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EFFECT OF FORMULATION VARIABLES ON SENSORY QUALITY OF THERMO-REVERSIBLE FRUIT FILLING FOR FROZEN SEMI-FINISHED BAKERY PRODUCTS: MODELLING AND OPTIMIZATION

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Abstract

Development of a food product requires integrated scientific and professional knowledge on the technological process, the final product and, the quality of the ingredients and their interaction. This research examined the effect of formulation variables on the sensory quality of a thermo-reversible sour cherry fruit filling, as well as the modelling and optimization of the variables for achieving the quality suitable for filling frozen semi-finished bakery products in industrial conditions. Each formulation for 15 model-samples was successively corrected, to achieve the appropriate sensory quality of the filling in finished products after baking. Their quality was evaluated by descriptive sensory and physico-chemical methods of analysis and compared. The basic formulation for the filling was defined after the successive production of 7 model-samples in laboratory conditions, their use in industrial conditions (puff pastry filling, shaping, quick freezing, storage for at least 24 hours at -18°C, baking and cooling to room temperature) and analysing their quality. Further formulation optimization included selecting: the type and amount of fruits (sour cherry, apple), food additives and cherry flavour for 8 new model-samples. The formulation and ingredients for the fruit filling production (30% sour cherry fruit, 30% apple puree, 58% sugar, 2% starch, 1% pectin, 0.03% firming agent E509, 0.03% acidity regulator E331, 0.025% cherry flavour) and quality parameters (dry matter 65%, acidity 0.85%, pH = 3.2-3.4) were defined. The fruit filling had appropriate sensory quality before and after baking of filled puff pastry: clear cherry-red colour, moderately firm consistency and stable volume, rich fruity aroma, and refreshing sweet-sour taste. The results also confirmed that the product was suitable for manual or machine filling of raw dough.

Keywords: food product formulation modelling, thermo-reversible fruit filling, sensory quality.

1. INTRODUCTION

Food production and consumption have changed dramatically in recent decades as a result of changes in consumers' eating patterns, behaviour and tastes. The increasing competition in food trends requires food industry innovations and development in food production, but these must be harmonised with consumers' demands and expectations at the same time (Grujić & Grujčić 2017; Salomann, Dous, Kolbe, & Brenner 2005; Siddiqui et al. 2022). The food industry should develop and improve the production conditions and offer consumer-oriented product quality to strengthen its competitiveness on the market (Grujić & Grujić 2021; Grujić & Odžaković 2016b; Soegoto & Walewangko 2020).

Descriptive and discriminatory sensory tests are used for determining the optimal ratio of sweetness and acidity, and other ingredients of delicious fruit toppings with wild berries, to make them suitable for ice cream or confectionery products (Grujić, Odžaković, & Ciganović 2014; 2016; Grujić, Odžaković, & Marković 2016; Grujić, Odžaković, & Stanković 2014). The sensory tests are also used as a tool for the formulation modelling of the fruit

topping with orange juice by selecting ingredients and pectin content suitable for achieving the expected sensory quality parameters of the product (Grujić & Odžaković 2016b). Taking this into consideration, conventional and low-calorie products such as fruit jellies have commercial value as an alternative for fruit processing and consumption, especially because of their sensory acceptability and nutritive quality (Lima, Flávia Mappa Domingos, de Souza Monteiro, dos Santos, & Pereira 2019; Rodrigues, de Souza, da Silva, de Oliveira, & de Lima 2017). Sour cherry is a type of fruit with a sweet but also very sour taste and a pleasant aroma. It is a good source of natural antioxidants with additional nutritional value. Particularly interesting are anthocyanins, water-soluble polyphenols with antioxidant activity, which are also a source of colour in different red, purple or blue fruit, and especially in the dark-red berry fruit. In addition, different ingredients and food additives may be used for controlling and modifying the nutritive and sensory quality of fruit jams and jellies (Banaś, Korus, & Korus 2018; Szajdek & Borowska 2008). Jelly texture is a very important quality parameter and it must maintain the semi-solid state. Different researchers studied the effects of sugar, acid and pectin, or other gelling agents, and fruit varieties on the nutritive and sensorial parameters of jam (Guimarães et al., 2019) and similar gelled fruit products. Also, other sensory properties such as colour, aroma and flavour participate in the product quality and acceptance (Acosta, Víquez, & Cubero 2008; Figueroa & Genovese 2019; Grujić, Odžaković, Jašić, & Blagojević 2008; Grujić, Plavšić, & Savanović 2008; Lima et al. 2019). Fruit-fillings are specific gelled products, which are in use in the food industry and households as ingredients of fine bakery products, biscuits and cakes. However, there are not enough available fruit products manufactured on the domestic market, in such a way that they have the required thermal stability and quality suitable for filling the products that are stored frozen before baking.

The sensory properties of a food product depend on the type, quantity and quality of the ingredients, and their interactions in a complex medium during the production process. All the mentioned factors significantly affect the quality of the final product, and special requirements for quality are set when using such products as ingredients of another complex multicomponent product. It is necessary to examine the influence of selected variables on the important parameters of product quality and determine the conditions for their achievement, in order to have final products with standard, uniform and acceptable quality, adapted to the purpose. The scientific and professional knowledge related to the technological process, final product and the quality of the ingredients, as well as their interaction, are essential for a successful food product formulation modelling. This research examined the effect of formulation variables on the sensory quality of a thermo-reversible sour cherry fruit filling, and their modelling and optimization of these variables for achieving the quality suitable for filling frozen semi-finished bakery products in industrial conditions.

2. MATERIALS AND METHODS

2.1. Materials

For the experimental production of fruit filling model-samples, the following ingredients were used: sour cherry filling, purchased as a commercial product available on the market (used as a control sample); frozen sour-cherry pitted fruit, total soluble solids (TSS) 14-15% (Ledo Zagreb, Croatia); apple puree TSS 11% (Vitaminka, a.d. Banja Luka, BA); table sugar (sucrose) in crystal; fine edible corn starch as a stabiliser and thickener, and citric acid (E330) packed in MLADEGS PAK d.o.o. Prnjavor, BA; gelling agent (E440): Pectin-A (Pectin Classic AB 902, a low methylester pectin, producer Herbstreith & Fox, KG, Germany); Pectin-B (Pectin Purple Ribon D-075X, a low methoxyl amidated pectin, producer Naturex Company, France); firming agent (E509) calcium chloride, dihydrate, p.a. (Lach-Ner, s.r.o. Czech Republic); acidity regulator (E 331) tri-sodium citrate, dihydrate, p.a. (Lach-Ner, s.r.o. Czech Republic); sour cherry flavour-E and thermostable sour-cherry flavour-T (ESAROM, GmbH, Austria); drinking water from the public supply system.

2.2. Methodology for fruit filling formulation development

All gelled model-samples were manufactured and their quality was analysed in the laboratories at the Faculty of Technology, University of Banja Luka, Bosnia and Herzegovina (BA). The sensory quality of the model-samples was analysed in the Laboratory for Sensory Analysis of Food, designed and equipped according to the standard (ISO 8589:2007 Sensory analysis – General guidance for the design of test rooms). The physicochemical properties of the model-samples were analysed in the Laboratory for Food Analysis. Baking tests were performed in industrial conditions in the Bakery in Banja Luka, BA.

The effect of the formulation variables on the sensory quality of a thermo-reversible sour cherry fruit filling was examined. First, the required sensory quality of the finished product was defined. After that, modelling and optimization of selected variables were performed to achieve the quality suitable for filling frozen semi-finished bakery products in industrial conditions. Each formulation for 15

model-samples was corrected successively, to achieve an appropriate sensory quality of the filling in finished products after the baking test. The descriptive sensory and physico-chemical methods of analysis were used for their quality evaluation and comparison.

The basic formulation for the filling was defined in the first part of the experiment by producing 7 model-samples successively in laboratory conditions, which were then filled into 720 ml glass jars and used in industrial conditions for puff pastry production. The pastry production included pastry filling, shaping, and quick freezing, storage of at least 24 hours at -18 °C, followed by baking and cooling to room temperature. The second part of the experiment was related to further formulation optimization by producing 8 new model-samples, selecting the best type and amount of fruits (sour cherry, apple), food additives and sour cherry flavour. The third, final part of the research was related to the defining of the formulation and ingredients for the production of fruit filling, with appropriate technological and sensory quality (sour cherry fruit, apple puree, sugar, starch, pectin E440, firming agent E509, acidity regulator E331, cherry flavour) and final product quality parameters (dry matter, acidity, pH).

2.3. Fruit filling production

The fruit filling production included: ingredients weighing; continuous hand-mixing for homogenizing during heating in an open container until reaching the temperature of ~70 °C; adding pectin-sugar mixture; control and correction of total soluble solids (TSS), acidity and aroma; product pasteurization (85 °C, 20 minutes) and filling (80–85 °C) into jars (60-65 °C). After that, the jars were manually hermetically sealed with twist-off metal lids and cooled at room temperature (~25 °C) until temperature equalization. The glass jars and lids were washed, dried and preheated to 65 °C before filling.

Approximately 20 g of fruit filling was manually and/or mechanically filled into puff pastry dough and the pastry was shaped, quickly frozen to extend the semi-finished product shelf life, stored for at least 24 hours at - 18 °C, baked, cooled to room temperature (on a factory scale) as defined by the manufacturer's specification, to test fruit filling suitability for use in products. Product quality parameters were analysed.

2.4. Instrumental and physico-chemical analyzes of product quality

The quality analysis of the produced fruit filling samples was performed at least 24 hours after cooking and conditioning. During modelling and optimization of the fruit filling quality, the following variables were analyzed: TSS (%) at 20 °C (Refractometer, LEICA); total acidity (%); pH values (pH-meter ISKRA) according to AOAC methods (Horwitz & Latimer 2000). The analyses of the products were done in triplicate.

2.5. Descriptive sensory analysis of product quality

Descriptive analysis of the quality of food product samples was performed in prescribed conditions, according to the procedures defined by the relevant standards (ISO 8589:2007 Sensory analysis – General guidance for the design of test rooms; ISO 6658:2005 Sensory analysis - Methodology – General guidance; ISO 13299:2003 Sensory analysis – Methodology – General guidance for establishing a sensory profile; ISO 11035:1994 Sensory analysis – Identification and selection of descriptors for establishing a sensory profile by a multidimensional approach; ISO 4121:2003. Sensory analysis – Guidelines for the use of quantitative response scales).

The evaluation of the fruit filling sensory quality and appropriate attributes (firmness, impression in mouth, colour, aroma, taste, overall quality) were recorded in a specially prepared evaluation form following the guidelines for sensory evaluation of fruit filling quality (Grujić 2015; Grujić, Grujić, & Poljašević 2010; Grujić, Plavšić, & Savanović 2008). Sensory analysis of the manufactured samples quality was performed by panellists, verified and trained according to the standard procedures (ISO 8586:2014 Sensory analysis–General guidelines for the selection, training and monitoring of selected assessors and expert sensory assessors). Each panellist received evaluation forms for all analysed samples. Quality assessments and ratings of all selected sensory properties (attributes) were done according to the instructions on the 5-point scale, where score 5 means appropriate quality and lower scores indicate less acceptable quality, while score 1 means unacceptable quality.

The samples were prepared, served and analysed under appropriate conditions. A five-member commission performed the descriptive sensory analysis of the quality of manufactured fruit filling samples by a consensus method. At least 24 hours after cooking and conditioning, approx. 30 g of each sample was served to assessors at room temperature. For the descriptive sensory analysis of the fruit filling in baked puff pastry, eight selected and trained panellists were recruited. In the judging booths, they individually analyzed the quality of the fresh-baked samples cooled at room temperature. All fruit filling and baked puff pastry samples were labelled with 3-digit codes and served to the panellists on white arcopal glass plates, with drinking water for cleaning the palate after each sample testing.

2.6. Statistical analysis

Data analysis was carried out through basic statistics and the comparative analysis by one-way analysis of variance (ANOVA) considering the sensory quality scores of the samples, followed by the Tukey Test for each of the parameters to determine differences between mean values; statistically significant were considered values of p below 0.05. The statistical analyses were performed using Statistical Software *3BStat* Gold Edition, Version 1.01 (Lovrić et al. 2006).

3. RESULTS AND DISCUSSION

3.1. Defining the fruit-filling sensory quality

Production of a gelled fruit filling with whole or chopped fruit, suitable for filling bakery products from puff or other dough, before final shaping and heat treatment (freezing/baking) presents a challenge for the researcher. The filling must have a balanced ratio of permitted ingredients, which should ensure the quality of the finished product adapted to the purpose. It must have stable gel firmness during production and use in bakery products, until the moment of consumption. In addition, the fruit filling as a finished product should be suitable for use directly from the packaging, for manual or machine filling of raw dough.

Efforts to develop new food products and increase consumers' interest in them should be part of the producer's strategy and sustainability concept (Grujić & Grujić 2021; Siddiqui et al. 2022; Soegoto & Walewangko 2020). In accordance with that, the creation of a thermo-reversible sour cherry fruit filling, as a new product, may begin with defining the expected technological and sensory quality followed by examining the effect of formulation variables on its sensory quality (Banaś et al. 2018; Grujić et al. 2010; Grujić, Odžaković, & Ciganović 2016; Grujić, Odžaković, & Marković 2016; Grujić, Plavšić, Jašić, & Blagojević 2008; Grujić, Plavšić, & Savanović 2008). It should be suitable for frozen semi-finished bakery products filling in industrial conditions. That means the fruit filling must have a balanced ratio of permitted ingredients, which should ensure the stabile quality of the finished product that is adapted to the bakery products filling before final shaping and heat treatment (freezing/baking). The expected sensory properties of the finished product should include the expressive colour of the fruit used as the basic ingredient, the appropriate structure and viscosity, with a refreshing sweet-sour taste. The aroma should be sufficiently pronounced and harmonized with the aroma and taste of the baked dough, in order to enable the enjoyment of consuming every bite.

The sensory quality is related to the technological quality of the food product, such as the type and amount of ingredients, the production process and its purpose. This type of product is usually manufactured with whole or coarsely chopped fruits, which can provide a clear expressive colour of the product. The fruit gel should also have a suitable stable firmness, structure and viscosity, and a harmonious refreshing sweet-sour taste in order to be associated with the fruit from which it is produced. The aroma should be sufficiently pronounced, recognizable and harmonized with the aroma and taste of the baked dough, in order to allow enjoyment of consumption. The product sweetness should be moderate and pleasant, harmonious with the filled dough. If the sweetness is not pronounced enough, it seems like there is not enough fruit. Contrary to that, a filling that is too sweet may dominate during chewing and prevent enjoying other product properties.

Formulation development is an important stage in new product creation. The initial formulation is usually created from available formulations for similar products. They are used for making a small quantity of model-samples or prototypes. They represent the basis for further research and optimization of product formulation and quality parameters, in an overall effort to achieve what is expected (Grujić 2015; Grujić & Grujić 2011; Grujić & Grujić 2012). Much research has been carried out and different methods have been developed for fruit gel quality improvement and optimization (Acosta et al. 2008; Banaś et al. 2018; Figueroa, , Genovese, & and 2018; Figueroa & Genovese 2019; Grujić, Odžaković, & Ciganović 2016; Grujić, Odžaković, & Stanković 2014; Lima et al. 2019). For example, Garrido, Lozano, and Genovese (2015)] analysed and modeled the effect of the main formulation variables (juice proportion in the juice-sugar mix, product pH, added pectin, and final content of soluble solids) to optimize formulation variables in order to maximize sensory quality and overall acceptability of apple jelly.

3.2. Modelling and optimization of the fruit filling basic composition

Recommendations for the selection of basic ingredients can be found in the literature, but the precise recipe and process parameters must be determined for the specific type and quality of available base ingredients. The first phase of the experimental part of this work involved the production of a series of model-samples (G1-5) in the laboratory conditions to define the fruit filling basic composition. The effect of formulation variables on the sensory quality of thermo-reversible sour cherry fruit filling samples (G1, G2, G3) was analyzed after conditioning the

Table 1. Formulation variables: quantitative content of basic ingredients, additives and quality parameters of sour cherry fruit filling.

Sample	Sour cherry (%)	Apple puree (%)	Sugar (%)	Pectin-B (%)[d]	Firming agent E509 (%)	Acidity regulator E331 (%)	Starch (%)	Sour cherry flavour-E (%)	Water (%)	Fruit filling quality parameters		
										Total soluble solids (%)	Acidity[a](%)	pH
G1	45	n	30.0	1.0	n	N	n	0.05	44	41.3	0.68	3.33
G2	45	n	40.0	1.0	n	N	n	0.05	44	47.0	0.68	3.28
G3	45	n	52.5	1.0	n	N	n	0.05	30	58.9	0.88	3.18
G4	45	n	52.5	1.0	n	N	n	0.05	30	60.2	0.86	3.28
G5	45	n	55.0	1.2	n	N	n	0.05	34	59.4	1.02	3.14
G6	34	11	52.9	0.8	n	N	n	0.05	33	58.9	0.60	/
G7	25	20	58.0	1.0	n	N	n	0.05	33	66.5	0.74	3.32

[a]Acidity of the finished product expressed as % of citric acid
n – not used

samples in prescribed storage conditions. All samples had the same amount of sour cherry, pectin-A, but different contents of TSS (G1=41.3%, G2=47.0%, G3=58.9%), as shown in Table 1. Sensory methods of analysis are a necessary tool during product development and quality control. Descriptive analysis is suitable for the qualitative and quantitative examination of one or more properties and corresponding attributes of food products (Grujić 2015; Grujić et al. 2010; Grujić, Odžaković, & Ciganović 2014; Grujić, Odžaković, et al. 2008; Grujić, Odžaković, & Marković 2016; Grujić, Plavšić, Jašić, & Blagojević 2008; Grujić, Plavšić, & Savanović 2008; Grujić & Grujić 2012). The results of the descriptive sensory analysis of the sour cherry fruit filling model-samples G1-5, obtained by the consensus method, showed that the sweetness was pleasant, moderately expressed and harmonious with the acidity, the product had an appropriate quality of aroma and the clear dark red colour, and sour cherry fruits were juicy and pleasant to consume. However, samples G1 and G2 had a gel, which was too soft, whereas G3 had the best gel consistency, but a more pronounced acidity compared to the sweet taste of the product. However, consumers usually preferred moderately expressed sweetness and acidity.

Identifying deficiencies in certain quality parameters in the research was used as a guideline for further modelling of the variables. Thus, the amount of pectin in the fruit gel-sample G3 formulation (with TSS 58.9%) was varied by producing sample G4 with 1% and G5 with 1.2% pectin (Table 1), in order to analyze their impact on the quality of the gel structure. In addition, the heat treatment during product cooking was shorter than the previous ones, in order to protect fruit colour and aroma quality from degradation. The sensory quality of the prepared G4-5 gel samples was analysed by the consensus method and afterward, a baking test was carried out in industrial conditions. The poor overall sensory quality of fruit filling samples visually identified after the baking test was an indicator that new combinations of ingredients ratio must be searched for. The descriptive sensory analysis of baked samples with panelists was not performed because it would be a waste of resources. Further modelling and quality optimization of the sour cherry filling was aimed at increasing the firmness and viscosity to maintain the volume of the filling after baking in puff pastry used as a model bakery product. Samples G6-7 were produced with the same total proportion of fruit in the filling (45%), but the sour cherry content was partially replaced by apple pure, in order to achieve thermal stability of the gel structure after the baking treatment. At the same time, the pectin content and total dry matter of the finished product were varied, as shown in Table 1, to test their impact on the product quality. Additionally, sour cherry fruit filling S1 – S8 provided additional variations of ingredients content Table 2. The descriptive sensory analysis is a useful method for the evaluation and identification of the achieved quality level of selected product attributes that may be indicators of the need for further quality improvements (Banaś et al. 2018; Grujić et al. 2010; Grujić, Odžaković, & Marković 2016). Table 3 shows the results of the descriptive sensory analysis of selected gel-samples sensory evaluation by 5-point scale and one-way

Table 2. Formulation variables: quantitative content of basic ingredients, additives and quality parameters of sour cherry fruit filling.

Sample	Sour cherry (%)	Apple puree (%)	Sugar (%)	Pectin-B (%)[d]	Firming agent E509 (%)	Acidity regulator E331 (%)	Starch (%)	Sour cherry flavour-E (%)	Water (%)	Fruit filling quality parameters		
										Total soluble solids (%)	Acidity[a](%)	pH
S1	30	15	58	1.0	n	n	n	0.06	22	64.0	0.84	3.26
S2	30	15	58	1.0	n	n	1	0.006	22	65.4	0.87	3.26
S3	30	15	58	1.0	0.03	n	n	0.012	15	64.5	0.98	3.21
S4	30	15	58	1.0	0.03	0.03	n	0.012	15	65.6	0.84	3.22
S5	30	15	58	1.0	0.03	n	1	0.012	22	64.5	0.86	3.24
S6	30	15	58	1.0	0.03	0.03	1	0.012	22	64.4	0.84	3.28
S7	30	15	58	1.0	0.03	0.03	2	0.025	22	64.0	0.84	/
S8	30	30	56	1.0	0.03	0.03	2	0.025	22	65.4	0.87	/

[a]Acidity of the finished product expressed as % of citric acid
n – not used

ANOVA for evaluated parameters (firmness, impression in the mouth, colour, aroma, taste and overall quality).

According to the results, the effects of changes in used ingredients content were noticeable, but the overall quality of samples G6 and 7 was not as expected after the baking test. The consensus method of the sensory analysis of the produced fruit filling indicated that the quality was adequate. However, the baking test in industrial conditions and descriptive analysis revealed that the overall quality of both samples was similar, significantly lower ($p<0.05$) than sample K, used as control (Table 3). At the same time, sample G6 was identified as unacceptable for the purpose due to the lower scored softer firmness and a slightly grainy impression in the mouth. Results indicated that these could be related to the instability of pectin in given conditions and that an optimal concentration of pectin should be determined to obtain a jelly with the desired structure. The samples had an acceptable red colour, but the taste was not sufficiently sour in combination with the dough (Table 3).

The apple aroma was more pronounced than that of sour cherry in fruit gel sample G7 and caused the lower aroma score due to double the apple puree content than in sample G6 (Table 3). A food product should have a specific, pleasant flavour, which is spontaneously released immediately before consumption or during chewing and crushing the product in the mouth. It is an important property for overall quality evaluation, because of the fact that any deviation can be associated with reduced quality, ageing or spoilage of the product. The sour cherry filling used as the control sample K did not have the expected overall sensory quality (Table 3), but it was purchased as the only product available on the market. Its colour was evaluated as lighter red than necessary, the gel was softer, and it leaked and stuck together with the dough after the baking test. The acidity was stronger than the sweetness, and the fruity aroma was insufficiently pronounced.

3.3. Selection of food additives type and optimization of their quantity of fruit filling

In the process of optimizing the quality of the new product, it is necessary to select the type and quantity of food additives to obtain thermal and mechanical gel stability for industrial use. It should be a moderately thick and viscous fruit filling, without the tendency of leaking out of the dough during dosing and baking. Descriptive sensory analysis provides a precise, pictorial description of the essential sensory properties of the fruit filling model-sample, which are directly related to its composition and quality parameters. Desserts and gelled products with fruit, such as gels, dressings and fillings, are often meal ingredients consumed with pleasure due to specific sensory properties (nice colour, consistency, taste and aroma). They are also interesting because of the biologically acceptable nutrients from fruit and pectin, the basic ingredients of the product (Barrett & Lloyd 2011; Grujić & Grujić 2011; Grujić, Odžaković, & Ciganović 2014; 2016; Grujić, Odžaković, & Stanković 2014; Guimarães, Alves, & Querido 2019). Some studies have shown that the ratio between sweetness and acidity, as well as the colour and aroma of the filling, are very important for the

Table 3. Results of descriptive sensory analysis of sour cherry fruit filling quality in bakery products and ANOVA.

	Results of descriptive sensory analysis of sour cherry fruit filling samples[1] (mean values of scores for n=8 measurements)										
Sensory properties of fruit filling	K	G6	G7	S3	S4	S5	S6	S7	S8	F-value[2]	p[3]
Firmness	3.69^{a}	2.89^{ac}	4.00^{abd}	3.73^{a}	3.69^{a}	4.00^{ab}	4.25^{abe}	3.00^{af}	5.00^{b}	7.418	0
Impression in mouth	3.81^{a}	3.17^{ab}	3.67^{a}	3.50^{ab}	3.31^{ab}	3.63^{ab}	3.75^{ab}	3.67^{ab}	5.00^{ac}	2.925	0.008
Colour	4.88^{a}	3.22^{b}	4.22^{ab}	3.63^{bc}	4.63^{ac}	4.63^{ac}	4.75^{a}	4.50^{ac}	5.00^{a}	6.571	0
Aroma	3.31^{a}	2.89^{a}	2.44^{a}	3.13^{a}	3.50^{ac}	3.88^{ac}	3.50^{ac}	4.00^{abc}	5.00^{b}	9.214	0
Taste	3.85^{a}	2.78^{b}	2.50^{a}	3.09^{a}	3.14^{a}	3.77^{ad}	3.56^{ad}	5.00^{c}	5.00^{c}	16.317	0
Overall quality	3.91^{a}	2.99^{b}	3.37^{ab}	3.41^{ab}	3.65^{ab}	3.98^{a}	3.96^{a}	4.03^{ad}	5.00^{c}	16.706	0

[1] Quality assessments of the selected sensory property are given according to the instructions in the range from score 5 (for appropriate quality) to score 1 (unacceptable quality).
[2]F–values for one-way analysis of variance (ANOVA) between the scores for fruit filling samples selected sensory properties ($p<0.05$)
[3]Statistically significant difference for mean values considered at the $p<0.05$ confidence level. Mean values followed by the same letter in a line are not statistically different.

overall quality of the gel (Grujić, Odžaković, & Ciganović 2014; 2016; Grujić, Odžaković, & Marković 2016; Grujić, Odžaković, & Stanković 2014). Garrido et al. (2015) find that consumers included in the preference test indicated that the taste and colour of the jellies were more important for them than gel consistency and had a significant effect on the overall product acceptability. Citric acid is a food additive that is used in food production according to the principle of *quantum satis* (Grujić 2018; Regulation, European_Commission 2008; Savjet ministara BiH 2018). It is usually used for standardising fruit product acidity. The insufficient acidity of the filling gives a bland impression even if the other sensory properties are in the expected optimal values. Excessive product acidity gives an unpleasant impression and is usually associated with green, insufficiently ripe fruit, thus reducing the desire for further consumption of the product. The production of thermoreversible fruit fillings is an interesting area of pectin use, as a gelling agent, because hydrocolloids, individually or in a mixture, can be used to achieve specific rheological properties, consistency or texture of the product (Chen 2014; Grujić, Odžaković, & Ciganović 2016; Grujić, Plavšić, Jašić, & Blagojević 2008; Grujić, Plavšić, & Savanović 2008; Peleg 2006). Relatively small changes in the concentration of hydrocolloids can lead to significant mechanical changes in the medium to which they are added, and it is important that they do not have a significant impact on other important sensory properties, such as colour, taste and aroma of the product. The fruit gel should have a clear colour, taste and smell, specific to the fruit from which it was produced, and a stable, moderately firm consistency even after reheating, mixing and cooling. During storage in jars, there must be no crystallization of sugar in the product, nor the separation of the liquid part, known as syneresis (Grujić, Plavšić, Jašić, & Blagojević 2008; Grujić, Plavšić, & Savanović 2008). The fruit jelly may be used as a filling for puff pastry or similar dough with yeast, which, after baking, has a golden-yellow colour, soft and airy-fluffy structure, which falls apart easily when touched. It offers a specific, pleasant aroma of dough and filling. The layer of dough directly below the filling can have a less pronounced laminar structure, depending on the type and amount of filling, but it must not be gooey or unbaked (Grujić, Odžaković, et al. 2008). In addition to the requirements for technological, sensory and nutritional quality, each food product must be attractive for consumption and with economically acceptable prices. Product development requires a lot of patience, persistence in work and varying parameters until the quality of the product that meets the expectations is achieved. Thus, a new series of samples was produced after modification of the previous formulation variables, with 30% cherry and 15% apple puree. The optimization of product quality continued with the selection of variables from the category of food additives (other types of pectin gelling agents, starch thickeners, hardeners, acidity regulators), thermostable cherry aroma and modelling their quantities during the production of gel samples S1-7. During the realisation of the experimental part of this research, we found out that the pectin-A was available on the market only in single packages of 10 kg and more. It was too much for the needs of the manufacturer, who cooperated in the research and was interested in the results. Therefore, further experimental research was carried out with Pectin-B, available in smaller quantities, sufficient for the planned annual production. During the definition of the quality parameters of the fruit gel, specific requirements were set according to the purpose of the product, because the filling froze at -18°C for 30 minutes, after filling into the puff pastry. After that, it was kept frozen for a certain time before the thermal processing (baking) of the pastry. The mentioned treatment can cause the loss of firmness and aroma of the fruit gel. The fact is that it is not easy to determine the optimal type and

amount and/or ratio between gelling agents (pectins) and thickeners (starch) with specific technological properties, which will give the expected quality of the final product.

The influence of hydrocolloids on the characteristics of fruit jellies and other similar products and their interaction with other functional classes of food additives (firming agents, acids, acidity regulators, stabilisers and thickeners) were the focus of different studies (Figueroa et al. 2018; Figueroa & Genovese 2019; Garrido et al. 2015; Lima et al. 2019). Modified starch products provide the necessary viscosity and stability of the fruit gel during heat treatment by baking, after freezing. However, they give a grainy, slightly floury gel structure, and a matte and cloudy appearance to the medium into which they are added. That is the reason for using starch in the mixture with selected food additives to obtain specific functional properties in the manufactured food product. Experimental fruit gel samples S1 and S2 differed in the corn starch content (0; 1%) and those variations may improve the consistency of the filling, while the thermostable cherry aroma-T (0.06%; 0.006%) was used with the aim to keep its quality after all thermal treatments, as shown in Table 2. The intensity of colour and aroma in the fruit filling must give an impression that the product contains a sufficient amount of fruit and is pleasant for consuming. That is why a new aroma type was included in S samples and the concentrations were varied in the manufacturing of subsequent samples (S1-7). After the baking test and visual inspection of the technological and sensory attributes of samples S1 and S2, sensory analysis was not carried out because inconsistency in quality was observed. Following samples S3-6 were made with the same amount of aroma (double the amount used in sample S2), with or without starch, firming agents and acidity regulator, which are all variables with a possible impact on the gel consistency (Table 2). It was found that sweetness as a product attribute can be related to the type and concentration of gelling and firming agents and the process of releasing sugars in the mouth (Lima et al. 2019), so it is important to examine the interaction of ingredients and their effect on sensory attributes for each medium. The specific structure of pectin ensures its functional properties, control of water binding capacity and cross-linking structure. The use of pectins as gelling and viscosity control agents has numerous advantages compared to other food additives with similar functional properties. Pectins make it possible to achieve the appropriate sensory quality of the gel; they control the degree of gelation and consistency of the product; they give the product a smooth, shiny surface and juiciness in the mouth during chewing and the fruit aroma comes to its full expression (Buggenhout, Sila, Duvetter, Loey, & Hendrickx 2009; Willats, Knox, & Mikkelsen 2006). Firming agents are food additives used for technological purposes as donors of calcium ions (calcium chloride E509) according to the principle of *quantum satis,* in order to bind calcium ions with pectic polysaccharides (Regulation, European_Commission 2008; Savjet ministara BiH 2018). Thermoreversibility and heat stability of the gel can be controlled by the addition of firming agents, which act as cation donors and have the ability to reduce unwanted gel softening at higher ion concentrations. It is known that in the presence of calcium ions, the crosslinks between pectin chains are formed, and gelation occurs. Low-esterified (amidated) pectins have certain advantages over non-amidated pectins because fewer calcium ions are required for gelation, they are less prone to precipitation at increased concentrations of calcium ions, and their gels are extremely thermoirreversible (Buggenhout et al. 2009; Willats et al. 2006). In their study, Lima et al. (2019) explain the effect of the concentration of gelling agents on the mechanical and sensory properties of gels and their impact on diffusion and flavour perception. In addition, the use of acids and acidity regulators, the changes in their concentration in the gelled products and temperature can control gelling speed (Buggenhout et al. 2009; Willats et al. 2006). Sensory analysis showed that the change in formulation variable in sample S6 resulted in a significantly better ($p<0.05$) firmness of the fruit filling gel, and a more pleasant sensation during chewing compared to the other analyzed samples, namely S5, S3, and S4 (Table 3). The required stability of consistency in the sample S6 in the packaging was identified after several consecutive manual mixing (with a spoon), as a good property for machine or manual dosing and normal conditions of use. Incorporation of increasing concentrations of starch, in the range 0±30 wt%, at low concentrations of calcium ions, may cause interactions between the starch and pectin polymers, promoting conversion to a compact associated form. However, large reductions in gel strength could happen when starch is incorporated at higher concentrations of calcium ions (Picout 2000). This was the reason for the selection and further modelling of fruit gel-sample S6 formulation variables to make samples S7 and S8 with double higher amount of starch, added to achieve better gel thermostability and double higher sour cherry aroma for a better, more refreshing fruity sensation of the baked product. As S1-S6 samples partly lost gel structure and consistency after the baking test, the formulation for sample S8 involved the increase in the total share of fruit from 45% to 60% compared to samples S1-7, which means 15% higher apple puree proportion (Table 2). The structure and consistency of the gel are particularly important for the overall impression of the sensory quality during consumption and the relative surface movement of the product pieces in the mouth, associated with thermal changes

during the heating or cooling of the bite. The manufacturer's task is to use all the possibilities offered by modern production conditions, in order to achieve harmony of all-important technological and sensory parameters of product quality. Descriptive sensory analysis of the cherry fruit filling of samples S7 and S8 after freezing, thawing and baking test in the dough, showed that sample S8 had appropriate, significantly better overall quality ($p<0.05$), the same as when compared with the other analysed samples. It was juicy, moderately firm with significantly the best firmness ($p<0.05$), and pleasant to chew. The colour of the filling was bright red, specific to cherries; the taste was pronounced, clean and distinctive, with a balanced ratio between sweetness and acidity of the filling in combination with a bite of baked dough (which was used as a carrier for testing the filling quality). The aroma was pronounced, clean and characteristic, so the mean score was excellent (Table 3). The mechanical and thermal stability, as well as the thermo-reversible properties of the gel, are especially important for required stability during heating, transport, dosing and filling into the product. In addition, it is important for further treatment and use depending on its purpose. Pectins, food additives from the gelling agents functional category, together with stabilizers and thickeners enabled the creation and production of a large number of dedicated products with the ability to form a gel of the desired sensory and technological quality and use (Buggenhout et al. 2009; Grujić et al. 2010; Grujić, Odžaković, & Ciganović 2016; Grujić, Odžaković, & Marković 2016; Willats et al. 2006). The presented results of the research confirmed that selection, modelling and optimization of food additives use affect the appearance of the gel with a specific purpose, the colour impression, release and identification of taste and aroma. During the new product creation or modification of quality parameters, manufacturers must try to correlate the mentioned activities with the purpose of the product.

3.4. Defining the fruit-filling formulation and quality parameters

The offer and availability of a large number of food products on the market are the results of positive competition and producers' desire to satisfy the identified requirements and expectations of product users. The sensory quality of offered food products must be optimal and acceptable, i.e., the appearance, smell, taste, colour and consistency, specific and pleasant for a given type of product. The formulation for a new product suggests basic ingredients in order to achieve the expected sensory properties of the product and equally important technological quality. Sensory methods of analysis are used as a tool for identifying quality parameters and for the overall assessment of the achieved product quality (Grujić & Grujčić 2017; Grujić & Grujić 2011; Grujić, Odžaković, & Ciganović 2016; Grujić, Odžaković, & Marković 2016; Guimarães et al. 2019) and offer a competitive product on the market (Grujić & Grujić 2021; Grujić et al. 2010). The final phase of the experimental part of this work included defining the recipe and quality parameters of the fruit filling, as a new product. Based on the results of descriptive sensory analysis and quality assessment, sample S8 cherry filling was selected as the best for filling bakery products that are treated by freezing to extend semi-finished product shelf life and then baked as needed. The basic ingredients for the production of sample S8 cherry fruit filling were used in the following ratio: 30% cherry fruit; 30% apple puree; 58% sugar; 1% pectin-B (Pectin Purple Ribon D-075X, manufacturer, Naturex Company, France); 2% corn starch; 0.03% firming agent E509; 0.03% acidity regulator E331; 0.025% cherry aroma-T (manufacturer ESAROM, GmbH, Austria). The TSS of the finished fruit filling was 65%, citric acid was used to correct the acidity up to 0.85% (expressed as citric acid), and pH was within the range of 3.2–3.4. This type of product is expected to be tasty and economically acceptable for manufacturing. The results of the analysis confirmed that the fruit filling was characterized by appropriate sensory quality, a specific clear cherry-red colour, and moderately firm consistency and that it was suitable for filling bakery products made of puff pastry or other dough, giving them a rich fruity aroma, a refreshing sweet-sour taste and a special pleasurable sensation during consumption. The fruit filling prepared as a finished product can be used directly from the packaging, for manual or machine filling of raw dough, as is usual. It is significant that the introduction of this product into the production program of the factory for the production of jams and marmalades can be economically acceptable because it does not require investments for new equipment.

4. CONCLUSIONS

The conclusion that can be drawn from the results of the presented research is that the formulation optimization and variable modelling in laboratory conditions, for achieving appropriate product sensory quality, demands an integration of scientific and professional knowledge on the technological process, final product and the quality and interaction of its ingredients, in order to achieve the desired sensory quality of the product. In addition, the use of experimental products in industrial conditions and the analysis of their quality parameters by descriptive sensory and physico-chemical methods are necessary for successful food product development. The expected technological and sensory quality and the basic formulation for

the sour cherry fruit filling were defined in the first part of the research, and, after that, the formulation optimization included selecting the type and amount of fruits, food additives and flavour. The final formulation should enable the production of a fruit filling with appropriate or expected technological and sensory quality, suitable for manual or machine filling of the puff pastry dough, shaping and quick freezing, storage for at least 24 hours at -18 °C, baking and cooling to room temperature. The paper presents a methodology for the development of a thermoreversible fruit filling, as a new product that is stable at heat treatment (freezing/baking) temperatures. The methodology can be used as a model for similar product development for the food industry or target market needs.

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