Agronomy Research **12**(3), 717–726, 2014

Vegetable ingredients in soft cheese made from concentrated skim milk by ultrafiltration

N. Iakovchenko* and L. Silantjeva

Institute of Refrigeration and Biotechnologies, ITMO University, Lomonosova Street 9, 191002, Saint-Petersburg, Russia; *Correspondence: frack@mail.ru

Abstract. The objective of this research was to develop the technology and composition of soft cheese made from concentrated skimmed milk by ultrafiltration with a low concentration factor. UF enables reduction in the quantities of starter, rennet, colorants, and cheese making costs per vat. The use of UF milk appeal to lactose intolerant consumers because of the low lactose levels in the product.

Ultrafiltration was carried out using polyethersulfone membranes. Jerusalem potato and carrot were chosen as vegetable ingredients. Since the soft cheese was made from skimmed milk retentate, there was a necessity to compensate the lack of fat. In this research the impact of orange fiber on organoleptic qualities was determined. For imparting mouthcoating, creaminess, and providing for an even meltaway effect in the mouth CITRI–FI 100 FG (pure orange fiber), CITRI–FI 200 FG (orange fiber with guar gum), CITRI–FI 300 FG (orange fiber with xanthan gum) were chosen. Application of CITRI–FI 200 FG and CITRI–FI 300 FG enables the production of high quality curd only up to certain concentrations, which do not have a significant impact on the organoleptic qualities of soft cheese. The use of CITRI–FI 100 FG enables to get firm curd and can at the same time create organoleptic properties of a fat-containing product in the finished soft cheese.

Thus, on the basis of data CITRI–FI 100 FG is recommended to use for manufacturing soft cheese where mouthfeel is needed. Optimal concentrations of CITRI–FI 100 FG were determined.

Key words: Ultrafiltration, Jerusalem potato, soft cheese, vegetable ingredients, orange fiber.

INTRODUCTION

Due to the present unfavourable environmental and economic situation, the dietary patterns of the population are undergoing a significant change towards an imbalance of major components in diet (Bogatyrev, 1985; Bobylin et al., 2000). Thus, the main problem in the field of nutrition is to create a range of products promoting improvement of human health in daily consumption. Our research tries to solve this problem by creating products with both dairy and non-dairy components. These components help to improve food and the biological values of the products.

Nowadays, with increasing concern about consumer health, the aim is to reduce fat and calorie consumption. Low fat, low calorie foods, which look and taste like their fatty counterparts higher in calories, have been gaining in popularity. Thus, it is topical to concentrate on the development of food products, which are nutritious and contain reduced levels of calories and fat.

By analyzing international experience, it was determined that increasing production and expanding the range of soft cheeses could be a good idea. Along with the high biological value, this type of cheese can be sold without ripening. Despite the perspective in the manufacture of soft cheese, most of the whey proteins are lost in the whey.

Ultrafiltration has been used in cheese making since about 1971 (Maubois & Mocquot, 1971). Eventually the use of ultrafiltration has gained significance in cheese making industry. Ultrafiltration enables the concentration, separation, and recovery of individual milk components (Salhab, 1998). It provides complete retention of whey proteins and improvement of the traditional technological process of manufacturing cheese (Lelievre & Lawrence, 1988).

Low concentration factor (CF) of skimmed milk permits the use of traditional equipment for cheese making and the only investment expenses are the purchase of an ultrafiltration plant and putting it in service. Ultrafiltration can help minimize seasonal variations in milk composition, which, in turn, can help standardize rennet coagulation time, gel strength, and cheese yield (Lucey, 2000).

Based on the analysis of information data, Jerusalem potato and carrot purée have been chosen as the vegetable ingredient. Jerusalem potato is a source of inulin and oligofructose. Inulin and oligofructose improve immunity as well as calcium absorption, reduce cholesterol in the blood and even reduce the risk of colon cancer (Davidovich, 1957; Perkovets, 2007). Jerusalem artichoke has an ability of not accumulating heavy metals (Reshetnik et al., 1997).

Carrot is used in cases of anemia, scurvy, rheumatism, visual disturbances, cardiovascular diseases, and loss of strength. Carrot has hematopoietic, bactericidal, anti-inflammatory, choleretic, diuretic, laxative, analgesic, and anti-sclerotic effect (Novichikhina, 2003).

Orange fiber is a natural fiber, derived from the cell tissues of dried orange pulp without using chemical reagents and only by mechanical treatment. It has a positive effect on the physiological processes of the human organism: purifies from slags, reduces cholesterol, eliminates heavy metals and improves the functioning of the gastrointestinal tract (Gubina, 2010).

Based on the foregoing, the objective of this research was to develop the composition of soft cheese made from concentrated skimmed milk by ultrafiltration, using vegetable components.

MATERIAL AND METHODS

Preparation of retentate

Whole cow milk was obtained from a local market. Fat was removed by mechanical separation that resulted in skimmed milk (8.65% non-fat solids, 3.19% total protein, 0.09% fat) and cream. Before concentration the skimmed milk was heated to 65°C and held at that temperature during 25 s. The skimmed milk was concentrated by using laboratory scale set Vivaflow 50. ('Vivascience', Sartorius group) (Fig. 1). Ultrafiltration was carried out using polyethersulfone membranes (molecular weight cut-off of 30 kDa, pump flow 200–400 ml min^{-1}), until a retentate with CF 2 was obtained. The temperature during the process was 50°C. Polyethersulfone membranes are preferred

for their low fouling characteristics, broad pH range, and durability. They also exhibit no hydrophobic or hydrophilic interactions.

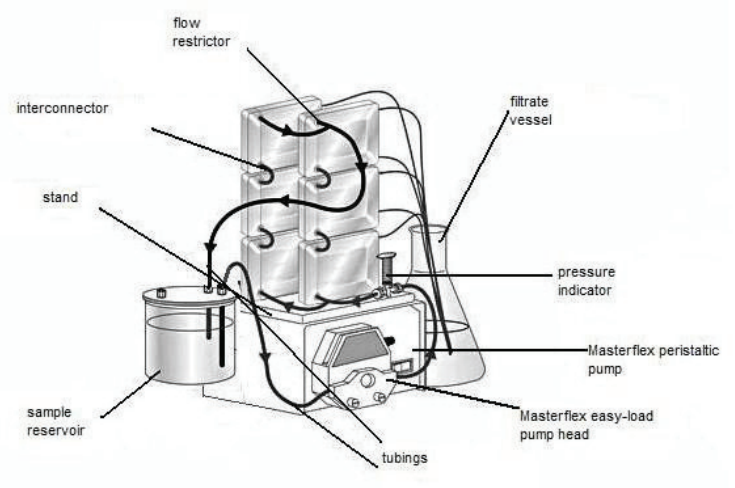

Figure 1. Vivaflow 50 set up.

Starter culture: BC–Uglich–No 4 (*Lactococcus lactis* subsp. *lactis*, *Lactococcus lactis* subsp. *cremoris*, *Lactococcus lactis* subsp. *diacetylactis*, *Leuconostoc lactis*).

Ferment: Calf rennet was obtained from Moscow rennet factory.

Jerusalem potato: Powder of Jerusalem potato was obtained from Seliger.

Carrot purée: Sterilized carrot purée was obtained from a local store.

CITRI-FI: Orange fiber was obtained from Fiberstar Inc., USA.

Non–fat solids, total protein, and fat of skimmed milk were measured using milk analyzer 'Klever–2'.

To determine the concentrations of Jerusalem potato suitable for cheese manufacturing, retentate was divided into several parts. Each part (1 l.) with added Jerusalem potato was heated at 74 ± 2°C for 20–25 s. and cooled to 29°C. The doses of Jerusalem potato ranged from 1% to 5% of retentate weight with the increment of 1%. The control sample contained no vegetable component. Starter culture prepared by inoculating sterilized skimmed milk with culture was added in the amount of 1%. *Lactococcus lactis* subsp. *lactis* is used as an active acidifier. *Lactococcus lactis* subsp. *cremoris*, *Lactococcus lactis* subsp. *diacetylactis*, *Leuconostoc lactis* are very important for the flavour of the cheese. During the fermentation of starter culture, lactic acid accumulates, which causes the pH–value to decrease, resulting in better whey drainage. The mixtures were coagulated with calf rennet and left to curdle. After coagulation the curds were subjected to organoleptic assessment. Jerusalem potato was chosen because of its medicinal properties, specific pleasant taste qualities, and medical recommendation for consumption. But adding this component resulted in cheese with unacceptable colour for consumers. Carrot purée was decided to add for correction.

Investigations for determining the concentrations of sterilized carrot purée were carried out according to the above procedure with only one addition, so that carrot purée was added after the pasteurization of the mixture. The concentrations of Jerusalem potato were 2% and 3%. The concentrations of sterilized carrot purée ranged from 1% to 9% with the increment 1%.

Despite the fact that inulin and oligofructose in Jerusalem potato have the capacity of being used as fat replacers with excellent mouthfeel characteristics and provide better organoleptic properties, their concentrations in the product are insufficient to get soft cheese with the appearance, taste, consistency, and texture of fat–containing cheese.

To maintain a desirable creamy mouthfeel characteristic of the product, orange fiber was chosen. This fiber is a powder of light cream colour with a neutral taste and smell. As fiber does not require pre-hydration, it was added in the mixture in different concentrations together with the other dry ingredient before heat treatment. The following additives recommended by the manufacturer were chosen: CITRI–FI 100 FG (pure orange fiber), CITRI–FI200 FG (orange fiber with guar gum), and CITRI–FI 300 FG (orange fiber with xanthan gum). To determine the possible use of the additive, samples of soft cheeses were obtained with additive dose ranging from 0.05% to 0.4% of mixture weight with the increment of 0.05%. After complete coagulation, the curds were cut into cubes, which were settled for 10 min. The curds were stirred carefully during the next 20 min and settled for 15 min. After that, the whey was drained and curds were transferred into perforated moulds for draining and pressed under the force of gravity. The samples of cheese were turned upside down three times during the first 5 h of draining and pressing. The pressing temperature was 16–18°C. Then the cheeses were soaked in concentrated brine solution (18–22%) for salting for an appropriate period of time depending on the size of the cheese sample.

Organoleptic assessment

Samples were evaluated for organoleptic properties by a taste panel of the 11 staff members and students from Milk Technology and Food Biotechnology Department. The participants were selected and trained in accordance with the ISO 8586-1 standard (1993). Requirements for the work of the group of assessors were according to ISO 8589 standard (2007).

Organoleptic evaluation of cheese curds

The aim of the cheese curds sensory evaluation was to determine the acceptable concentrations of vegetable additive for the manufacturing of soft cheese. The quality of the cheese curds was evaluated for appearance (colour, colour homogeneity), consistency, and texture (hardness, and flavour (odour and taste), using a 7–point scale (Pereira et al., 2011). The participants were asked to assess a number of specific attributes (Tables 1 and 2). The cheese curds were randomly coded with three-digit numbers.

Table 1. Description of organoleptic attributes for several sensory features, used by selected assessors to assess cheese curds with various concentrations of Jerusalem potato

Sensory features	Organoleptic attribute	Continuous scale	
		0	7
Appearance	Colour	White	Dark beige
Taste and odour	Intensity of Jerusalem potato taste and odour	Not detected	Pronounced
	Creaminess	Not detectable	Intensive
	Aftertaste	Not intensive	Intensive
Consistency and texture	Firmness	Weak, very soft	Very firm

Table 2. Description of organoleptic attributes for several sensory features, used to assess cheese curds with concentrations of Jerusalem potato (2% and 3%) and various concentrations of sterilized carrot purée

Sensory features	Organoleptic attribute	Continuous scale	
		0	7
Appearance	Colour	Gray beige	Creamy
	Colour homogeneity	Heterogeneous	Homogeneous
Taste and odour	Intensity of Jerusalem potato taste and odour	Slight	Pronounced
	Creaminess	Detectable	Intensive
	Aftertaste	Slight	Very intensive
Consistency and texture	Firmness	Weak, very soft	Very firm

Cheese organoleptic evaluation

The aim was to compare more than two samples; therefore, the method of ordering by preference was applied. The samples were coded with three-digit random numbers. A cheese sample was divided into various portions and equilibrated at room temperature. Its overall acceptability was evaluated, using a five–point hedonic scale (from 1 = I disliked very much to 5 = I liked very much). The samples were presented to the group in randomized order after salting. For assessment were chosen samples with CITRI–FI concentrations that allowed to obtain firm cheese curds with a sharp, clean split which were suitable for manufacturing cheeses with more or less improved organoleptic quality.

pH measurement

pH values were measured using pH–meter (pH 4–10 with a glass combination electrode).

Moisture measurement

Moisture content was determined by drying method using moisture determining device 'ELEX – 7'.

RESULTS AND DISCUSSIONS

The results of the sensory assessment of cheese curds quality are given in Figs. 2–4.

It can be seen (Fig. 2) that appearance, taste and odour, consistency, and texture of cheese curds were affected by the concentrations of Jerusalem potato.

The control cheese curd was a little firmer than the cheese curds with increasing concentration of Jerusalem potato. The colour range of the control sample and the samples with Jerusalem potato addition varied significantly. The concentration increase up to 3% led to insignificant decrease in curd firmness. The increase in concentrations of vegetable additive more than 3% led to a gradual decrease in organoleptic characteristics. The consistency of cheese curds became weaker, porous and even deliquescent. The taste and flavour of Jerusalem potato were strongly pronounced. All that makes these cheese curds the least acceptable for manufacturing cheese.

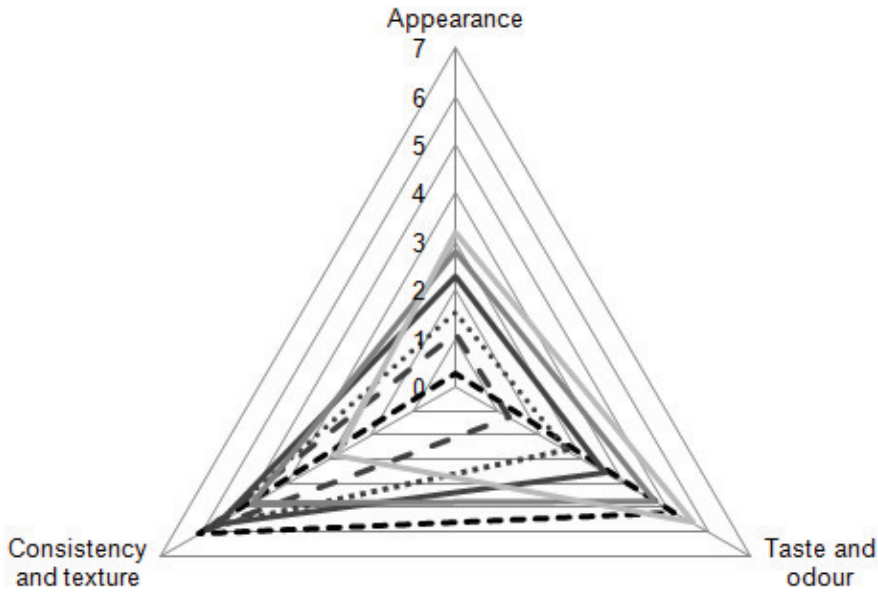

Figure 2. Spider plot of sensory attributes (lowest = 0; highest = 7) of cheese curds samples with various concentrations of Jerusalem potato, where: ---- control sample, – – 1%, ····· 2%, —— 3%, —— 4%, —— 5%.

Thus, the most acceptable concentrations of Jerusalem potato for cheese manufacturing are in the range from 2% to 3%. Further concentration increase leads to deterioration in the consistency of the curds, which complicates obtaining soft cheeses and makes them unacceptable for the consumer.

The data obtained from the profiles (Figs. 3, 4) showed that with the increase in carrot purée concentration and constant Jerusalem potato concentration, the cheese curd appearance became better. The samples gradually obtained a creamy colour. At the same time, an increase in carrot purée concentration resulted in a decrease in the consistency quality of the curd. When comparing the samples, it was found out that the higher the concentration of carrot purée, the lower the intensity of Jerusalem potato taste and odour, creaminess, and aftertaste in the cheese curd samples.

Based on the data, the recommended concentration of Jerusalem potato is no more than 2%, while for sterilized carrot purée the concentration should be no more than 8%. The optimal concentration of carrot purée is 8%, as this concentration improves colour and positively influences the taste of the product. With the increase in concentration of Jerusalem potato more than 2% and sterilized carrot purée more than 8%, deterioration in the quality of the curd occurred.

Research on laboratory scale has established relationships between concentrations of orange fiber and organoleptic characteristics of the soft cheese. The increase in the amount of CITRI–FI 300 FG has a negative effect on the quality of the curds. Acceptable curds may be obtained if the amount of the additive does not exceed 0.05 % of the weight of the mixture. But this amount has no positive effect on the organoleptic characteristics of the final product. With increasing dosage of CITRI–FI 300 FG, curds became mushy

and with a ragged split, making the further process of obtaining a product with acceptable organoleptic characteristics complicated.

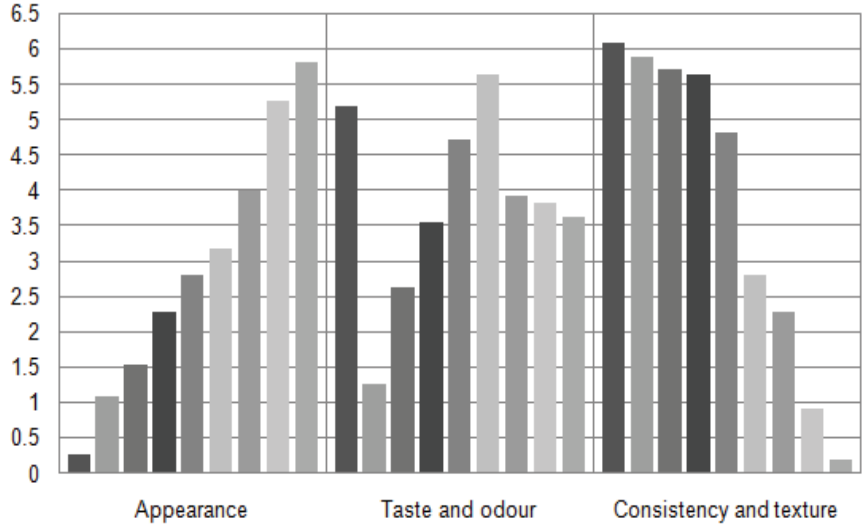

Figure 3. Descriptive sensitive profiles for samples with 3% of Jerusalem potato and various concentrations of carrot purée, where: ■ 1%, ■ 2%, ■ 3%, ■ 4%, ■ 5%, ■ 6%, ■ 7%, ■ 8%, ■ 9%.

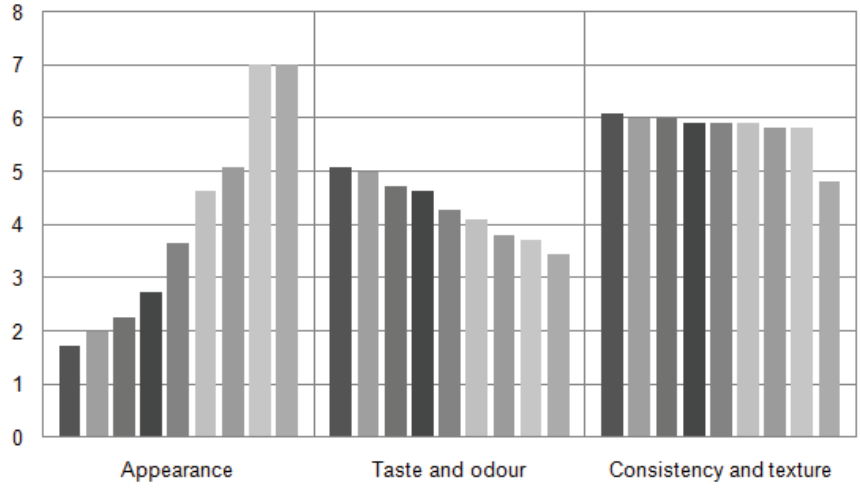

Figure 4. Descriptive sensitive profiles for samples with 2% of Jerusalem potato and various concentrations of carrot purée, where: ■ 1%, ■ 2%, ■ 3%, ■ 4%, ■ 5%, ■ 6%, ■ 7%, ■ 8%, ■ 9%.

The application of CITRI–FI 200 FG to improve the organoleptic characteristics of cheese revealed that an increase in the amount of additive has a negative impact on the taste and consistency of the obtained curds, and hence on the organoleptic characteristics of the product. The concentration of the additive more than 0.25 % of the weight of the mixture resulted in porous consistency of the curds, which further resulted in large losses of solids in the whey. With increasing dosage of CITRI–FI 200 FG, the finished product obtains an off-flavour. The amount of the additive lower than 0.25 % did not lead to significant improvement in the taste characteristics of the final product.

The application of CITRI–FI 100 FG at an approximate level of 0.05% to 0.4% enables to obtain curds with a sharp, clean split. The finished product has gained creamy mouth feel characteristics and an acceptable texture. Based on the sensory characteristics of the soft cheese, the addition of CITRI–FI 100 FG to the cheeses at levels 0.25 % or 0.3% of mixture weight was preferred. Further increase does not lead to significant improvement in the quality of the finished product.

For providing a soft cheese with the texture, smoothness, and organoleptic properties of a fatty product, the possibility of using CITRI–FI was investigated. The positive data were obtained. The researches on the effect of CITRI–FI concentrations on pH value of the soft cheeses were carried out. The data are presented in Fig. 5.

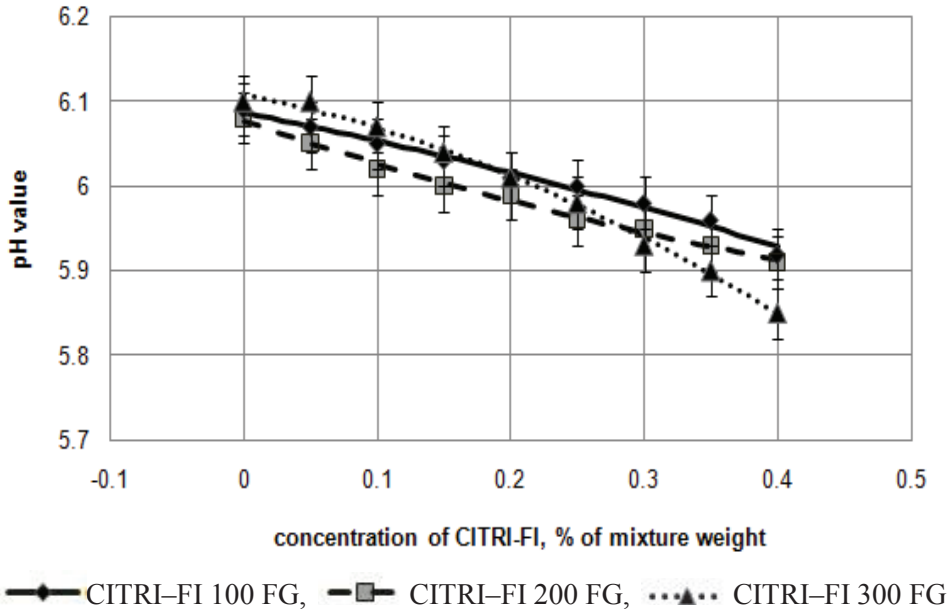

Figure 5. Effect of CITRI–FI concentrations on pH value of the soft cheeses.

The overall quality of cheese samples (Fig. 6) with the addition of CITRI–FI 100 (0.25%) was more acceptable for the panelists than control samples without CITRI–FI and with concentrations of CITRI–FI 300F G (0.05%) and CITRI–FI 200 FG.

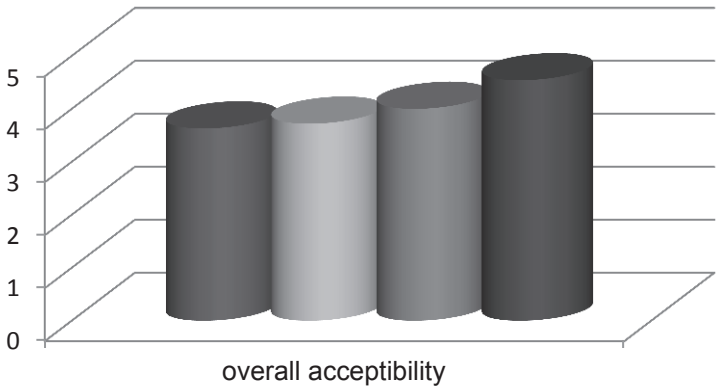

Figure 6. Overall quality of the products investigated, where: ■ control sample, ■ CITRI–FI 300FG, ■ CITRI–FI 200FG, ■ CITRI–FI 100FG.

CONCLUSIONS

1. In the course of the production of soft cheese from ultrafiltrated skimmed milk, Jerusalem potato and carrot purée can be used as vegetable ingredients with dosage 2% and 8%, respectively.

2. In order to produce soft cheese with the texture, smoothness and organoleptic properties of a fatty product, but containing no substantial fat, it is recommended to use CITRI–FI 100 FG at a level 0.25%.

3. The increase in CITRI-FI concentrations was stated to reduce the pH value of the soft cheese inconsiderably.

ACKNOLWLEDGEMENTS. This work was partially financially supported by the government of the Russian Federation, Grant 074-U01. The author, Iakovchenko N., is very grateful to the family for moral and financial support. The author wish to acknowledge Zyryanova A., Rykov S., and all those persons who have supported me.

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