Production of yoghurts with the addition of microencapsulated cinnamon, garlic and cumin oil with corn oil

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Abstract. The active components in spice oil are easily degradable, which limits its application in the food industry. The volatile compounds of garlic oil, cinnamon oil and cumin oil were encapsulated with 20 % corn oil and incorporated into the yoghurt while maintaining the standard process. The chemical composition, microbiological analysis and sensory evaluation were conducted to identify the efficiency of incorporating encapsulated oils in yoghurt. The results implied that 20% corn oil has improved the stability of spice oil emulsions and the encapsulation efficiency of spice oil microcapsules. As can be seen from the data obtained, the emulsion of garlic oil, cinnamon oil and cumin oil produced a good outcome, indicating a reduction in the overall number of bacteria. The texture and solids content of the yoghurts were studied, and it was discovered that the solids and pH of the yoghurts were very minimally changed but the yoghurt's stability was substantially improved. Garlic oil encapsulation has been discovered to be the most effective spice oil for suppressing viable bacteria and mold in yoghurt recipes due to the bioactive substance present there.

1 Introduction

Yoghurt is a popular fermented milk product that has health benefits owing to the probiotic bacteria and is made from the bacterial fermentation of milk. The most widely utilized milk to produce yoghurt is cow milk and other milks are not much used in the production due to its limitations [1]. Milk and dairy products are major sources of nourishment in many regions of the world. Because of the addition of certain raw ingredients such as ginger, and garlic to yoghurt, value-added yoghurt is a popular fermented milk product across the world. It plays an important function in nutrition and also enhances people's immunization ability. Fermented milk products, such as yoghurt, may only be stored for a few days.

Yoghurt is a widely consumed dairy product across the world. The activity of milk and starting cultures is sufficient to make a yoghurt product at the customary level. This product

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has a high fat and protein content. These molecules are crucial in the creation of its sensory characteristics. The adoption of an optimum approach for standardizing the fat level during the manufacture of natural yoghurt is critical for the end product's quality [2]. Yoghurt's acceptance is hampered by its lack of body, syneresis, and poor taste and flavour. In practice, however, in large companies, the total solids content of yoghurt milk must be altered to make superior products without syneresis. The standardization procedure is used to balance the fat level in milk to achieve the desired amount.

It may be consumed in a variety of ways, economically in a variety of forms, and under a wide range of conditions. There is a vast market all over the world due to its digestion, flavour, texture, and availability. Cow's milk is widely available around the world and is the milk most usually used to produce yoghurt [3]. However, switching to ginger, cumin, mustard, cinnamon and garlic helps to boost the value of specific yoghurt which can suppress dangerous microorganisms such as Salmonella typhimurium, E. coli, Listeria monocytogenes, Staphylococcus aureus and Bacillus cereus [4]. Garlic is one of the well-studied medicinal spices, having been used as medicine and food for over 400 years. As a result, this evaluation of the manufacturing and quality of cow milk yoghurt with spice and its derivatives provides an effective approach to combining information on value-added yoghurt and its special quality features [5].

Yoghurt can be improved by fortifying it with spices or the oil extracted from spices to improve its functionality. It explains how spices impact the quality of the final product of yoghurt, as well as the various methods of adding those components and related technologies [6].

The primary traditional application of spice oils produced from various spices is as natural flavouring elements, which have significant economic value. The global demand for spice oils produced from spices, particularly desiccated leaves, is expanding. Due to customer preferences, flavouring compounds play an important role in yoghurt. As a result, spice oils derived from spices, as well as certain plants, are added to the yoghurt as a Nano-emulsion and functional components, and act as flavouring agents, to make spicy or leafy flavoured herbal yoghurt for the market and test for its quality features and microbiological level. Several forms of spices, such as juice, powder, and oils were employed in the creation of spiced yoghurt, as well as diverse forms of garlic, such as garlic paste, fresh garlic juice, and isolate. The development of new technologies, as well as increased research efforts to understand the properties and potential applications of these chemicals are driving the increase in interest in bioactive compounds, along with public interest and consumer requirements [7]. The primary traditional use of spice oil produced from various spices is natural flavouring materials, which have a high economic value [8].

The global demand for essential oils produced from spices, particularly desiccated leaves, is expanding [9]. Therefore, this research was conducted to provide an updated assessment of spice oils such as cumin, cinnamon and garlic oil encapsulated with 20% corn oil and the implications on the shelf life of target components in storage [10, 11]. The key findings were also presented, as well as the benefits and downsides of chemical, physical-chemical, and physical approaches.

2 Methods

The production tests of the technology for producing yoghurts with the addition of functional additives to the formulation were developed and conducted at the Tashkent Chemical-Technological Institute. As functional additives, an oil emulsion obtained by microencapsulation of cinnamon, garlic, and cumin oils with corn oil in an amount of 20% was used. The experiments were carried out using milk with a fat content of 2.0%, 10 litres for each sample. In addition, functional oil emulsion was added to yoghurt in the amount of

0.3 ml/kg. The titratable acidity was 0.8%. Based on the results of laboratory tests, we used a starter prepared from strains of *Streptococcus thermophiles and Lactobacillus delbrueckii.*

The whole milk was preheated to 45°C and it was centrifuged. Subsequently, the milk was homogenized under 7 MPa of pressure, pasteurized in batches for 10 minutes at 90°C, and cooled to the incubation temperature. To the mixture, a ready-to-use emulsion of useful oils was added, and a starting culture was introduced. Yoghurt was put into sterilized containers, which were then incubated for 2.5 hours at 42° C. Then, 5°C was reached for the chilled yoghurts and sent for storage and further analysis at this temperature.

The evaluation of the shelf life of the obtained products was carried out by the method of plate count and the total count of *Escherichia coli* from the 1st to the 30th days with an interval of 10 days. Every 10 days, the chemical composition was determined in the samples, and the pH of the medium and titratable acidity were measured [12]. An organoleptic evaluation was carried out to determine the best samples with a long shelf life. A tasting panel of 10 participants assessed aroma, texture, and overall acceptability by using a 5-point hedonic scale.

Table 1 shows yoghurt formulations with the addition of functional oil emulsions, where 0.3 ml/kg microencapsulated emulsions of cinnamon, garlic and cumin were added to improve the functional properties of these samples T_1-T_3. In the control sample, which is designated sample T_0, purified water was used instead of the oil emulsion. The addition of essential oils to the manufactured product was carried out after inoculation and mixing to exclude thermal inhibition of functional properties in yoghurt [13].

Strains of *Lactobacillus bulgaricus and Streptococcus thermophilus* (LB and ST), which are lactic acid bacteria, were used in equal amounts as a starter culture for satisfactory flavour development.

Table 1. Formulations of the studied yoghurt samples with and without emulsions of functional oils.

Ingredients	T_0	T_1	T_2	T_3
Milk, with a fat content of 3.0%, L	10	10	10	10
Gelatin, g/kg	1	1	1	1
Sugar, g/kg	4	4	4	4
Starter culture, g/100g	2	2	2	2
Source of encapsulated functional oil, ml/kg of sample	Water 0.3	Cinnamon 0.3	Garlic 0.3	Cumin 0.3

3 Results and Discussion

The resulting product according to the classification of yoghurts by following the standard of GOST 31981-2013 “Yoghurts. General technical conditions” is a product of group 1 – enriched semi-fat yoghurt. Organoleptic and physico-chemical parameters of the obtained products are given in Tables 2 and 3.

The sensory evaluation was performed on parameters that determine the acceptance of encapsulated oil-added yoghurt, including the aroma, texture, and overall acceptability of the samples.

Table 2. Organoleptic quality indicators of yoghurt.

The name of the indicator	The norm according to GOST	T_0	T_1	T_2	T_3
Appearance and consistency	Homogeneous, moderately viscous. When adding food flavour components - with their presence	Up to the standard			
Taste and smell	When working with food flavouring components and flavouring agents - due to the added components.	With the taste of milk	With cinnamon flavour	With a slight taste and smell of garlic	With a slight smell of cumin
Colour	When working with food flavour components - due to the colour of the added component.	milky white, uniform			

Table 3. Physical and chemical indicators of the quality of yoghurt.

The name of the indicator	The norm according to GOST	T_0	T_1	T_2	T_3
mass fraction of fat %	0.1-10.0	2.91	2.93	2.94	2.93
mass fraction of milk protein, %, min	2.8	4.12	4.18	4.17	4.11
mass fraction of Solid Non Fat(SNF)%, min	8.5	14.91	14.94	14.95	14.94
acidity	not more than 100	29	33	31	33
Phosphatase	Absent	Absent	Absent	Absent	Absent

The number of viable cells of the starter culture bacteria in the completed product must exceed their number, normalized at the end of the shelf life, because the number of viable cells falls during product storage owing to extinction. The extinction rate depends on the type of starter microflora, product storage temperature, pH values and shelf life. The number of bifidobacteria in probiotic products is especially intensively reduced

Table 4. Microbiological indicators of the quality of yoghurt .

The name of the indicator	according to GOST	T_0	T_1	T_2	T_3
The number of dairy microorganisms (*Streptococcus thermophilus and Lactobacillus bulgaricus)* in 1 g of the product at the end of the shelf life, CFU, min	$1\cdot10^7$	$1\cdot10^7$	$4\cdot10^7$	$4\cdot10^7$	$3\cdot10^7$
The number of Bifidobacteria (Bifidobacterium) in 1 g of the product at the end of the shelf life, CFU, min	$1\cdot10^6$	No			
The number of lactic acidophilus bacillus bacteria (*Lactobacillus acidophilus*) in 1 g of the product at the end of the shelf life, CFU, min	$1\cdot10^6$	$7\cdot10^5$	$2\cdot10^6$	$2\cdot10^6$	$2\cdot10^6$

In experiments, determined that the content of ST and LB ranges from 3 x 10^7 in sample T_3 to 4 x 10^7 CFU/g of product in samples T_1 and T_2, which indicates the beneficial effect of functional oil emulsions. At the expiration of the storage period, the control sample, the content of lactic microorganisms ST and LB was 1x10^7 CFU/g of product, which is satisfactory. However, analyses showed that the amount of lactic acidophilus bacteria *Lactobacillus acidophilu*s in 1 g of the product at the end of the shelf life was 7x10^5 CFU/g of the product, which does not meet the requirements of GOST standard. Modern food manufacturers are continuously trying to comprehend essential oils to explain why they have the therapeutic and functional benefits that they do. Chemical examination of essential

oils, for example, demonstrates that their principal active component is critical to their activity. As preservatives, flavourings, and antioxidants, several essential oils offer viable alternatives to artificial food additives.

More scientific study investigations on their compositions and uses, however, are necessary. The antibacterial properties of essential oils in food matrices must be thoroughly investigated; such studies will aid in the development of novel essential oil preservatives. Furthermore, research on essential oil shelf life and stability during food processing is of special interest.

In addition, according to microbiological safety indicators, yoghurt must comply with the requirements and standards specified in Table 5.

Table 5. Microbiological safety indicators of yoghurt.

The name of the indicator		**Standard according to GOST**	**T_0**	**T_1**	**T_2**	**T_3**
the mass of the product (g) in which it is not allowed	bacteria of the *E. coli* group	0.1	not detected			
	Staphylococcus (*staphylococcus aureus*)	1.0	1.0	not detected		
	pathogenic microorganisms, including salmonella	25	not detected			
Listeria / (*L. monocytogenes*)		not allowed	not detected			
yeast, CFU/g (cm^3) of the product, not more than		50	89	34	28	32
mold, CFU/g (cm^3) of the product, not more than		50	48	21	not detected	19

As can be seen from the data given in Table. 5, in the control samples, and the experimental ones, no bacteria of the *Escherichia coli* group and pathogenic microorganisms were detected during 30 days of storage. However, in the control samples, in contrast to the experimental ones, although within the normal range, *staphylococci* were found. The yeast content in the experimental samples is much lower (34, 28 and 32 CFU/g, respectively, to the samples added with emulsions of essential oils of cinnamon, garlic and cumin) than the control sample, where this figure is much higher (89 CFU/g) than allowed by GOST (50 CFU/g).

4 Conclusion

As can be seen from the data obtained, during production tests, the technology for producing yoghurts with the addition of functional additives to the formulation, obtained by emulsion of cinnamon, garlic and cumin oil, gave a positive result, which showed a decrease in the total amount bacteria. The texture and solids content of the yoghurts were studied, and it was discovered that the solids and pH of the yoghurts were very minimally changed, but the yoghurt's stability was substantially improved. Garlic spice oil encapsulated with 20% corn oil has been discovered to be the most effective oil for suppressing viable bacteria and mold in yoghurt recipes. Based on the efficiency and manufacturability, the developed technology is accepted for use in industrial production based on the implementation of a business contract for implementation.

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