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# The Influence of Jerusalem Artichoke as Nutrition Value Increaser on Microbiological Parameters of Confectionery Products

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**Abstract.** The confectionery industry is one of the fastest growing segments in the global food market. Unfortunately, confectionery products, including marmalade and cakes, have low nutrition value and high energetic value, which does not respond the rules of healthy diet. Jerusalem artichoke syrup and Jerusalem artichoke powder made from Jerusalem artichoke roots also are valuable products, rich in inulin, as well as vitamins and minerals, and can be used for fortification of marmalades and cakes. Concerning to new products consumers today demand high-quality products that are safe for health, but food production companies willing to produce new food products whom storage time is not less than of traditional food products, to find out this information is necessary to determine the microbiological parameters of freshly prepared new products and during storage. The objective of this work was to evaluate microbiological parameters of sugar confectionery and pastry, also and the changes during storage time if one of ingredient is partly replaced by product made of Jerusalem artichoke. The results of this research show, that sugar it possible to replace with Jerusalem artichoke syrup up to 40% of total amount of sugar, and so increase nutrition value of marmalades, taking into account the condition that after the clotting marmalades need to leave to dry. The study indicates that Jerusalem artichoke powder can be used for enrichment of cakes also to prolonging the storage time.

**Keywords:** Jerusalem artichoke syrup, Jerusalem artichoke powder, Confectionery, Microbiological parameters

## 1. Introduction

Confectionery products are an integral part of the human diet because they can be used as a high density food energy source, it improves the feeling and mood of consumers, and they are an important part of celebrations, festivities and family traditions.

Marmalade of sugar confectionery group traditionally has been a permanent demand for all people because of high sensory properties, therapeutic-prophylactic characteristics due by the content agar substances and the relative accessibility to consumers. Marmalade is a product manufactured from fruit juice and high amount of sugar, last ingredient is not so good for health of consumers.

Cakes are most popular pastry products worldwide. Cakes have sufficiently long storage time, good taste, and cake making is no long a complicated procedure. Unfortunately, cakes contain high content of fat and sugar, as in result them cakes are product with high content of calories, but are low in dietary fibre, vitamins, and minerals which does not respond the rules of healthy diet.

The confectionery industry is one of the fastest growing segments in the global food market [1] and this trend will be observed in the future. For most of people, however, indulging in sweets must be done with care. More than half of developed countries adults are overweight or obese [2]. Therefore, scientists and nutrition experts must look for opportunities to make healthier confections using new solutions.

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The Jerusalem artichoke tubers are known to be a health-promoting source. They contain inulin instead of starch as a carbohydrate reserve. Inulin and its degraded product oligofructose are the major compounds of interest in the food industry as functional food ingredients and low-calorie food materials [3]. Many scientists have discovered that it has a beneficial effect on the gastro-intestinal activity stimulating reproduction of beneficial bacteria. Jerusalem artichokes have also been promoted as a healthy choice for diabetics. The reason for this being the case is because fructose is better tolerated by people that are diabetic. It has also been reported as a folk remedy for diabetes [4].

Jerusalem artichoke roots are one of the raw materials used for production of inulin syrups. Inulin, polysaccharide composed of fructose, is legally classified as a food ingredient, a low-calorie sweetener [5] in all countries where it is used. Jerusalem artichoke syrup (JAS) contains group of vitamins B and it is optimal for enrichment of marmalades [6].

The Jerusalem artichoke powder (JAP) made from Jerusalem artichoke roots also is a valuable product, rich in inulin, as well as vitamins and minerals [7] and [8]. Powder of dried Jerusalem artichoke tubers is more convenient to store for a longer time and easier to use in technological processes. Jerusalem artichoke powder has lower moisture, protein, and fat content in comparison with the high quality wheat flour but the dietary fibre, sugars, vitamins, and minerals amount is higher [9]. Powder of the whole tubers of Jerusalem artichoke with high of inulin may be applied as substitute of cereal flour in cakes.

Food choice is a complex function of sensory characteristics (taste, odour and texture), and non-sensory characteristics such as physiochemical properties, familiarity, food-related expectations, attitudes and health claims [10]. Concerning to new products consumers today demand high-quality products that are safe for health, but food production companies willing to produce new food products whom storage time is not less than of traditional food products, to find out this information is necessary to determine the microbiological parameters of freshly prepared new products and during storage.

The objective of this work was to evaluate microbiological parameters of sugar confectionery and pastry, also and the changes during storage time if one of ingredient is partly replaced by product made of Jerusalem artichoke (*Helianthus tuberosus* L.).

## 2. Materials and Methods

Experiments were carried out in the Laboratory of Food Analyses, Laboratory of Packaging Material Investigations, and Research Laboratory of Microbiology at the Department of Food Technology at the Latvia University of Agriculture in 2012. The object of research was confectionery – marmalades with Jerusalem artichoke syrup and cakes with Jerusalem artichoke powder.

For experiments were used three kinds of samples of marmalades: control sample and two kinds of samples with JAS. To prepare control sample the classical recipe was used: agar, glucose syrup, sugar, citric acid, and water. Experimental samples were prepared substituting sugar by JAS in the following proportions - 20% and 40% from the total amount of sugar. Agar water solutions was boiled for 5 minutes at the temperature of 100 ℃, sucrose and citric acid were added to the boiled solution and cool down to 85 ℃. Then JAS was added, mixture stirrer and store 5 minutes at the temperature 85 ℃ and was hot filled in polymer forms and stored for three hours at the room temperature (+20±1.0 ℃) for solidification marmalades were removed from the polymer forms.

For experiments were used JAP, commercial high quality wheat flour, and six kinds of samples of pastry products: control sample and five kinds of samples with JAP. Cakes prepared using classical recipe (commercial high quality wheat flour, sugar, dry skim milk powder, dehydrated eggs, drinking water, corn oil, baking powder, vanilla sugar) and technology, were used as a control sample. In samples with Jerusalem artichoke wheat flour was substituted with JAP in concentrations – 10, 20, 30, 40, and 50% of planned amount of wheat flour.

For storage samples of marmalades and cakes were packaged into polypropylene (PP) film bags and kept in room temperature at +20±1 ℃ and air moisture <75%. The stored products did not contact products and substances with a specific aroma. Samples were analyzed on their preparing day and then on the 7th, 14th, 21st, and 28th day of storage.

The following mechanical and physical characteristics were analysed:

- Moisture content was determined by ISO 6496:1999 as accordant to the storage time by verified balance KERN (Germany) with precision ±0.001g; mass loss calculation (%) – were determined by weighing packed samples on the electronic scales, by standard LVS ISO 1442: 1997.
- pH was measured by JENWAY 3510 pH-meter, standard method LVS ISO 5542:2010.
- Water activity was determined by standard ISO 21807:2004, AquaLab LITE device.
- Soluble dry matter was measured at 20 ℃ by using a refractometer Mettler Toledo, Refracto 30PX according to LVS 249:2000.
- The acidity was determined by titrating the diluted samples with 0.1 M NaOH.
- Hardness analyses (cutting force in N) of marmalades were determined on the Texture Analyzer, "TA.XT.plus Texture Analyser" (Stable Micro Systems Ltd., Surrey, UK) and the measuring probe A/BC (butter cutter, can be used for soft samples, supplied in association with the Texture Analyser). Cutting force was determined of marmalade samples; thickness of each sample was 2 cm. Each piece of marmalade candy sample for cutting was placed centrally under the cutter edge. The system was equipped with compression cell of 50 kg and software Texture Exponent 32. Hardness was measured as the maximum penetration force (N) reached during breakage of tissue. The measuring parameters were: pre-test speed 1 mm s-1; test speed 1 mm s-1; post-test speed 10 mm s-1; cutting distance: 13 mm pressing into the sample. The measurement is triggered automatically at 0.09807 N. The samples were cut partly through, in order to check the differences of structural characteristics. The maximum force required for sample compression was calculated as an average of 10 measurements.
- Microbial analyses: determination of the yeast cells and moulds number for all the analyzed samples was done in compliance with LVS ISO 21257-2:2008 "Microbiology of Food and Animal Feed. Horizontal method for counting yeasts and moulds fungi".

Program SPSS 14.0 for Windows and Microsoft Excel for Windows 7.0 processed the data mathematically. Mean arithmetic value and standard deviation were calculated for the obtained results. Data were interpreted by single factor and multifactor analysis of variance (ANOVA).

# 3. Results and Discussion

## 3.1. Effects of JAS and JAP on Physical Parameters of Marmalades and Cakes

To characterise experimental samples was detected some physical parameters, which have influence on microorganisms development on marmalades and cakes.

Marmalade is characterized by the formation of a gel in jellies, and these properties are developed by the interaction of sugar, gelling substances, and acidity. Acidity plays an important role in the process of gel formation using the agar. If the acidity is too high in gel formation of a liquid mass sineresis go on, but if the acidity is too small gel will not develop at all. The acidity of control sample was evaluated at 4.3±0.13°, but acidity increasing was observed in marmalades with JAS (Fig.1).

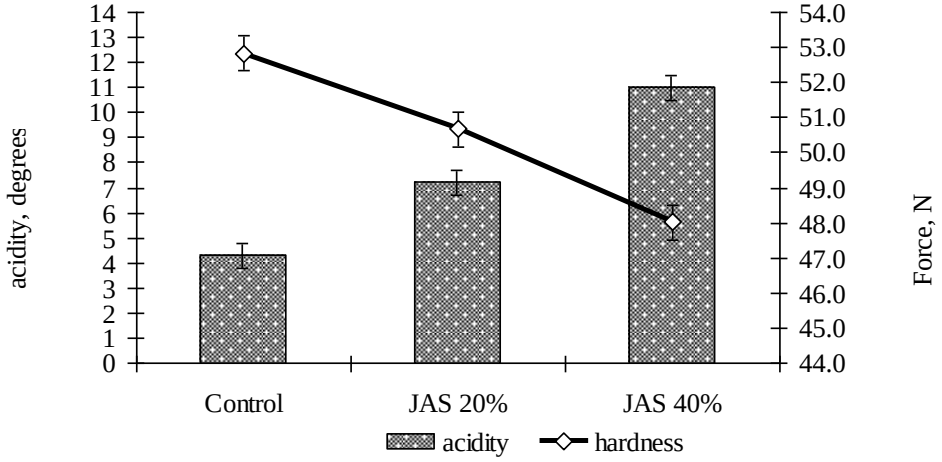


Fig. 1: Acidity and hardness of marmalades

With increasing acidity, decreased sample hardness (Fig.1), because it interferes an agar to form a gel with firm consistency.

The results of analyses showed that the pH of the control was 3.52, but with addition of JAS pH was increased: for marmalades with 20% of JAS were 3.81, but for marmalades with 40% of JAS – 3.93.

Marmalade is product called intermediate moisture foods. The total soluble solids of control was 65.55 Brix%, but samples with JAS total soluble solids decreased (Fig.2). The decline reason is the fact that there no forms stable grid at product, but there occurs unrelated water sineresis during which the product exude, and then in this dilution dissolves soluble solids of current product.

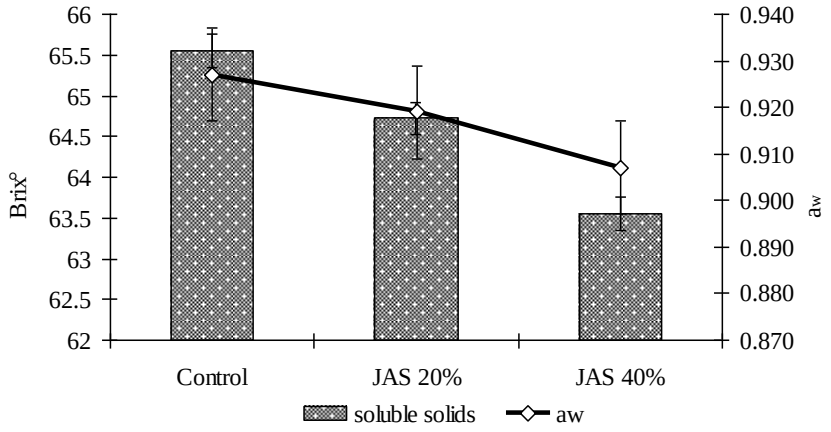


Fig. 2: The total soluble solids and water activity of marmalades

The value of water activity ($a_w$) of control sample of marmalade was 0.927 (Fig. 2). With addition of JAS $a_w$ of marmalade samples not change significantly ($p>0.05$), but there is observe a tendency of $a_w$ decreasing.

$a_w$ characterizes free, unrelated water in the products. It is the ratio of the quantity of water which is available used for biological and chemical reactions which impact significantly grow of microorganisms. In the cake with Jerusalem artichoke powder should be develops microorganisms slower than in cakes made from high quality wheat flour, which was approved in advanced research. Experimentally determined physical parameters of cakes show that addition of JAP has significant influence on moisture, water activity and pH – factors which influenced microorganisms' development on cakes. The obtained results show that the moisture content of control was 19.97%, and addition of 10 and 20% of JAP, moisture content increase, but from 30% of JAP moisture content decreased (Fig.3), because in cakes increase part of JAP, which content of moisture is three times less than of wheat four (12%).

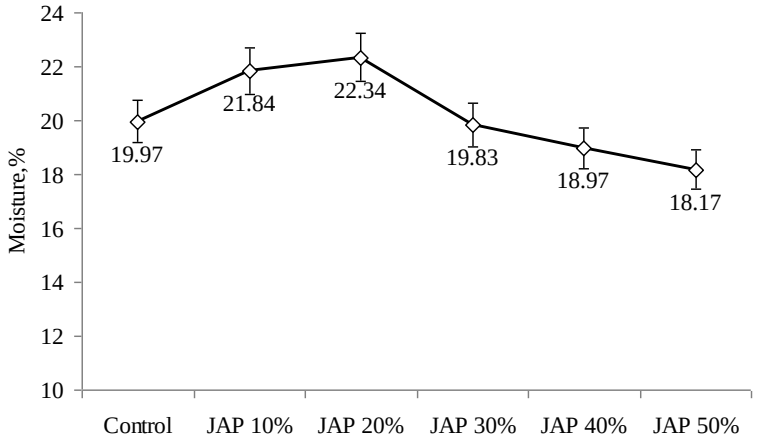


Fig. 3: Moisture content of cakes

Comparing control with samples containing JAP, there can observe pH and water activity decreasing in increasing of concentration of JAP in cakes (Fig.4).

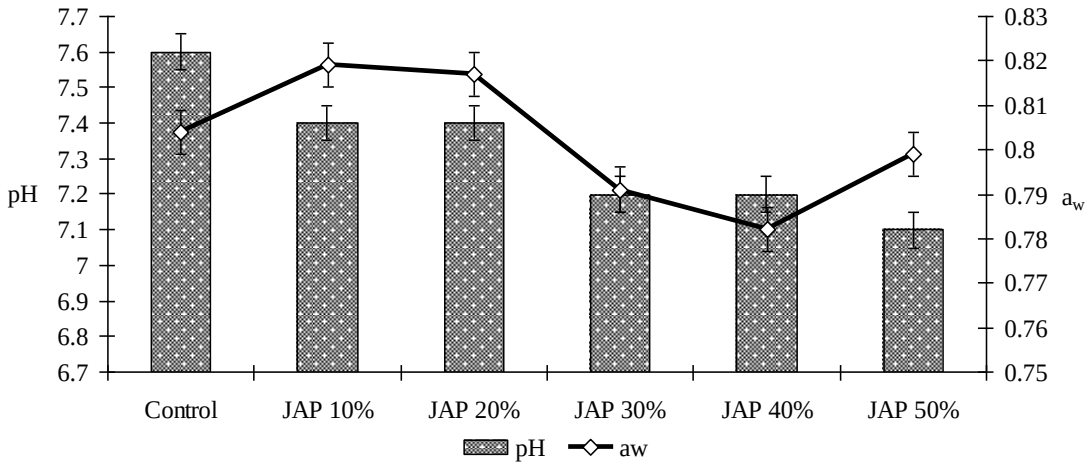


Fig. 4: pH and water activity of cakes

## 3.2. Effects of JAS and JAP on Microbiological Parameters of Marmalades and Cakes

In sugar confectionery sugar prevents deterioration of microbiological parameters, which could be caused by bacteria, yeasts or molds. Reducing the amount of sugar in the product we should follow the validity of indicators. Traditionally, sugar confectionery products are considered as microbiologically stable and safe to use due to the inherent low water activity. Such sugar confectionery products as marmalades realization term limits the changes of the quality, which primarily due to changes in its structure, because it could be related to the crystallization of sugar and water activity changes and moisture loss during storage [11]. Important role should be given to marmalades cooling to a certain temperature. Marmalades prematurely packed, mostly can contribute to mold growth. Temperature change, the package is formed by condensation that enters the surface of the product and increases the moisture concentration, thus creating a favorable environment for mold development.

Microbiological analyses of marmalades showed that yeast cells and moulds number practically was no observed up to day 21, but after day 21 the development of microorganisms was minimal and the amount of them was in permissible limits (Fig. 5, Fig. 6).

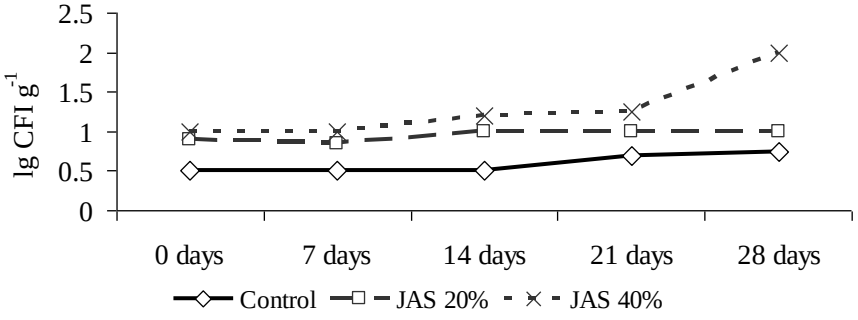


Fig. 5: Development of yeasts in the marmalades during storage time

Marmalade sample with 20% of JAS is accentuate as optimal because earlier done sensory experiments and this experiments confirm the best sensory, the storage and safety results. Marmalades with JAS, which after clotting puts to drying for obtaining the thin crystalline crust, which protects the marmalade from the yeast and mold development, it is possible to store for 3 months, which conform to the traditional sales period for this product. Overall, results of this research show, that sugar it possible to replace with JAS up to 40% of total amount of sugar, and so increase nutrition value of marmalades, taking into account the condition that after the clotting marmalades need to leave to dry.

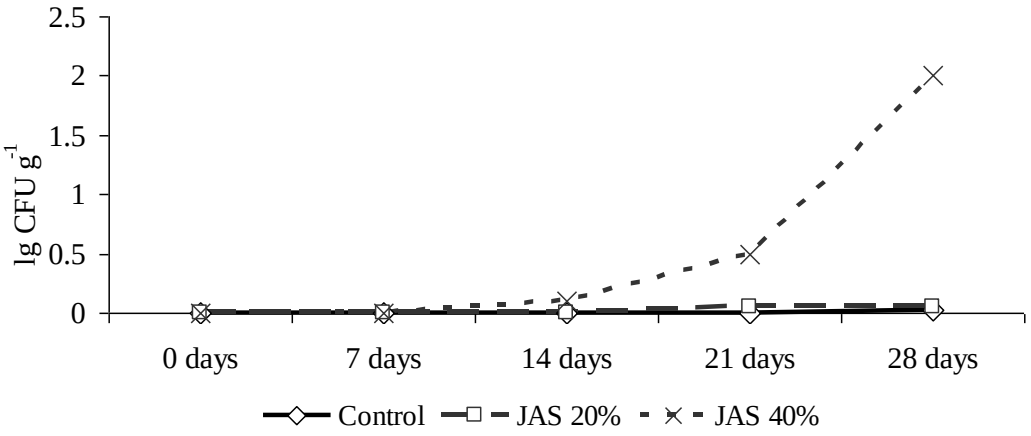


Fig. 6: Development of moulds in the marmalades during storage time

When analyzing the microbiological quality JAP, the study indicates that colony forming units of yeast in JAP and high quality wheat flour differs significantly, Weil colony forming units of yeast in JAP is 3.19, but in wheat flour two times more – 6.83.

The development of mesophilic microorganisms stimulates the high humidity, mold germinate, if humidity is 14-16%, and if is a high water activity, also pH range is in 6.0 to 8.0. As noted in the literature [12] and [13], high moisture content and water activity are contributing factors in the development of microorganisms. Cakes have relatively high moisture (18.2 to 22.3%) and water activity (0.790 to 0.817), and pH ranges of 7.3 to 7.8, these conditions are most optimal for growth of microorganisms. These factors could also reason to the development of microorganisms on cakes.

After storage time 7 and 14 days yeast and mold development at experimental cakes with JAP was not detected. On the experimental day 21 on some of the samples, there were detected colonies with microorganisms. Among all types of cake samples as the first perish samples without JAP (control) and the samples with 10% of JAP, that confirmed the results of yeast and mold colony forming units of assessment results (Fig. 7, Fig. 8).

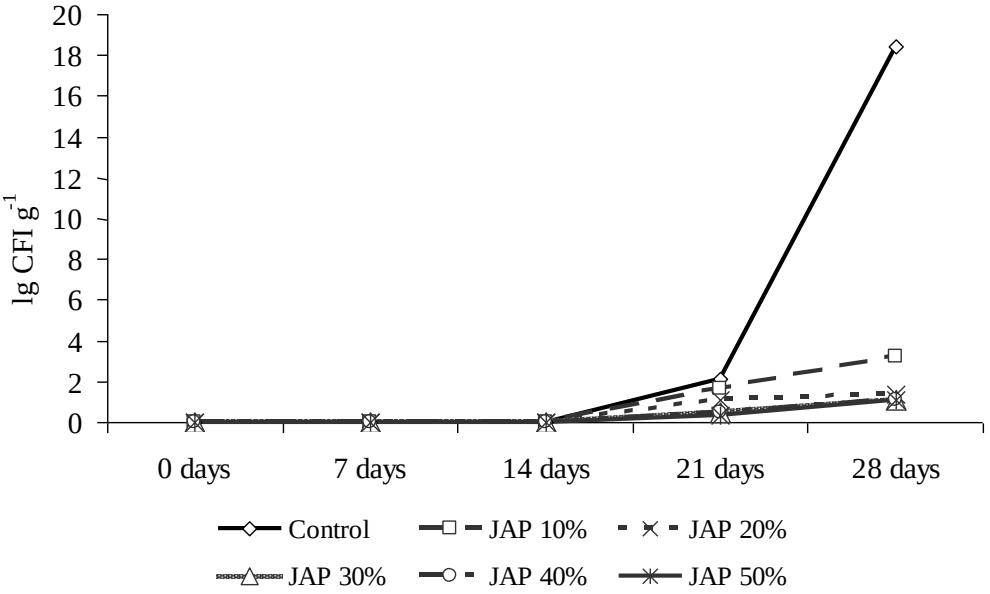


Fig. 7: Development of yeasts in the cakes during storage time

As shown by the results of research, after storage time 28 days control sample and the samples with JAP in concentrations 10% and 20% had deteriorated and for human consumption was not good. Experimental samples with JAP in concentration 30%, 40% and 50%, yeasts and moulds development was minimal and not exceeding the allowed concentrations (Fig. 7, Fig. 8).

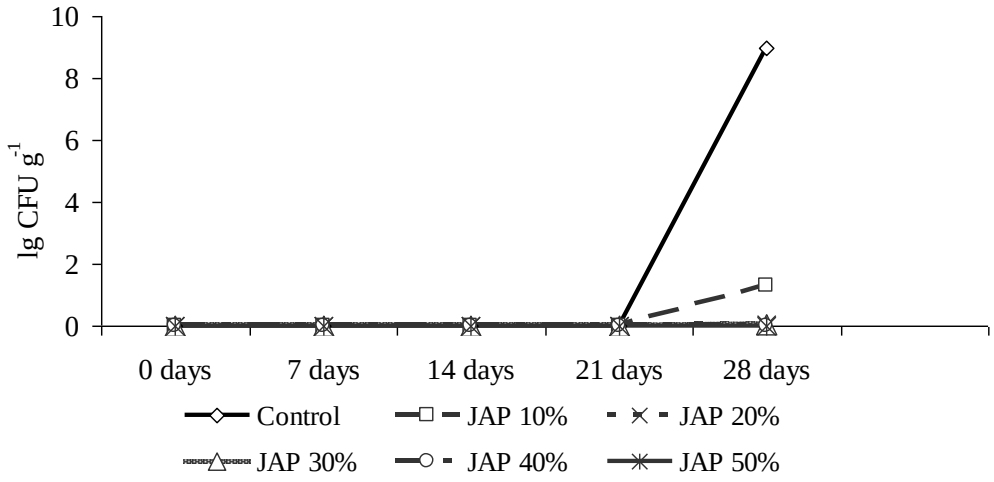


Fig. 8: Development of moulds in the cakes during storage time

Assessing the results of studies replacement of wheat flour with JAP more than 30% inhibited significantly the development of yeasts cells and moulds number in cakes ($p<0.05$). Overall, the number of yeast cells and moulds in the cakes with JAP decreased with the increase of JAP amount. Benzoic acid and octanoic acid, which was found due previous experiments in the content of volatile aroma forming compounds of JAP, might prevent the growth of yeast cells and moulds number.

In cakes which have been prepared with a 30% Jerusalem artichoke powder, yeast and mold do not form and product lifespan is prolonged to 21 days. The study indicates that JAP can be used for enrichment of cakes also to prolonging the storage time.

## 4. Conclusion

JAS and JAP additions into confectionary had considerable effects on physical properties of confectionary. Besides being traditional high sugar and low nutrition value marmalades and cakes, which are not associated with healthy diets by most consumers can be modified to produce a healthy alternative, the finding of this study confirmed that JAS and JAP does not stimulate the development of microorganisms products and are successfully usable for confectionaries product preparation. The results of this research show, that sugar it possible to replace with JAS up to 40% of total amount of sugar, and so increase nutrition value of marmalades, taking into account the condition that after the clotting marmalades need to leave to dry. If the wheat flour is replaced with Jerusalem artichoke powder 30% and more than the quantity of the added Jerusalem artichoke powder inhibits significantly the development of yeasts cells and moulds number in cakes.

## 5. Acknowledgements

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