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Compatibility evaluation of spices as an additive in cream cheese

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Abstract
The present study was carried out to evaluate the compatibility of different spices as an additive in Cream cheese. Cream cheese had 0.5% of nine different spices- mace, nutmeg, cumin, coriander, mustard, pepper, cinnamon, clove, and fenugreek were added to it. The 0.5% of cumin, pepper, coriander, and cinnamon added to the Cream cheese samples provided satisfactory results in terms of flavour and overall sensory acceptability. Using the Folin-Ciocalteu method and the DPPH assay, the total phenolic content and antioxidant potential of cheese samples were evaluated. Cream cheese samples that included spices had higher levels of total phenolic content and DPPH radical scavenging activity than the control cheese sample.

Keywords: Cream cheese, spices, sensory, TPC, DPPH

Introduction
As the world's largest producer of milk, so the cheese market has enormous growth potential in India. Cheese is among the most popular fermented dairy foods consumed worldwide. The consumption of cheese has grown steadily over the past several years in the majority of the chosen nations as well as globally (Tologana *et al*., 2023) [15]. Cheese is defined as a product made from milk by coagulating the casein with rennet or similar enzymes in the presence of lactic acid produced by added or adventitious micro-organisms, from which part of the moisture has been removed by cutting, cooking and/or pressing, which has been shaped in a mould, and then ripened at suitable temperature and humidity (Krishna *et al*., 2020) [11]. Cream cheese is one of the most popular soft cheese products in North America. Cream cheese is the unripened cheese made by the Neufchatel process from whole milk enriched with cream. It contains in the water-free substance not less than 65% of milk fat." This product would be considered nowadays as a high-fat Neufchatel cheese (Anindita *et al*., 2017) [1]. Cream cheese is produced through sequential manufacturing processes including homogenisation, pasteurization, acidification, coagulation and whey separation (Kim *et al*., 2022) [10]. Cream cheese has a soft, creamy white, spreadable texture, a smooth consistency, and a slightly acidic taste, which makes this product sensorially attractive (Tologana *et al*., 2023) [15]. Shelf life of Cream cheese is limited mainly due to the high moisture content and lipolytic activity. Spices are added to cheeses to impart unique flavours. These cheeses are regularly considered as specialty cheeses. Most spices impart specific flavours to cheeses, and some may affect the microbiological quality of cheeses (El-Sayed and Youssef, 2019) [4].

Materials and Methods
Cream cheese production
Cream cheese was prepared by the method given by Phadungath (2005) [13] with some modifications. Skim milk was standardized to 12% fat and homogenized and then pasteurized at 75 °C for 15s. DVS culture- Delvo Tec DX 33B DSL were added at 31 °C and incubation until pH reaches 4.6. Cutting of the curd was done after incubation followed by resting for 15 min. cooking of the curd was done by increasing the temperature to 55-60 °C with 1 °C rise in every 5 min. Whey was separated from the cheese curd and selected spices and 0.75% salt were added to the cheese curd and blended properly. Control cheese was prepared without the addition of spice powders. The cheese was packed in PP tubs and stored at 7±2 °C.

Proximate composition of cheese
The Cream cheese was analysed for their proximate composition and chemical characteristics using BIS (1981) [3] and AOAC (1980) [2] procedure.

Preparation of spice extract
Methanolic extracts (0.1 g of each spice powders were extracted in 10 ml methanol for 24 h at 37°C, after the mixture had reached room temperature, it was centrifuged for 10 minutes at 4,000 rpm) of spices and samples were used for total phenolic content (TPC) and radical scavenging activity (DPPH) analysis.

Preparation of cheese sample
Cheese samples (2.5 g) were treated with 50 ml of methanol at 30°C for 24 h in a shaking water bath. The mixture was then cooled to room temperature and centrifuged at 4,000 rpm for 10 min. The supernatant was recovered for the determination of the total phenolic content and radical scavenging activity by DPPH assay.

Total phenolic content (TPC)
Total phenolic content of cheese samples was analyzed by Folin Ciocalteu method (Singleton and Rossi, 1965) [14].

Determination of TPC content of Cream cheese
To 1 ml of methanolic extract in a test tube, 0.5 ml of Folin-Ciocalteu (1N FC) reagent and 10 ml of 7.5% Na_2CO_3 were added, mixed and incubated at room temperature for 30 min. Then the absorbance was measured at 750 nm against blank. Standard curve was prepared by using different aliquots of gallic acid concentration (10-100 µg). Using the standard curve, TPC of cheese samples were calculated and expressed as gallic acid equivalent (GAE) (mg GAE/g cheese).

DPPH radical scavenging activity of Cream cheese
The free radical scavenging activity was measured using 2, 2-diphenyl-1-picryl-hydrazyl (DPPH) assay (McCune and Johns, 2002) [12]. Exactly 0.75 ml of methanolic extract was added to 0.75 ml of DPPH (0.2 mM). The contents were mixed for 5 s, incubated for 30 min at 37°C away from direct light and absorbance was measured at 517 nm. Methanol was used as blank. Standard curve was prepared using (10-80 µM) of trolox solutions in methanol.
Based on the % inhibition of sample, trolox equivalent was determined from standard curve. The results were expressed as trolox equivalent antioxidant capacity (TEAC) values i.e. mM trolox equivalence per g of cheese.

$$\text{Inhibition (\%)} = \frac{(A_0 - A_1)}{A_0} \times 100$$

A_0 is the absorbance of control
A_1 is the absorbance of sample

Sensory evaluation of Cream cheese
All the samples of Cream cheese were evaluated for their sensory characteristics (flavour, colour and appearance, body and texture, overall acceptability) on a 9-point hedonic scale (ranging from 9 = like extremely to 1 = dislike extremely) by a trained panel of 9 judges. The panelists included scientists, technical officers/assistants and students of the institute. All the judges were familiar with the quality characteristics of cheese. The judges received a sample of 20 g each.

Results and Discussion
Proximate composition
As per FSSAI standards (2020) [5], maximum moisture permitted in Cream cheese is 55% and fat content shall not be less than 70% on dry basis. The Cream cheeses prepared in the present study met standards laid by FSSAI. The yield of Cream cheese curd was 30.05%.

Table 1: Proximate composition and chemical characteristics of Cream cheese

Proximate composition (%)	
Constituents	**Mean* ± SD**
Moisture	50.41 ± 0.11
Fat	38.40 ± 0.24
Fat on dry matter basis	77.44 ± 0.57
Protein	7.85 ± 0.22
Lactose	2.17 ± 0.10
Salt	0.76 ± 0.01
Ash	1.17 ± 0.04
Chemical characteristics	**Value**
pH	5.19 ± 0.02
Acidity (% lactic acid)	0.76 ± 0.01
*Values are means of six observations	

Table 1 shows the proximate composition and chemical characteristics of Cream cheese. As cheese consists primarily of fat, milk protein and water, the major factors that influence the yield of cheese from a given quantity of milk are the protein and fat content of the milk, losses during manufacture and moisture left in the cheese. Other factors include the amount of salt added and retained in the curd and the amount of whey solids retained in the curd.

Sensory characteristics of Cream cheese with different spices
In the present study, spices were incorporated in Cream cheese for enhancing the shelf life. Addition of spices in Cream cheese necessitated some preliminary screening in order to check their compatibility with respect to sensory characteristics of Cream cheese. From an array of available spices nine different common culinary spices *viz*. mace, nutmeg, cumin, coriander, mustard, pepper, cinnamon, clove and fenugreek were selected for the study. Each of the above spices in the powder form were added at the rate of 0.5% (w/w) into the Cream cheese.

Table 2: Effect of spice powders on sensory characteristics of Cream cheese

Type of spice powder added*	Sensory score			
	Flavour	Colour and appearance	Body and texture	Overall acceptability
Mace	6.63^{f}	7.61^{d}	8.00^{d}	6.59^{f}
Nutmeg	6.80^{e}	7.93^{c}	8.10^{c}	6.71^{e}
Cumin	8.20^{a}	8.15^{b}	8.24^{abc}	8.16^{a}
Coriander	8.15^{a}	8.19^{b}	8.26^{ab}	8.13^{a}
Mustard	7.64^{b}	8.16^{b}	8.24^{abc}	7.62^{b}
Pepper	8.14^{a}	8.15^{b}	8.20^{abc}	8.12^{a}
Cinnamon	8.12^{a}	7.95^{c}	8.20^{abc}	8.10^{a}
Clove	6.94^{d}	7.55^{e}	8.15^{bc}	6.93^{d}
Fenugreek	7.15^{c}	8.07^{bc}	8.19^{abc}	7.12^{c}
Control	8.10^{a}	8.41^{a}	8.30^{a}	8.08^{a}
SEm	0.04	0.05	0.04	0.03
CD (0.05)	0.13	0.17	0.14	0.11
CV%	1.07	1.26	1.01	1.01

*All spice powders were added at the rate of 0.5% (w/w) in the method.
Control = Cream cheese without spice.
The values are means of three observations and the values within a column with same superscript did not differ significantly (p>0.05) from each other.

All the nine samples were subjected to sensory evaluation for their attributes *viz*., flavour, colour and appearance, body and texture and overall acceptability using 9 points hedonic scale. The Cream cheese without spice served as control. Results along with their statistical analysis are presented in Table 2.

Flavour is the most important criteria for evaluating the quality of any product which in turn determines is acceptability. Examination of the data for flavour of Cream cheese indicated that the flavor score for Cream cheese samples containing mace, nutmeg, cumin, coriander, mustard, pepper, cinnamon, clove, fenugreek and control were 6.63, 6.80, 8.20, 8.15, 7.64, 8.14, 8.12, 6.94, 7.15 and 8.10 respectively. Among all the experimental samples, the Cream cheese containing cumin powder had the highest flavour score (8.20).

The flavour score of control and Cream cheese sample containing cumin, coriander, pepper and cinnamon were in the range of 8.10 to 8.20; and the difference among them was non-significant (p>0.05). Also, they differed significantly from the other experimental sample (p<0.05).

Colour and appearance score is another important parameter for sensory acceptability of any dairy product. This attribute is highly influenced by ingredients of the product. From the Table 2, it is very clear that the type of spice powder had great influence on colour and appearance score. Examination of the data for colour and appearance of Cream cheese indicated that the colour and appearance score for Cream cheese samples containing mace, nutmeg, cumin, coriander, mustard, pepper, cinnamon, clove, fenugreek and control were 7.61, 7.93, 8.15, 8.19, 8.16, 8.15, 7.95, 7.55, 8.07 and 8.41, respectively.

Food acceptance and preference are functions of product quality. Often colour is the first sensory characteristic perceived by the consumer and colour tends to modify other perceptions such as flavour and aroma. Fruits and spice added to the yogurt samples had a strong effect on the colour properties (Garcia-Perez *et al*., 2005) [6].

Body and texture score of the cheese samples as affected by addition of spices powder are shown in Table 2. Examination of the data for body and texture of Cream cheese indicated that the average scores for Cream cheese samples containing mace, nutmeg, cumin, coriander, mustard, pepper, cinnamon, clove, fenugreek and control were 8.00, 8.10, 8.24, 8.26, 8.24, 8.20, 8.20, 8.15, 8.19 and 8.30 respectively.

The overall acceptability score of control and Cream cheese sample containing cumin, coriander, pepper and cinnamon were in the range of 8.08 to 8.16; with the difference among them being non-significant (p>0.05). Also, they differed significantly from the other experimental sample (p<0.05).

Karin *et al.* (2000) [9] found that the fat content was the main influencing parameter on taste, flavour and texture of Cream cheese. They further observed that the butter flavour and saltiness were more intense in samples with high fat content. An increase in fat content resulted in a texture, which was perceived as more compact, fat-creamy and yellow. Salt content not only influenced saltiness but also sourness. The yellow colour, the droplet size, and the aggregation of the milk proteins were also affected by the salt content.

The overall acceptability score was highest for Cream cheese containing cumin (8.16), followed by coriander (8.13), pepper (8.12), cinnamon (8.10) and control cheese (8.08); the difference among these samples was non-significant (p>0.05).

The overall effect of different spices on any dairy product depends on the type of spice, its concentration, type of product to which spice is added etc.

Based on sensory analysis, spice powders namely pepper, cumin, coriander and cinnamon were found to be compatible with respect to sensory attributes of Cream cheese.

So Cream cheese samples added with 0.5% of pepper, cumin, coriander and cinnamon were evaluated for total phenolic content and antioxidant potential.

Total phenolic content of spices

Spices and herbs are rich sources of phenolic compounds. Table 3 shows that among all the selected spices, cinnamon (3.83±0.02 mg GAE/g spice) showed higher phenolic content and lowest was for coriander (0.31 ± 0.01 mg GAE/g spice).

Table 3: Total phenolic content of spices

Types of spice	TPC (mg GAE/g spice)
Cumin	0.82 ± 0.01
Coriander	0.31 ± 0.01
Pepper	0.69 ± 0.02
Cinnamon	3.83 ± 0.02
* Mean± SD; n=6	

Total phenolic content of Cream cheese

Total phenolic content in the cheese samples varies widely as evaluated by Folin-Ciocalteu (FC) method (Table 4). This method is based on the measurement of the reductive capacity of the FC reagent in an alkaline environment. The calculation for total phenolic content of all the cheese samples were carried out using the standard curve of Gallic acid and expressed as Gallic acid equivalents mg (GAE) per g of cheese. The Total phenolic content among the spices in selected cheese samples (cumin, coriander, pepper and cinnamon were analysed). The TPC of control cheese, Cream cheese containing spices namely cumin, coriander, pepper and cinnamon was 1.12, 1.27, 1.14, 1.19 and 1.56 mg GAE/ g of cheese, respectively.

Table 4: Total phenolic content of Cream cheese

Cheese samples	TPC (mg GAE/g)
Control cheese	1.12±0.03
Cumin	1.27±0.02
Coriander	1.14±0.02
Pepper	1.19±0.03
Cinnamon	1.56±0.02
* Mean± SD; n=6	

The control cheese also had TPC value inspite of having no spices. According to Josipovic *et al.* (2015) [8], the addition of plants high in bioactive phenolic compounds can enhance the biological value of cheese. This is because Folin-Ciocalteu reagents, which only measure phenols and can react with a wide range of other substances, such as carbohydrates, amino acids, nucleotides, thiols, unsaturated fatty acids, vitamins, amines, aldehydes, and ketones, were used to estimate the total phenolic contents of cheese samples. This is demonstrated by the Cream cheese sample's greater TPC when compared to control cheese, which contains 0.5% cumin, coriander, pepper, and cinnamon.

DPPH radical-scavenging activity of spice

The antioxidant potential of Cream cheese samples added with different selected spices were determined by DPPH assay and results are expressed as mM of TEAC/g cheese.

Table 5: DPPH radical scavenging activity of spice

Types of spice	DPPH radical scavenging activity (mM of TEAC/g spice)
Cumin	10.27± 0.01
Coriander	3.09±0.02
Pepper	4.45 ±0.02
Cinnamon	17.15±0.01
* Mean± SD; n=6	

The DPPH radical scavenging activity of different spices used in the present study is shown in Table 5. Among the selected spices cinnamon (17.15 mM of TEAC/g spice) showed higher DPPH radical scavenging activity and lowest was for coriander (3.09 mM of TEAC/g spice).

Table 6: DPPH radical scavenging activity of Cream cheese

Cheese samples	DPPH radical scavenging activity (mM of TEAC/g cheese)
Control cheese	0.56±0.02
Cumin	0.85±0.01
Coriander	0.60±0.02
Pepper	0.73±0.03
Cinnamon	1.34±0.03
* Mean± SD; n=6	

The DPPH radical scavenging activity of control cheese, Cream cheese containing spices namely cumin, coriander, pepper and cinnamon was 0.56, 0.85, 0.60, 0.73 and 1.34 mM of TEAC/g of cheese.

Phenolic and flavonoid compounds are important antioxidant substances that deactivate free radicals because of their ability to donate hydrogen atoms to free radicals. Moreover, they possess the perfect structural qualities for scavenging free radicals (Gordhanbhai *et al*., 2021) [7].

Several studies have found a linear relationship between total phenolic and flavonoid concentration and antioxidant capacity (Yoon *et al.,* 2015) [16]. This is correlated to high phenolic content in cinnamon and cumin as compared to coriander and pepper as shown in Table 6. The DPPH radical scavenging activity controlled many metabolic changes involving redox processes and may as a result have a beneficial effect on the cheese's shelf life.

Conclusion

Cream cheese samples were analysed for the compatibility by the addition of nine different spices. Among the nine spice powders, Cream cheese containing cumin, coriander, pepper and cinnamon had significantly better sensory acceptability compared to control and other experimental samples. The total phenolic content and DPPH radical scavenging activity was found higher in Cream cheese samples containing spices than the control cheese sample which not only improved the sensory characteristics of the product but also improved its phenolic content and antioxidant potential which can positively influence the shelf life of the product in addition to enhancing its bio-functional properties.

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