	$8.6\pm0.52^{A,c,B}$	$9.0\pm0.67^{A,bc,B}$	$9.2\pm0.79^{A,ab,B}$	$9.1\pm0.32^{A,a,B}$
Odor (10)	1	$8.3\pm0.67^{B,b,A}$	$8.5\pm0.85^{B,a,A}$	$8.6\pm0.52^{B,a,A}$	$8.7\pm0.48^{B,a,A}$	$8.4\pm0.97^{A,b,A}$	$9.2\pm0.63^{A.a,A}$	$9.2\pm0.79^{A,a,A}$	$9.3\pm0.48^{A,a,A}$
	7	$8.3\pm0.48^{B,b,A}$	$8.4\pm0.52^{B,a,A}$	$8.55\pm0.50^{B,a,A}$	$8.5\pm0.53^{B,a,A}$	$8.4\pm0.70^{A,b,A}$	$9.1\pm0.57^{A,a,A}$	$9.1\pm0.57^{A,a,A}$	$9.2\pm0.42^{A,a,A}$
	14	$8.3\pm0.48^{B,b,A}$	$8.4\pm0.97^{B,a,A}$	$8.35\pm0.58^{B,a,A}$	$8.4\pm0.52^{B,a,A}$	$8.3\pm0.82^{A,b,A}$	$8.9\pm0.31^{A,a,A}$	$8.9\pm0.32^{A,a,A}$	$9.0\pm0.0^{A,a,A}$
Taste (10)	1	$7.7\pm1.16^{B,c,A}$	$8.0\pm0.47^{B,b,A}$	$8.5\pm0.95^{B,ab,A}$	$8.7\pm0.95^{B,a,A}$	$8.2\pm0.63^{A,c,A}$	$8.9\pm0.57^{A,b,A}$	$8.9\pm0.57^{A,ab,A}$	$9.2\pm0.63^{A,a,A}$
	7	$7.3\pm0.95^{B,c,B}$	$7.65\pm0.47^{B,b,B}$	$8.1\pm0.57^{B,ab,B}$	$8.2\pm0.92^{B,a,B}$	$7.9\pm0.57^{A,c,B}$	$8.8\pm0.42^{A,b,B}$	$8.9\pm0.56^{A,ab,B}$	$9.2\pm0.42^{A,a,B}$
	14	$7.1\pm0.74^{B,c,B}$	$7.4\pm0.52^{B,b,B}$	$7.65\pm0.58^{B,ab,B}$	$7.8\pm0.79^{B,a,B}$	$7.9\pm0.73^{A,c,B}$	$8.7\pm0.48^{A,b,B}$	$8.8\pm0.42^{A,ab,B}$	$9.1\pm0.32^{A,a,B}$
Texture (10)	1	$8.3\pm0.48^{B,a,A}$	$8.35\pm0.58^{B,a,A}$	$8.5\pm0.53^{B,a,A}$	$8.5\pm0.52^{B,a,A}$	$8.6\pm0.52^{A.a,A}$	$8.7\pm0.67^{A,a,A}$	$8.7\pm0.67^{A,a,A}$	$8.8\pm0.63^{A,a,A}$
	7	$8.2\pm0.63^{B,a,AB}$	$8.3\pm0.48^{B,a,AB}$	$8.4\pm0.52^{B,a,AB}$	$8.4\pm0.52^{B,a,AB}$	$8.5\pm0.53^{A.a,AB}$	$8.7\pm0.67^{A.a,AB}$	$8.6\pm0.52^{A.a,AB}$	$8.8\pm.42^{A.a,AB}$
	14	$8.0\pm0.67^{B,a,B}$	$8.2\pm0.63^{B,a,B}$	$8.3\pm0.67^{B,a,B}$	$8.2\pm0.63^{B,a,B}$	$8.3\pm0.67^{A.a,B}$	$8.5\pm0.53^{A.a,B}$	$8.5\pm0.53^{A.a,B}$	$8.6\pm0.52^{A.a,B}$
Overall acceptability	1	$8.2\pm0.63^{B,b,A}$	$8.2\pm0.42^{B,a,A}$	$8.5\pm0.48^{B,a,A}$	$8.7\pm0.48^{B,a,A}$	$8.3\pm0.67^{A,b,A}$	$9.0\pm0.82^{A,a,A}$	$9.2\pm0.79^{A,a,A}$	$9.1\pm1.00^{A,a,A}$
	7	$8.1\pm0.74^{B,b,A}$	$8.2\pm0.42^{B,a,A}$	$8.4\pm0.52^{B,a,A}$	$8.5\pm0.53^{B,a,A}$	$8.2\pm0.63^{A,b,A}$	$9.0\pm0.67^{A,a,A}$	$9.3\pm0.48^{A,a,A}$	$9.1\pm0.98^{A,a,A}$
	14	$8.1\pm0.88^{B,b,A}$	$8.2\pm0.79^{B,a,A}$	$8.5\pm1.08^{B,a,A}$	$9\pm0.94^{B,a,A}$	$8.2\pm0.63^{A,b,A}$	$8.8\pm0.63^{A,a,A}$	$9.0\pm0.47^{A,a,A}$	$9.0\pm0.94^{A,a,A}$

* Treatments: Control; T_1; T_2 and T_3 consist of goat or sheep milk pudding samples supplemented with (0%, 1.5%, 3% and 5%) strawberry puree, respectively.

Results are the mean of three different determinations _ standard deviation, and letters of significant effects of factors (the type of milk, fruit puree ratio, storage period), respectively. Means that are followed by the same letter in the row and the same capital letter in the column did not differ significantly ($p \leq 0.05$).

CONCLUSION

In recent years, consumer demand for health-promoting foods has surged as people become more aware of the connection between diet and health. Additionally, the sensory attributes of the product play a crucial role in determining its acceptance among consumers. Strawberry puree was found to be a good flavor to mask the undesirable flavor of goat and sheep milks and was successfully applied in the pudding industry to improve the properties of pudding based on goat and sheep milk.

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الملخص العربى

دراسة تأثير بيوريه الفراولة على خصائص الجودة للبودنج المصنع من ألبان الماعز والأغنام

مى جلال محمد – أحمد محمد هلال[1] – سامح على عوض[2] – سامح سعيد يعقوب[1]
(1) قسم علوم وتكنولوجيا الأغذية والألبان ، كلية الزراعة ، جامعة دمنهور ، ، مصر.
(2) قسم علوم وتقنية الألبان ، كلية الزراعة ، جامعة الإسكندرية ، مصر.

تم إجراء البحث بهدف دراسة تأثير تعزيز/ تدعيم البودنج المصنع من ألبان الماعز أو الأغنام بمستويات مختلفة من بيوريه الفراولة بنسب 1.5%، 3% و 5% على الخصائص الطبيعية والكيماوية والريولوجية والحسية للمنتجات. أظهرت النتائج أن نوع اللبن وإضافة بيوريه الفراولة كان له تأثير معنوي على الخواص الطبيعية والكيماوية لعينات البودنج. أظهرت عينات البودنج المُطعم ببيوريه الفراولة والمصنع من ألبان الماعز أو الأغنام محتوىً أعلى من الكربوهيدرات والرماد والألياف ومضادات الأكسدة مع وجود فروق معنوية ($p\leq0.05$) مقارنة بعينات الكنترول، بينما كان محتواها من المادة الجافة والدهن والبروتين على العكس من ذلك. أظهرت عينات البودنج المصنع من لبن الماعز والمُطعم ببيوريه الفراولة بنسبة 5% أعلى محتوى من مضادات الأكسدة (61.24 مجم/100 جم)؛ بالإضافة إلى ذلك، في حين كان البودنج المصنع من لبن الأغنام والمُطعم ببيوريه الفراولة بنسبة 5% أعلى محتوى للألياف (100.26±0.06 مجم/100 جم) ، بينما أظهرت العينات المُطعمة بنسبة 1.5% و 3% زيادة في محتواها من مضادات الأكسدة والألياف مقارنة بالكنترول. أدى دمج بيوريه الفراولة إلى حدوث انخفاض معنوي ($p\leq0.05$) في قيم خصائص القوام لعينات البودنج المصنع من ألبان الماعز والأغنام والمُطعم ببوريه الفراولة مقارنة بالكنترول. أظهرت نتائج التقييم الحسي أن إضافة بيوريه الفراولة ساهمت بشكل معنوي ($p\leq 0.05$) في تحسين صفات عينات البودنج المصنع من ألبان الماعز أو الأغنام، مما أدى إلى زيادة القبول لدى المستهلكين. علاوة على ذلك، من بين جميع العينات حصلت عينات البودنج المصنع من لبن الأغنام المُطعم ببيوريه الفراولة بنسبة 5% على أعلى الدرجات وكانت الأكثر تفضيلا من حيث اللون والرائحة والطعم والقوام بين جميع عينات البودنج. أظهرت إضافة بيوريه الفراولة الحفاظ على جودة البودنج خلال التخزين المبرد على درجة حرارة 5 درجات مئوية لمدة 14 يومًا. والخلاصة، التعزيز/ التدعيم ببيوريه الفراولة ساهم في تحسين الخصائص الطبيعية والكيماوية والريولوجية والحسية لكل من البودنج المصنع من ألبان الماعز والأغنام.