Yield, Composition, Texture, and Sensory Characteristics of Cottage Cheese Produced with the Incorporation of Different Herb Extracts

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Abstract. Herb cheese is cheese that contains herbs extracted for their antioxidant and bioactive properties. This study aims to determine the impact of adding herb leaf extracts to cottage cheese on its yield, composition, texture, and sensory characteristics. Three different herbs were used to prepare the extracts: bidara (*Ziziphus mauritiana*), moringa (*Moringa oleifera*), and bay (*Syzygium polynthum*). Cottage cheese was made in the the following process: cheese made of full-fat milk (FF), cheese made of low-fat milk (LF), cheese made of low-fat milk + 20% bidara extract (LB), cheese made of low-fat milk + 20% bay extract (LS), cheese made of low-fat milk + 20% moringa extract (LM), cheese made of low-fat milk + 10% bidara extract + 10% bay extract (LBS), cheese made of low-fat milk + 10% bidara extract + 10% moringa extract (LBM), cheese made of low-fat milk + 10% bay extract + 10% moringa extract (LSM) and cheese made of low-fat milk + 6.67% bidara + 6.67% bay + and 6.67% moringa extracts (LBSM). Each treatment was replicated three times. The variables included cheese yield, compositions, texture profile, and sensory characteristics. Herb extracts resulted in a slight variation in cheese yields ranging from 7.73 to 13.8%. Full-cream milk (FF) cheese contained the least moisture, while low-fat bay+moringa (LSM) cheese contained the most protein and the least fat. The texture profile showed a significant difference in hardness, cohesiveness, adhesiveness, gumminess, and chewiness but the springiness and resilience were similar. Herb extracts significantly contributed to the variation of sensory characteristics, including flavor, aroma, texture, and color. Adding herb extracts produces cheese with a slightly grassy aroma and bitter flavor. The addition of bidara, moringa, and bay leaf extracts during the manufacture of cottage cheese from cow milk resulted in the variation in yield, textures, composition, and sensory characteristics. Adding herbs produces cheese with higher moisture content but lower ash content than non-herb cheese. Cheese made with the addition of bay leaf extract had a higher hardness level than the control cheese and cheese added with other herbal extracts. The addition of herbal extracts makes a noticeable color change in cheese.

Keywords: Cheese, extract, herbs, sensory, texture profile

Abstrak. Keju herbal merupakan sejenis keju yang mengandung herbal yang diekstraksi karena memiliki sifat antioksidan dan bioaktif. Penelitian ini bertujuan untuk mengetahui pengaruh penambahan ekstrak daun herbal pada keju cottage terhadap rendemen, komposisi, tekstur, dan karakteristik sensori. Tiga herbal yang berbeda digunakan untuk membuat ekstrak: bidara (*Ziziphus mauritiana*), kelor (*Moringa oleifera*), dan salam (*Syzygium polynthum*). Keju cottage dibuat sebagai berikut: keju dari susu full-fat (FF), keju dari susu rendah lemak (LF), keju dari susu rendah lemak + 20% ekstrak bidara (LB), keju dari low- susu lemak + 20% ekstrak salam (LS), keju dari susu rendah lemak + 20% ekstrak kelor (LM), keju dari susu rendah lemak + 10% ekstrak bidara + 10% ekstrak salam (LBS), keju yang dibuat susu rendah lemak + 10% ekstrak bidara + 10% ekstrak kelor (LBM), keju dari susu rendah lemak + 10% ekstrak salam + 10% ekstrak kelor (LSM) dan keju dari susu rendah lemak + 6,67% bidara + 6,67% salam + dan 6,67% ekstrak kelor (LBSM). Setiap perlakuan dilakukan ulangan sebanyak tiga kali. Variabel tersebut meliputi rendemen keju, komposisi, profil tekstur, dan karakteristik sensori. Ekstrak herbal menghasilkan sedikit variasi dalam rendemen keju mulai dari 7,73 hingga 13,8%. Keju full cream milk (FF) mengandung kadar air paling sedikit, sedangkan keju salam+kelor(LSM) rendah lemak mengandung protein paling banyak dan paling sedikit lemak. Profil tekstur menunjukkan perbedaan yang signifikan pada kekerasan, kekompakan, kelengketan, gumminess, dan kekenyalan tetapi kekenyalan dan kekenyalannya relatif sama. Ekstrak herbal memberikan kontribusi yang signifikan terhadap variasi karakteristik sensorik, termasuk rasa, aroma, tekstur, dan warna. Penambahan ekstrak herbal menghasilkan keju dengan aroma seperti daun dan rasa pahit.

Kata kunci: Keju, ekstrak, herbal, sensori, profil tekstur

Introduction

Cheese is an excellent source of protein, fat, essential fatty acids, and minerals, including calcium and phosphorus. Low-fat cheese is produced from low-fat milk. Low-fat milk is favored by people attempting to limit their fat consumption. As the composition of low-fat milk differs from that of whole milk in terms of the proportion of fat, reducing the fat content will modify the quality of the milk's primary constituents, such as making it less creamy and less aromatic. Therefore, low-fat cheese is the optimal ingredient for making functional food products, particularly for consumers who limit fat consumption.

Developing functional foods for dairy products fortified with natural herbs would provide health benefits. Plant-based antioxidants are mainly phenolic compounds, carotenoids, and vitamins, while animal-based antioxidants are mainly whole proteins or peptides of meat, fish, egg, milk, and plant proteins. The plant-based and animal-based antioxidants consist mainly of aromatic rings and amino acids, respectively (Abeyrathne et al., 2022). Herbs, such as bidara (Ziziphus mauritiana), moringa (Moringa oleifera), and bay (Syzygium polynthum) are functional food ingredients as well as natural preservatives. The antioxidant properties of moringa are positively correlated with the total phenolic (Molehin and Adefegha, 2014; Adefegha et al., 2016).

The addition of herbal extract to low-fat milk in cheese production may alter cheese characteristics, including fat content, color, texture, and sensory. Besides antioxidant properties, leaves of herbs contain antimicrobial activities against Staphylococcus aureus, Listeria monocytogenes, Salmonella typhimurium, and Escherichia coli. Leaves of bay plants are common ingredients that generate specific flavors for traditional Indonesian food. Bay leaves contain bioactive components, such as antimicrobials (Kusuma et al., 2011) and antioxidants (Hidayati et al., 2017). Environmental conditions and the growth location affect the metabolites produced by moringa leaves (Olaoye et al., 2021).

Nutrition experts emphasize the existence of bioactive compounds in dairy products (Sánchez-Muñoz et al., 2017). Plant raw materials are excellent sources of phenolic compounds for the enrichment of yogurt (Kulaitienė et al., 2021). Some phenolic compounds are extracted from various plants to improve the functional properties of dairy products (Boroski et al., 2012). Products fortified with phenolic compounds are yogurt (Boroski et al., 2012), goat milk, whey, and cheese (Chávez-Servín et al., 2018).

Herb extracts are beneficial as preservatives, notably in dairy products. Incorporating varying proportions of herbs into cheese will modify the cheese's general properties, enhancing its functional characteristics. Herbs have distinct characteristics, such as aroma and color, that Indonesians typically incorporate into food and traditional medicine. Bidara, moringa, and bay plants are widespread, environment-tolerant, and inexpensive. The addition of these three herbs is to produce cottage cheese with distinctive characteristics. Thus, this study aimed to examine the effects of adding various herb extracts on the product yield, composition, texture, and sensory characteristics of cottage cheese manufactured from low-fat milk.

Materials and Methods

Cheese Manufacture and Treatments

Nine treatments were assigned in the making of cottage cheese, each with three replicates. Full-fat milk standardized at 4.0% fat content and commercially available low-fat milk standardized at 1% fat content were used in this study.

Table 1. Treatments

Abbreviation	Description
FF	cheese made of full-fat milk,
LF	cheese made of low-fat milk,
LB	cheese made of low-fat milk + 20% *bidara* extract,
LS	cheese made of low-fat milk + 20% bay extract,
LM	cheese made of low-fat milk + 20% moringa extract,
LBS	cheese made of low-fat milk + 10% *bidara* + 10% bay extracts,
LBM	cheese made of low-fat milk + 10% *bidara* + 10% moringa extracts,
LSM	cheese made of low-fat milk + 10% bay + 10% moringa extracts,
LBSM	cheese made of low-fat milk + 6.67% *bidara* + 6.67% bay + and 6.67% moringa extracts.

Table 2. The texture profile of cheese

Texture Parameter	Description
Hardness (N)	Force required for a pre-determined deformation
Cohesiveness (no unit)	Strength of internal bonds in the sample
Adhesiveness (J)	Work required to overcome the sticky forces between the sample and the probe
Gumminess (N)	Energy needed to disintegrate the sample until it is ready to swallow
Chewiness (J)	Energy needed to chew the sample until it is ready for swallowing
Springiness (mm)	Rate at which a deformed sample returns to its original size and shape

Preparation of Herb Leaf Extracts

The leaves of *bidara*, moringa dan bay plants were washed and cleaned from twigs and attached dirt. Then, the leaves were dried in a conventional dryer at 70^{o}C for 8 hours, then pulverized using an electric grinder, and the powdered leaves were sieved to obtain fine powder. Herb extracts were prepared by mixing powdered leaves with water in a ratio of 1:10 (w/w), then stored at a cold temperature.

Preparation of Cottage Cheese

Cottage cheese was prepared according to procedures described by Setyawardani *et al*. (2017). Raw material for cheese was cow milk, both full-fat or low-fat. Initially, full-fat milk was pasteurized at 72oC for 30s, and the commercial low-fat milk was warmed to 50oC. Each type of milk was added with different powdered herb leaves extract (*bidara*, moringa, bay, and their combination) according to treatments. Then, a mesophilic cheese starter was added, followed by incubation until the pH reached 6.1. Animal rennet was incorporated to achieve perfect coagulation, and the formed curd was immediately cut. The curd was heated at 40oC and filtered to separate the remaining whey. The formed curd was hung, pressed to solid, and ready for measurement and evaluation.

Measurements

The milk compositions were measured using a milk analyzer (Lactoscan, Milkotronik Ltd. Bulgaria), and the powdered herbs were subjected to the proximate analysis (AOAC, 2005). Product yield (%) was measured as the ratio of fresh cheese to the weight of milk, and titratable acidity (% acid) was measured by titration.

The texture profile of cheese was measured according to Chavan and Goyal (2018) using a texturometer (TAXT plus, Stable Microsystem, Godalming UK) connected to Exponent Lite ver. 6.1.17.0. The texturometer was loaded with a 5kg load cell and probe P/35 (35-mm diameter) aluminum cylinder. The cheese sample was cut 1 x 1 x 1 cm. The pre-test speed setting was one mm/d, the test speed was 5 mm/d, the post-test speed was 5 mm/d, the target mode wa a distance of 5 mm (50 % strain), the trigger auto force was 5g, and the compression interval was

5 seconds. The measured cheese profile includes hardness (g), fracturability (g), adhesiveness (g.sec), springiness, cohesiveness, gumminess, chewiness, and resilience.

Semi-trained panelists evaluated the sensory characteristics (flavor, aroma, texture, color, and general preference) using a scoring method (Setyawardani et al., 2018). Aroma is generated by chemical stimuli and caught by the olfactory nerves in the nasal cavity. Cheese aroma is produced by substances in lactic acid bacteria that emit aroma and acid. Color is the first sensory that can be seen directly by the panelists. The texture referred to the softness of the cheese measured by the panelists' sense of touch. The general preference is acceptance panelists. The cheese flavor is a complex sensation comprising aroma, taste, and texture (Singh and Schwan, 2011). The scale flavor is bitter, not bitter, slightly bitter, and rather bitter. The scale aroma is grassy, not grassy, slightly grassy, and rather grassy. The scale texture is soft, not soft, slightly soft, and rather soft. The scale color is green, not green, slightly green, and rather green. The scale general preference is like, dislike, slightly like, and rather like.

Statistical Analysis

Statistical analysis of data for the effects of different herbs on cheese yield, composition, texture, and sensory characteristics of cottage cheese was performed by analysis of variance (ANOVA) procedures using the SPSS program for Windows version 25.0. Tukey's Honest Significant Difference test identified differences among means.

Results and Discussion

Table 3 presents the chemical compositions of milk, bidara, moringa, and bay leaf powder. The protein content of all three powdered herbs was higher than that of milk. Powdered moringa leaf has the highest protein content. Full-fat milk contained a much higher fat content than low-fat milk (4.02 vs. 1.19%). The powdered leaf of bidara, bay dan moringa was acidic. Table 3 shows moringa leaves have the highest protein content. This is in accordance with Abdel-Latif et al. (2022) that moringa leaves contain considerably high crude protein levels, vitamins, minerals, fatty acids, microelements, and antioxidant polyphenols.

Effects of Herbs on Yield of Cottage Cheese

The average cottage cheese yield ranged from 7.73 to 13.8%. incorporating herbs resulted in a slight variation in cheese yield (Figure 1). Low-fat moringa cheese (LM) yielded the most cheese, while low-fat bidara cheese (LB) yielded the least. In general, herb that increases cheese yield is moringa.

Table 3. Chemical compositions of the milk and powdered herbs leaves (%)

Compositions	Full-cream cow milk	Low-fat cow milk	Herbs		
			Bidara	Moringa	Bay
Moisture content	87.6	88.15	11.41	14.41	12.26
Protein	4.32	3.93	11.5	23.42	8.74
Fat	4.02	1.10	1.53	3.14	1.11
Lactose	4.40	5.90	-	-	-
Ash	-		8.56	10.76	4.80
Crude fiber	-		14.5	11.51	20.89
pH	6.77	6.79	5.43	5.59	5.06
Antioxidant (DPPH) (%w/w)	-		90.96	90.54	88.24

Determination of the composition was made in triplicate, no statistical analysis was made.

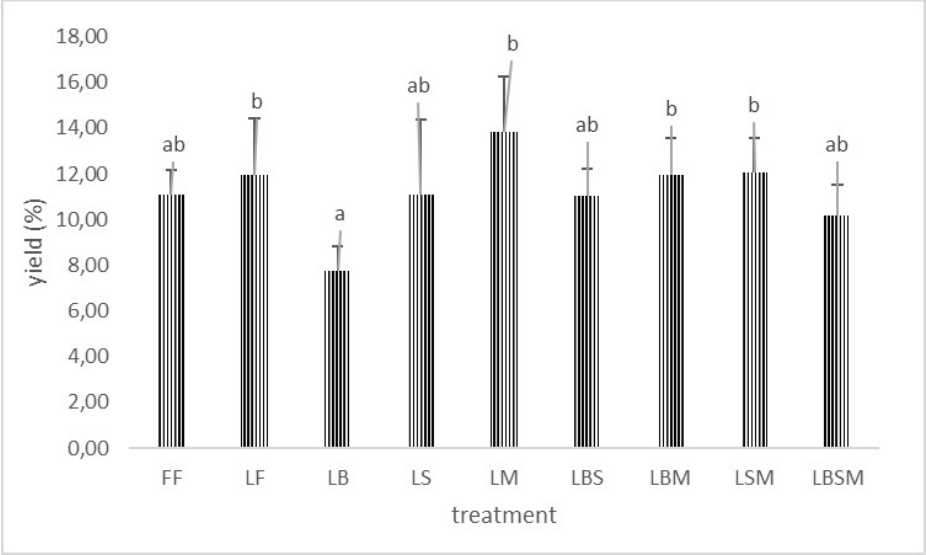

Figure 1. The product yield of cottage cheese added with different herb extracts during the manufacturing process (Cheese made of full-fat milk (FF), cheese made of low-fat milk (LF), cheese made of low-fat milk + 20% bidara extract (LB), cheese made of low-fat milk + 20% bay extract (LS), cheese made of low-fat milk + 20% moringa extract (LM), cheese made of low-fat milk + 10% bidara extract + 10% bay extract (LBS), cheese made of low-fat milk + 10% bidara extract + 10% moringa extract (LBM), cheese made of low-fat milk + 10% bay extract + 10% moringa extract (LSM) and cheese made of low-fat milk + 6.67% bidara + 6.67% bay extract + and 6.67% moringa extract (LBSM)

Table 4. The texture profile of cottage cheese added different herb extracts during the manufacturing process

Cheese	Hardness (N)	Springiness (mm)	Cohesiveness	Adhesiveness (J)	Gumminess (N)	Chewiness (J)
FF	131.22 ^{a}±13.8	0.46±0.01	0.407 ^{bc}±0.0	-8.014 ^{bc}±3.3	57.29 ^{a}±3.2	24.76 ^{a}±0.9
LF	210.41 ^{ab}±5.8	0.52±0.01	0.364 ^{abc}±0.01	-14.966 ^{a}±4.0	73.86 ^{ab}±8.9	37.41 ^{ab}±4.7
LB	616.04^{c}±74.6	0.60±0.06	0.334^{a}±0.01	-4.170 ^{d}±0.8	172.21 ^{c}±9.0	71.81 ^{c}±12.2
LS	168.82^{ab}±20.0	0.46±0.02	0.388^{bcd}±0.03	-4.685 ^{d}±0.4	57.69 ^{a}±0.6	27.53 ^{ab}±3.1
LM	237.89^{b}±29.6	0.52±0.05	0.369 ^{abc}±0.03	-3.038 ^{d}±1.6	92.06 ^{b}±1.8	48.20 ^{b}±4.6
LBS	181.19^{ab}±52.3	0.52±0.1	0.369 ^{abc}±0.01	-3.249 ^{d}±0.7	59.93 ^{a}±12.8	28.59 ^{ab}±15.7
LBM	150.39^{ab}±59.0	0.49±0.08	0.374 ^{abcd}±0.03	-10.504 ^{b}±1.1	65.25 ^{a}±27.2	35.05 ^{ab}±18.4
LSM	202.76 ^{ab}±35.1	0.48±0.01	0.416^{d}±0.03	-4.719^{cd}±0.3	78.16 ^{ab}±3.1	36.04 ^{ab}±1.09
LBSM	216.02 ^{ab}±75.6	0.48±0.01	0.354 ^{ab}±0.01	-4.762 ^{cd}±0.4	76.51 ^{ab}±16.5	46.73 ^{b}±16.0

Means with different superscripts within the same column differ significantly (P<0.05). Cheese made of full-fat milk (FF), cheese made of low-fat milk (LF), cheese made of low-fat milk + 20% bidara extract (LB), cheese made of low-fat milk + 20% bay extract (LS), cheese made of low-fat milk + 20% moringa extract (LM), cheese made of low-fat milk + 10% bidara extract + 10% bay extract (LBS), cheese made of low-fat milk + 10% bidara extract + 10% moringa extract (LBM), cheese made of low-fat milk + 10% bay extract + 10% moringa extract (LSM) and cheese made of low-fat milk + 6.67% bidara + 6.67% bay extract + and 6.67% moringa extract (LBSM)

The influence of adding herbs on variation in cheese yield was minimal. This suggests that herbs had an insignificant effect on the coagulation of milk casein. High yield of LM cheese was positively correlated with high protein content of the powdered moringa leaf. Moringa leaves have a higher protein content than low-fat milk, the addition of moringa leaf powder causes a higher yield of cheese. Prior research demonstrated that the yield of cottage cheese increased significantly with increasing levels of powdered moringa leaves, up to 1, 1.5, and 2 percent (Mahami *et al*., 2012).

Effects of Herbs on Texture of Cottage Cheese

Table 4 demonstrates that the addition of herb extract substantially alters the texture of low-fat cheese. The addition of herbs has a significant effect on hardness, cohesiveness, adhesiveness, gumminess, and chewiness. In contrast, adding herbs did not affect springiness. The highest level of hardness was observed in low-fat cottage cheese added with 20% of bidara leaf extract (LB cheese).

The texture profile is an essential attribute of cheese. The texture profile analysis enables the expressions of hardness, adhesiveness, cohesiveness, springiness, chewiness, and gumminess parameters of cheese (Amar and Surono, 2012). Adding herbs had a significant contribution to the cheese texture profile. Cheese with herbs had a greater level of hardness, adhesiveness, gumminess, and chewiness. While herb's addition improved cheese hardness, the water content of non-herbs cheese is lower than the other cheese. Adding herb extract improved cheese hardness. This result contradicts to that of Wen *et al*. (2021) that hardness, springiness, and chewiness are affected by moisture content. Cheese texture is influenced by many variables, such as the interactions between casein and casein, casein and water, and casein and fat, as well as the state of the water (free or bound in the casein matrix), pH, calcium (ionic or bound in the casein matrix), total sodium chloride, temperature, and proteolysis. Ozcan et al. (2017) found that different raw materials and herbs affect the texture of cheese, as well as the way it is made, how it ripens, how it is packaged, and the temperature at which it is stored.

Parameters observed in the texture profile analysis, hardness, adhesiveness and cohesiveness have been widely used for comparison of the sensory attributes and rheological properties of various foods. Hardness is peak force during the first compression cycle. Adhesiveness is negative force area A_3 for the first bite. Cohesiveness is ratio of positive force area during the second compression to that during the first compression (A_2/A_1) (Nishinari et al., 2013). Gumminess is the result of calculating the hardness value multiplied by the cohesiveness value, which is a characteristic of semi-solid foodstuffs with a low hardness value but a high cohesion value. Chewiness is the result of calculating the gumminess value multiplied by the springiness value. Table 2 shows that LB cheese produced the highest gumminess and chewiness. This is in accordance with Abdelmontaleb et al. (2021) which stated that gumminess and chewiness were higher in QF-added samples than in control, meaning that those samples had stronger internal bonds due to the harder network. Gumminess (hardness × cohesiveness) and chewiness (hardness × cohesiveness × springiness) are the derived textural parameters and their behavior is influenced by the primary parameters they are dependent on.

Effects of Herbs on Compositions of Cottage Cheese

Table 5 shows that compared to the other treatments, the cottage cheese made with low-fat milk and 20% bay extract (LS) had the highest water content, indicating a significant difference from the other treatments. However, despite having the same amounts of fat and ash as the other treatments, this cheese had the lowest protein content (22.18 percent).

The water content of non-fortified cheese is lower than that of other cheese. A high level of water content may be due to the low quantity of water discharged during the pressing stage. Whole-milk cottage cheese had the lowest water content, even lower than that reported previously, i.e., 68% (Mahami et al., 2012), but also had the highest fat content. Traditionally made cheese may contain 80% of water. Regarding protein, adding herbs extracts produced different levels of protein and ash.

Table 5. Compositions and titratable acidity of cottage cheese added with herb extracts (Mean±SD, %)

Cheese	Moisture	Protein	Fat	Ash	Titratable Acidity
FF	44.74 ^{a} ±0.23	25.23 ^{c} ±0.33	21.073 ^{e} ±0.07	2.45 ^{c} ±0.07	0.435±0.085
LF	50.02 ^{b} ±0.19	31.09 ^{h} ±0.15	0.62 ^{ab} ±0.15	2.50 ^{c} ±0.10	0.459±0.059
LB	59.22 ^{e} ±0.45	25.10 ^{c} ±0.10	0.55 ^{ab} ±0.08	1.49 ^{b} ±0.13	0.516±0.069
LS	63.18 ^{f} ±0.42	22.18 ^{a} ±0.16	1.14 ^{c} ±0.11	1.21 ^{a} ±0.03	0.327±0.065
LM	58.89 ^{e} ±0.21	26.61 ^{d} ±0.42	1.69 ^{d} ±0.12	1.21 ^{a} ±0.05	0.357±0.124
LBS	59.02 ^{e} ±0.73	23.43 ^{b} ±0.22	1.13 ^{c} ±0.11	1.45 ^{b} ±0.04	0.415±0.084
LBM	59.11 ^{e} ±0.39	28.39 ^{f} ±0.31	1.31 ^{c} ±0.05	1.45 ^{b} ±0.03	0.381±0.046
LSM	53.21 ^{c} ±0.10	30.36 ^{g} ±0.21	0.46 ^{a} ±0.09	1.52 ^{b} ±0.03	0.447±0.092
LBSM	54.89 ^{d} ±0.48	27.67 ^{e} ±0.16	0.75 ^{b} ±0.29	2.4 ^{c} 7±0.04	0.356±0.052

Means with different superscripts within the same column differ significantly (P<0.05). Cheese made of full -fat milk (FF), cheese made of low-fat milk (LF), cheese made of low-fat milk + 20% bidara extract (LB), cheese made of low-fat milk + 20% bay extract (LS), cheese made of low-fat milk + 20% moringa extract (LM), cheese made of low-fat milk + 10% bidara extract + 10% bay extract (LBS), cheese made of low-fat milk + 10% bidara extract + 10% moringa extract (LBM), cheese made of low-fat milk + 10% bay extract + 10% moringa extract (LSM) and cheese made of low-fat milk + 6.67% bidara + 6.67% bay extract + and 6.67% moringa extract (LBSM).

Table 6. Scores of the sensory characteristic of cottage cheese added with different herbs extracts during the manufacturing process

Cheese	Flavor		Aroma		Texture		Color		Preference	
FF	2.85^{ef}	slightly bitter	3.7^{d}	not grassy	2.75^{cd}	soft	4^{e}	not green	2.1^{c}	rather like
LF	2.95 ^{f}	slightly bitter	2.9^{c}	slightly grassy	2.75^{cd}	soft	3.6^{d}	not green	1.95^{bc}	rather like
LB	2.4^{cdef}	rather bitter	2.9^{c}	slightly grassy	1.85^{a}	rather soft	3.2^{c}	slightly green	1.7^{abc}	rather like
LS	2.3^{bcde}	rather bitter	2.65^{c}	slightly grassy	2.1^{ab}	rather soft	3.4^{cd}	slightly green	1.7^{abc}	rather like
LM	1.5^{a}	rather bitter	1.65^{a}	rather grassy	3^{d}	soft	1.65^{a}	rather green	1.2^{a}	dislike
LBS	2.55^{def}	slightly bitter	2.8^{c}	slightly grassy	2.3^{abc}	rather soft	3.55^{cd}	not green	1.6^{abc}	rather like
LBM	1.9^{abc}	rather bitter	2.3b^{c}	rather grassy	2.3^{abc}	rather soft	2.65^{b}	slightly green	1.3^{a}	dislike
LSM	1.75^{ab}	rather bitter	1.95^{ab}	rather grassy	2.3^{abc}	rather soft	2.35^{b}	rather green	1.5^{ab}	rather like
LBSM	1.95^{abcd}	rather bitter	1.95^{ab}	rather grassy	2.4^{bc}	rather soft	2.35^{b}	rather green	1.45^{ab}	dislike

Means with different superscripts within the same column differ significantly (P<0.05). Cheese made of full-fat milk (FF), cheese made of low-fat milk (LF), cheese made of low-fat milk + 20% bidara extract (LB), cheese made of low-fat milk + 20% bay extract (LS), cheese made of low-fat milk + 20% moringa extract (LM), cheese made of low-fat milk + 10% bidara extract + 10% bay extract (LBS), cheese made of low-fat milk + 10% bidara extract + 10% moringa extract (LBM), cheese made of low-fat milk + 10% bay extract + 10% moringa extract (LSM) and cheese made of low-fat milk + 6.67% bidara + 6.67% bay extract + and 6.67% moringa extract (LBSM)

The nutrient content of soft cheese was reported to increase with the addition of 1% of moringa and was more preferred than the non-herbs cheese (Hassan *et al*., 2017). Moringa leaf powder given to male hypercholesterolemic mice has a positive result (El Rabey *et al*., 2018).Extract of *bidara* exhibits antioxidant activities and antimicrobial potentials with 28 identified phenolic compounds (Dahiru and Obidoa, 2008). Titratable acidity is expressed as a lactic acid percentage. Titratable acidity of cheese with or without herbs addition was not significantly different, ranging from 0,327 to 0,516 %. This result is different from Mushtaq *et al*. (2016), who reported incorporating probiotics didn't affect physico-chemical characteristics of cheese accept titrable acidity.

Effects of Herbs on Sensory Characteristics of Cottage Cheese

Semi-trained panelists tested the cottage cheese samples with and without the addition of extract herbs to evaluate the flavor, aroma, texture, color, and general preference (Table 6).

Sensory evaluation by the panelists showed that cheese without herb extract had better sensory characteristics than cheese with herb extract, confirming El-Sayed and Youssef (2019) that semi-hard cheese made of milk without herb addition showed the best sensory evaluation. Meanwhile, Salih et al. (2020) reported that adding powdered moringa to cheese resulted in a good preference level. Herbs added to the cheese produced specific flavors, and food flavor is generated from aromatic compounds obtained from

biosynthesis during normal metabolism in plants and animals that may undergo modification in the process (Reineccius et al., 2003). The interaction between polyphenols and protein (Frazier et al., 2010) incorporated into the milk produces cheese with a pleasant look due to hydrophobic-hydrophilic interaction (Hasni et al., 2011).

Table 6 displays the sensory characteristics evaluated by the semi-trained panelists using a scoring system. Adding extract herb leaves resulted in flavor scores ranging from 1.5 to 2.95, from mildly bitter to quite bitter, and aroma scores ranging from 1.95 to 3.7, from not grassy to somewhat grassy. The control group (unfortified cheese) yields the best results, with a flavor score of 3.7 and an aroma devoid of grassiness. Intriguingly, the inclusion of herb extract resulted in a soft texture in the LM cheese (addition of 20 percent moringa extract). Cheese texture, with or without herb extracts, is usually soft or relatively soft. The most crucial characteristic of cheese with herb extract is the color it imparts. The color of control cheese manufactured with whole milk or low-fat milk was yellowish, whereas cheese with herb extract ranged from faintly green to green, with scores ranging from 1.65 to 3.50. The preference level for cheese with herbal extract goes from rather like to dislike, scored 1.3-1.7. There were no differences between cheeses manufactured from full-fat milk and low-fat milk regarding their sensory properties.

Conclusions

The addition of bidara, moringa, and bay leaves extracts during the manufacture of cottage cheese from cow milk resulted in the variation of yield, textures, composition, and sensory characteristics. The addition of herbs produces cheese with higher moisture content but lower ash content than non-herb cheese. Cheese made with the addition of bay leaf extract had a higher hardness level than the control cheese and cheese added with other herbal extracts. The addition of herbal extracts makes a noticeable color change in cheese and produce slightly grassy aroma and bitter flavor. In brief, herb extracts significantly impacted the variation of sensory characteristics, including flavor, aroma, texture, and color.

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References

Abdelmontaleb, HS, FA Othman, MA Degheidi and KA Abbas. 2021. The influence of quinoa flour addition on the physicochemical, antioxidant activity, textural, and sensory characteristics of UF-soft cheese during refrigerated storage. Journal of Food Processing and Preservation 45(5):1-10.

Abeyrathne, EDNS, K Nam, X Huang and DU Ahn. 2022. Plant-and Animal-Based Antioxidants' Structure, Efficacy, Mechanisms, and Applications: A Review. Antioxidants 11(5):1025. DOI https://doi.org/10.3390/antiox11051025.

Abdel-Latif, HMR, MM Abdel-Daim, M Shukry, J Nowosad and D Kucharczyk. 2022. Benefits and applications of Moringa oleifera as a plant protein source in Aquafeed: A review. Aquaculture 547(2022): 1-18.

Adefegha, S, G Oboh, O Molehin, J Saliu, M Athayde and A Boligon. 2016. Chromatographic Fingerprint Analysis, Acetylcholinesterase Inhibitory Properties and Antioxidant Activities of Redflower Rag (C rassocephalum Crepidioides) Extract. Journal of Food Biochemistry 40(1):109-119.

Amar, A and IS Surono. 2012. Physico-chemical, and sensory properties of soy based Gouda cheese analog made from different concentration of fat, sodium citrate and various cheese starter cultures. Makara Journal of Technology 16(2):149-156.

Boroski, M, HJ Giroux, H Sabik, HV Petit, JV Visentainer, PT Matumoto-Pintro and M Britten. 2012. Use of oregano extract and oregano essential oil as antioxidants in functional dairy beverage formulations. LWT-Food Sci.Technol. 47(1):167-174.

Chavan, RS. and MR. Goyal. 2018. Technological Interventions in Dairy Science: Innovative

Approaches in Processing, Preservation, and Analysis of Milk Products. CRC Press.

Chávez-Servín, JL., HM Andrade-Montemayor, CV Vázquez, AA Barreyro, T García-Gasca, RAF Martínez, AMO Ramírez and K de la Torre-Carbot. 2018. Effects of feeding system, heat treatment and season on phenolic compounds and antioxidant capacity in goat milk, whey and cheese. Small Ruminant Research. 160:54-58.

Dahiru, D and O Obidoa. 2008. Evaluation of the antioxidant effects of Ziziphus mauritiana lam. extracts against chronic ethanol-induced hepatotoxicity in rat liver. African Journal of Traditional, Complementary and Alternative Medicines 5(1):39-45.

El-Sayed, SM and AM Youssef. 2019. Potential application of herbs and spices and their effects in functional dairy products. Heliyon 5(6):e01989.

El Rabey, HA, JA Khan, MI Sakran and MA Al-Ghamdi. 2018. The antioxidant activity of low doses of moringa seeds in hypercholesterolemic male rats. Reactive Oxygen Species 6(17):363–370-363–370.

Frazier, RA, ER Deaville, RJ Green, E Stringano, I Willoughby, J Plant and I Mueller-Harvey. 2010. Interactions of tea tannins and condensed tannins with proteins. Journal of pharmaceutical and biomedical analysis 51(2):490-495.

Hasni, I, P Bourassa, S Hamdani, G Samson, R Carpentier and HA Tajmir-Riahi. 2011. Interaction of milk α-and β-caseins with tea polyphenols. Food.chem 126(2):630-639.

Hassan, FA, A Enab, MA Abdel-Gawad, HM Bayoumi and Y Youssef. 2017. Utilization of moringa leaves powder in production of soft white cheese. Int. J. Dairy Sci 12:137-142.

Hidayati, MD, T Ersam, K Shimizu and S Fatmawati. 2017. Antioxidant activity of *Syzygium polyanthum* extracts. Indonesian Journal of Chemistry 17(1):49-53.

Kusuma, IW, H Kuspradini, ET Arung, F Aryani, Y-H Min, J-S Kim and Y-u Kim. 2011. Biological activity and phytochemical analysis of three Indonesian medicinal plants, *Murraya koenigii, Syzygium polyanthum* and *Zingiber purpurea*. Journal of Acupuncture and Meridian Studies 4(1):75-79.

Kulaitienė, J, N Vaitkevičienė and D Levickienė. 2021. Studies on proximate composition, mineral and total phenolic content of yogurt bites enriched with different plant raw material. Fermentation 7(4):2-12

Mahami, T, F Ocloo, S Odonkor, C Owulah and S Coffie. 2012. Preliminary study on the influence of moringa seed extracts supplementation on the yield and quality of cottage cheese. International Journal of Recent Trends in Science and Technology 2(1):4-8.

Molehin, O and S Adefegha. 2014. Comparative study of the aqueous and ethanolic extract of Momordica foetida on the phenolic content and antioxidant properties. International Food Research Journal 21(1):401-405.

Mushtaq, M, A Gani, FA Masoodi and M Ahmad. 2016. Himalayan cheese (Kalari/Kradi) – Effect of different probiotic strains on oxidative stability, microbiological, sensory and nutraceutical properties during storage. Food Sci. Technol. 67:74-81. doi: http://dx.doi.org/10.1016/j.lwt.2015.11.039

Nishinari, K, K Kohyama, H Kumagai, T Funami and MC Bourne. 2013. Parameters of Texture Profile Analysis. Food Science and Technology Research 19(3):519–521.

Olaoye, AB, CA Ologunde, OR Molehin and I Nwankwo. 2021. Comparative antioxidant analysis of moringa extracts from south western states in Nigeria. Future Journal of Pharmaceutical Sciences 7(1):1-15.

Ozcan, T, L Yilmaz-Ersan and A Akpinar-Bayizit. 2017. Textural properties of herby cheese. International Journal of Food Engineering 3(1):23-28

Reineccius, T, G Reineccius and T Peppard. 2003. Flavor release from cyclodextrin complexes: Comparison of alpha, beta, and gamma types. J. Food Sc. 68(4):1234-1239.

Salih, ZA, H AAbdelsalam, AA Aburigal and AME Sulieman. 2020. Physicochemical, microbiological and sensory characteristics of white cheese made by adding moringa seeds extract. Academic Journal of Life Sciences 6(7):76-82.

Sánchez-Muñoz, MA, MA Valdez-Solana, C Avitia-Domínguez, P Ramírez-Baca, MG Candelas-Cadillo, M Aguilera-Ortíz, JA Meza-Velázquez, A Téllez-Valencia and E Sierra-Campos. 2017. Utility of milk coagulant enzyme of moringa seed in cheese production from soy and skim milks. Foods 6(8):62.

Setyawardani, T, K Widayaka, J Sumarmono, A Rahardjo, S Santoso and M Sulistyowati. 2018. Texture, hedonic test and fatty acid profile of goat cheese with *L plantarum* TW14 and L. rhamnosus TW2 isolates stored at different temperaturee conditions. Journal of the Indonesian Tropical Animal Agriculture 43(3):230-237.

Singh, SP and AL Schwan. 2011. Sulfur Metabolism in Plants and Related Biotechnologies. Comprehensive Biotechnology 4(20):257–271.

Wen, P, Y Zhu, J Luo, P Wang, B Liu, Y Du, Y Jiao, Y Hu, C Chen and F Ren. 2021. Effect of anthocyanin-absorbed whey protein microgels on physicochemical and textural properties