TECHNOLOGICAL SOLUTIONS OF FRUIT PASTILLES AND THEIR QUALITY ASSESSMENT

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Abstract

The production of fruit pastille was aimed at replacing traditional sugar-rich sweets. For ecological and economic reasons, they were mainly made from local raw materials. These fruit pastilles were produced using natural materials such as fruit and vegetables, without the use of any food colouring or other artificial additives such as sweeteners, etc. To produce a healthier alternative to traditional sweets, appropriate technological solutions have been taken. Fruit pastilles were made exclusively from different varieties of apples, as well as by mixing apples and carrots, apples and blueberries without added sugar and with 20 % sugar. The fruit pastilles were evaluated by children aged 4-10 years. The fruit pastilles without added sugar, made from Bogatyr apples and blueberries scored the highest points due to their distinctive taste, as the panellists identified them as blackcurrant pastilles. The moisture content and water activity of the fruit pastilles, which affect texture and shelf-life, were determined. These physico-chemical parameters were found to be higher in the samples with added sugar: 43 % moisture, 26 % water activity and 62 % ash compared with the samples without added sugar. This could be due to the sugar-pectin structure formed. Fruit pastilles, both without and with added sugar, were lower in calories than traditional sweets.

Keywords: *fruit pastilles, apples, berries, vegetables, quality*

1. INTRODUCTION

Agro-innovation and food processing aim to rationalise the use of local raw materials, to produce innovative food products or to improve existing ones, which must be safe, with good organoleptic qualities, appealing to the consumer, satisfying the body's physiological needs, and free of added sugar. Foods containing sugar are often high in calories and low in valuable nutrients. Consumption of such foods provides more calories than our bodies need and puts us at risk of various diseases: tooth decay, obesity, diabetes, cardiovascular disease, and some types of cancer (Welsh, Cunningham, 2011; Fardet et al., 2019).

According to the WHO, the number of obese people, including children, is increasing worldwide (Erickson, Slavin, 2015). In the US, 38% of the population is overweight, whereas in Lithuania 26.3%, compared to the EU average of 23.3%. It is estimated that there are 14 million overweight children living in 27 countries of the EU and 3 million are already obese. Excess weight is one of the reasons why people suffer from cardiovascular disease and high blood pressure. Health experts, in line with the findings of the World Health Organisation (WHO), recommend reducing or eliminating added sugars, improving the appearance and taste of food products by using natural ingredients of natural origin, preserving their beneficial properties, and avoiding synthetic food additives (Erickson, Slavin, 2015; Fiji, 2018).

One of the problems with the consumption of fruit, berries and vegetables is that many of them are unsuitable for storage, e.g.*Antonovka* apples (known for their strong acid flavour) and berries are perishable, vegetables such as pumpkins are large and cannot always be consumed all at once. Also, the shelf-life of freshly cut pumpkin is very short and its quality deteriorates during storage. Thus, different methods of preserving the raw material are used, by processing them into purees and dried products. Fruit/berry/vegetable puree is a user-friendly product that can easily be incorporated into the production of pastilles (Azevedo-Meleiro, Rodriguez-Amaya, 2007).

Fruit pastilles are an alternative to traditional Lithuanian apple cheese, which production requires a high amount of sugar and is therefore not very healthy for children. Pastilles can be made from raw materials such as fruit, berries and vegetables, of which apples are the main ingredient.

Fruit pastilles are made by mixing the raw material into a puree which can be spread evenly on a baking tray and dried to form a skin-like substance that can be eaten. Mixing different types of fruit produces a combination of flavours from different types of raw materials. All the raw materials used must be of good quality and have good sensory qualities.

Another important factor in the choice of raw materials is pectin, which influences consistency. It creates a viscous gel, preserves the structure of the products, stabilises and prevents drying. It also retains moisture, prolongs shelf life, increases resistance to adverse agents, and enhances taste and aroma (Ropartz, Ralet, 2020).

Pectin is present in the cell walls of all plants. Different types of plants contain different amounts of pectin. Concentration is also affected by the ripeness of the fruit (Boca et al., 2011).

In apples, the pectin mass is concentrated in the apple peel. Here the pectin concentration is 1,21 % ± 0,1127 (Virk and Sogi, 2007). However, not all apples have the same pectin concentration. Apples with a more acidic taste (e.g. *Antonovka*) have a higher pectin concentration (Boca et al., 2011).

Pectin strengthens the consistency of the product and acts as a jelly. Pectin has the property of combining with other pectin molecules to form even larger structures that form a gel. A gel is a dense substance between the solid and liquid phases (Zhang et al., 2018). In the case of HM pectin, these bonds occur in an acidic environment, which may also contain a high concentration of sugar. When only LM pectin is present in the raw material, a divalent cation such as Ca2+ must also be present for the ionic bond to form, e.g. Ca2+(20).

In addition, pectins, like soluble dietary fibre, are physiologically valuable food additives (functional ingredients) whose presence in traditional dietary foods improves human health. The specific physiological effects of soluble dietary fibre are attributed to its ability to lower blood cholesterol levels, normalise the gastrointestinal tract, and bind and remove some toxins and heavy metals from the body. The recommended daily intake of pectic substances in a healthy person's diet is 5-6 g (Blanco-Perez et al., 2021).

The pastilles contain high levels of dietary fibre. Researchers Anderson et al (1994) claim that fibre forces monosaccharides entering the body to break down more slowly and has minimal effect on blood glucose levels. This ensures a more even blood glucose concentration and avoids sudden spikes in sugar.

The pastilles are naturally enriched with β-carotene, vitamins, minerals, etc., using various raw materials (Tinker et al., 1991). It is important to have a balance, to maintain the right concentration of minerals in the body. Adverse effects occur when concentrations are too low or too high (Moore, 2020).

In the production of pastilles, it is also very important to select the raw materials according to the appropriate taste and aroma characteristics and to achieve a pleasing appearance of the product.

Raw materials with a high sugar content, such as apples, pears, various berries and vegetables, are used to give a sweeter taste without the use of added sugar. Apples (and most other fruits, berries and vegetables) contain fructose, glucose and sucrose. Very sweet apples are the *Golden Delicious* variety, which has a high fructose content (Ticha et a., 2015) *Golden Delicious* is the only variety in terms of sugar content that is not affected by storage time (Costa, Andrade Pina, 2020).

Fruits, berries and vegetable peels contain higher concentrations of flavonoids and anthocyanins, which give the product its intense colour and have antioxidant, anti-inflammatory and free radical-binding properties.

The purpose of pastilles is to transform fruit, berries and vegetables into an attractive, tasty, easily digestible food with no or 20% added sugar as an alternative to traditional sweets.

2. MATERIALS AND METHODS

2.1. Technological research

Only raw materials available in Lithuania were used for the production of fruit pastilles. The fruit pastilles with the best sensory qualities are presented, using the apple varieties *Antanovka*, *Bogatyr*, and *Golden Delicious*, the carrot variety *Nerac* and blueberries.

The production process for fruit pastilles starts with the initial selection, processing and weighing of the raw materials according to the quantities specified in the recipe. Fruit, berries and vegetables are thoroughly washed and drained, seeds and fruit seed pods are removed, and darkened areas are cut out.

Making fruit puree: apples are halved or quartered and placed in the oven on baking trays lined with parchment paper. It is preferable to have the apple pulp facing downwards to maintain a higher temperature and to release more moisture. Apples are baked until soft at 180º C for 30 minutes for sour apples *Antanovka*, *Bogatyr* and 50 minutes for sweet apples *Golden Delicious* (Abano and Sam-Amoah, 2011; Yan et al., 2008; Hasanuzzaman et al., 2014). This is followed by cooling and mashing in a blender (Omolola et.al, 2017; Molla, 2008).

Making vegetable puree: *Nerac* carrots are used with the skin on. Only damaged areas and the surface of carrots that have been stored for a long time and are wilted are removed. They are cut in half and baked at 180 oC for 30-60 min to a soft consistency on baking paper. The carrots are then cooled and pureed in a blender until smooth.

Making berry puree: the blueberries are cooked by adding some water, bringing to a boil and continuing to cook over low heat until they start to soften and the water has evaporated a little, about 10-15 minutes. Once cooked, the mixture is homogenised in a blender.

The purees produced from different raw materials are combined in appropriate proportions to produce pastilles with the desired taste, appearance and consistency. The consistency of the puree affects the drying time of the final product. Puree that is too runny will take a very long time to dry and puree that is too thick will be difficult to spread evenly for drying.

Samples using carrots are orange in colour due to the pigment carotenoid (Bozalan, Karadeniz, 2011). Pastilles with blueberries take on a deep purple colour due to the presence of anthocyanins such as malvidin, petunidin, delphinidin, cyanidin, etc. (Lohachoompol et al., 2004) (Fig. 1).

The mixed mass is spread evenly in a layer of 5 to 8 mm on a special tray and dried for 12 to 24 hours in a drying oven with active ventilation at 45 to 50 °C (Fig. 1). This depends on the consistency of the mass, the free moisture present and the thickness of the puree layer.

The dried mass is carefully removed from the special tray and cut into strips with a sharp knife or scissors. Cut strips can be rolled into rolls (Singh et al., 2008; Molla, 2008).

apples | apple puree | dissemination of the puree | drying | apple pastille | apple+carrot pastille | apple+blueberry pastille

Fig. 1. Pastille manufacturing process

The recipes for the pastilles are given in Table 1.

Raw material	Quantity, g	Production (drying) losses, %
Apple pastille (AP-S without added sugar; AP+S with sugar)		
Antanovka apple puree	0,200	78,61
Golden Delicious apple puree	0,600	
Bogatyr apple puree	0,200	
Apple-carrot pastille (ACP-S without added sugar; ACP+S with sugar)		
Golden Delicious apple puree	0,300	76,89
Bogatyr apple puree	0,400	
Nerac carrot puree	0,300	
Apple-blueberry pastille (ABP-S without added sugar; ABP+S with sugar)		
Bogatyr apple puree	0,500	80,12
Blueberry puree	0,500	

Note: For the fruit pastilles with sugar, the raw materials were weighed in the same proportions and 100 g of sugar were added.

Table 1. Pastille recipes

2.2. Sensory analysis

The sensory analysis was carried out with children (aged 5-10 years, 17 subjects in total). The children tasted pastilles with no added sugar and 20% sugar content. A questionnaire was developed based on the children's ability to correctly evaluate certain sensory characteristics of the product. A 5-point system was applied, from a minimum of 1 point to a maximum of 5 points. An example of a sensory assessment of children is given in Table 2.

Questions	Bad		Neutral		The best
How does the candy look?	1	2	3	4	5
How does the candy taste?	1	2	3	4	5
How does the candy feel in your mouth? (texture)	1	2	3	4	5
Is the smell intensive?	1	2	3	4	5
How would you rate the candy overall? (Would you buy the candy?)	1	2	3	4	5

Table 2. Sample questionnaire for sensory evaluation of children

2.3. Physico-chemical parameters

There were determined moisture content, water activity, ash content and calorific value of the fruit pastilles. Measurements were repeated three times for each sample.

Dry matter and moisture content were determined by drying the samples to constant weight in a *Venticell 55* oven (MMM Medcenter Einrichtungen GmbH, Germany) at (102±l) °C. The crushed samples, each weighing 5,0 g, were placed in clean, dry, labeled crucibles. They were placed in a drying cabinet and dried to constant weight at 102 °C for about 16 hours and then cooled in a desiccator. This method measured the weight loss due to moisture evaporation.

The loss in mass is calculated as a percentage of the mass of the sample using the formula:

$$H_2O\% = \frac{weight\ of\ wet\ sample - weight\ of\ dried\ sample}{weight\ of\ wet\ sample} * 100\%$$

The water activity (a_w) was determined by measuring the vapour pressure of the water entering the sample against the vapour pressure of pure water. The pastille samples were placed in the container of the apparatus and filled to 2/3 of the final volume. The water activity meter *Rotronic*® was used to measure water activity at 25 °C. Scale from 0 for no free water to 1 for pure water (Levi, 2016).

The water activity is calculated using the formula:

$$a_w = \frac{vapor\ pressure\ of\ water\ in\ sample}{vapor\ pressure\ of\ pure\ water}$$

The organic matter in the samples was burnt off, leaving a light grey ash inorganic materials. Clean, dry ceramic crucibles were heated in a *Venticell* oven at 105 °C for 2 hour, cooled in a desiccator and weighed before testing. 3,0 g of each crushed sample was placed in the appropriately labelled crucibles. They were then incinerated in a *Nabertherm* muffle furnace (Nabertherm GmbH, Germany) at 550 °C for 2 hours. The crucibles and their contents were then cooled in a desiccator to room temperature and weighed. The weight difference was calculated as ash content.

The ash content is the ratio of the mass of the product after combustion to the mass before combustion, calculated according to the formula (Baraem, 2017).

$$ash\% = \frac{weight\ after\ oxidation}{weight\ before\ oxidation} * 100\%$$

Determination of the calorific value of pastilles by calorimeter IKA C200 using a high-pressure oxygen calorimetric bomb. The energy value of the product is determined by taking into account changes in water temperature. A calorie describes the amount of energy a person can obtain from eating food (Gavin, 2018).

The results are calculated on the basis of the analysis in quintuplicate ($n = 3$). The results of the analyses were summarised by estimating the arithmetic mean (M), and the standard deviation (SD) describing the spread of the random values around the mean using Excel.

3. RESULTS AND DISCUSSION

Most of the respondents liked the samples tested. The best tasting fruit pastilles with apples and blueberries ABP-S (4.37 points) with no added sugar were rated by the children participating in the tasting (Figure 2).

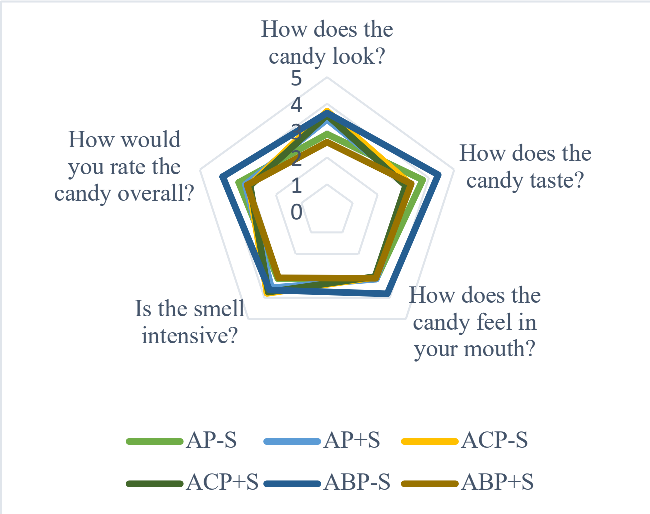

Fig. 2. Sensory evaluation of a group of children

The appearance, taste and mouthfeel of all types of fruit pastilles with added sugar scored lower than the samples without added sugar. The main influence on these results was the stickiness of the surface of the products, which could be felt both on the surface of the product and during chewing. The smell of the fruit pastilles did not differ significantly between products of the same type with or without added sugar. However, the most intense odour was found for fruit pastilles containing carrots. These samples, ACP-S and ACP+S, scored the highest compared to the others. It has been observed that the samples that the children consider to have the best taste are also the ones with the best overall score.

The moisture content of the samples was found to be 12-25 % (Fig. 3). Fruit pastilles with carrots have almost the same moisture content with and without added sugar.

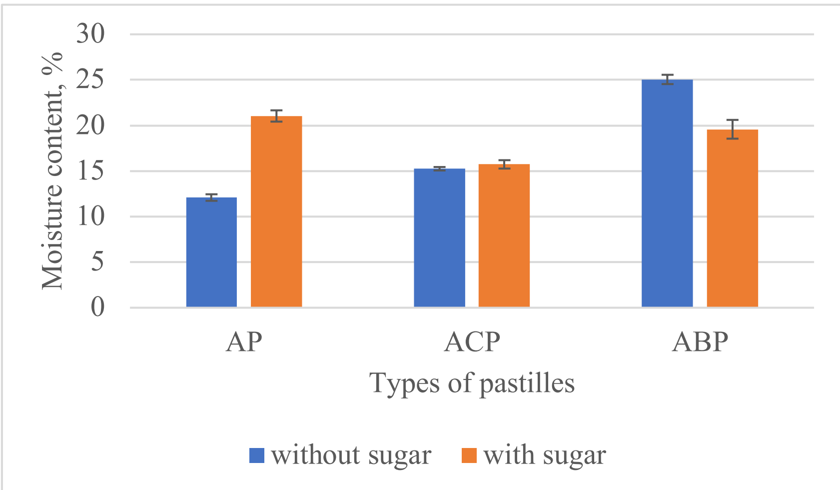

Fig. 3. Moisture content of pastilles without and with added sugar

The highest moisture content was found in the samples with blueberries without added sugar, while it was lower 5% with sugar. Fruit pastilles with apples show the opposite results, with a difference of around 21% with sugar and 12% without added sugar. This could be due to the pectin, which, together with the sugar, forms structures in which water is removed during drying.

Water activity may be more important for food spoilage than the total amount of water present, as a_w is a critical factor in the growth of micro-organisms and is directly related to chemical and enzymatic stability (Maltini, Torreggiani, Venir ir Bertolol, 2003). The results show that most of the samples have a water activity of around 0.6 or lower (Fig. 4).

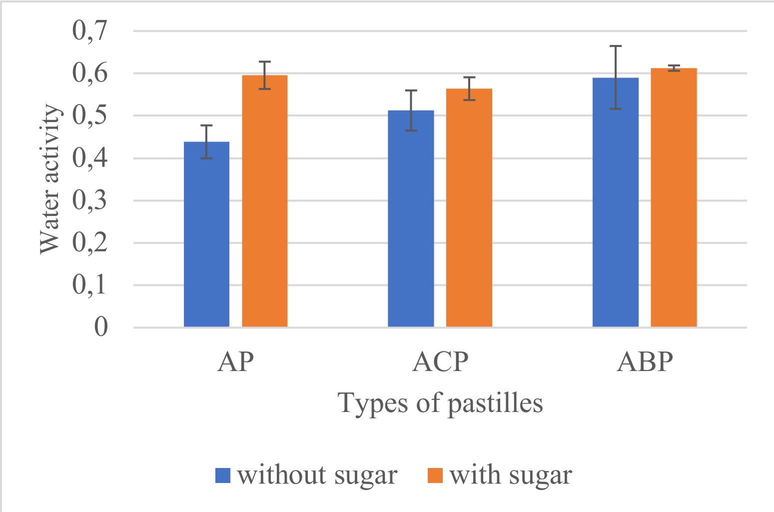

Fig. 4. Water activity of pastilles without and with added sugar

This means that fruit pastilles have a low chance of spoilage , as they do not allow the growth of micro-organisms (range of values a_w 0,4385-0,6125) (value range a_w 0.4385-0.6125). In fruit pastilles, added sugars contributed to the higher values of water activity. A particularly significant difference of 26% was found between apples with and without added sugar. The water activity measured in the fruit pastilles is in line with that of dried fruit and therefore the products have a long shelf life.

The ash content refers to the total amount of minerals contained (potassium, sodium, calcium, magnesium, etc.). The ash content was found to be higher in the samples containing added sugar, especially in the samples AP containing apples (Fig. 5).

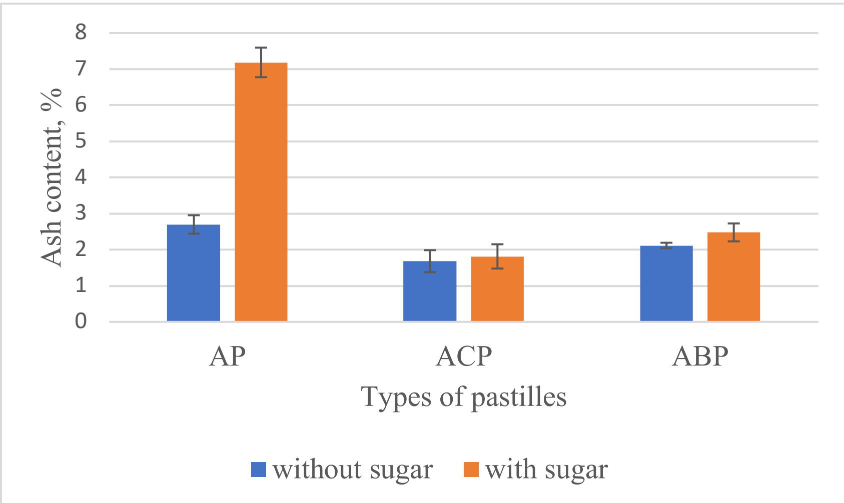

Fig. 5. Ash content of pastilles without and with added sugar

The ash content was found to be higher in the samples containing sugar, especially in the samples containing apples, as apples have the highest mineral content in the raw material itself compared to carrots and blueberries.

Samples with and without added sugar show a slight difference in calorie content. Adding sugar to a product usually increases the calorie content. As the amount of added sugar is not high (20%), it does not have a significant effect. In comparison, a typical chocolate candy has about 535 kcal of energy per 100 g, equivalent to 2238 kJ of energy (FoodData Central, 2023).

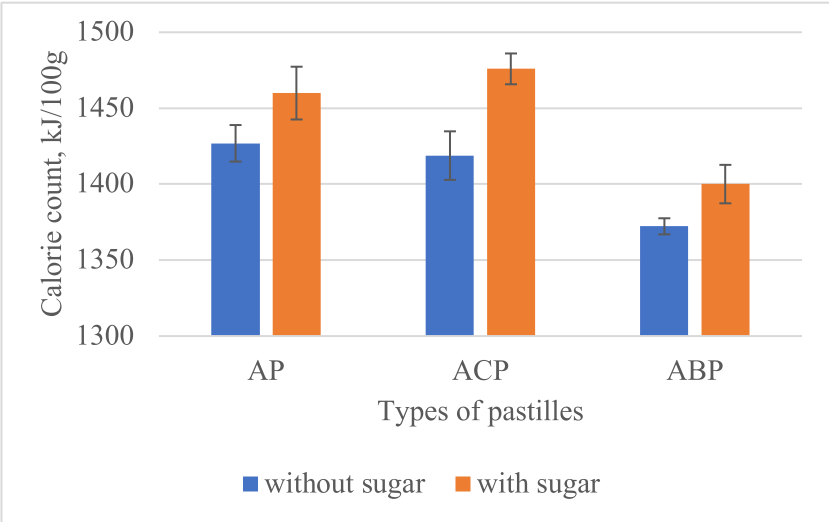

Fig. 6. Calorie content of pastilles without and with added sugar

As the samples contain significantly fewer calories than traditional sweets, it can be argued that prepared samples with and without added sugar are healthier in terms of calorie content.

5. CONCLUSIONS

The best samples for children are those that have the most acceptable taste and do not have unpleasant sensations such as stickiness.

The fruit pastilles without added sugar, made from Bogatyr apples and blueberries, scored the highest for the distinctive taste, which the children identified as blackcurrant pastilles.

Physico-chemical studies show that the raw materials used have an impact on moisture content, water activity, ash content and calorific value.

Fruit pastilles made exclusively from apples of different varieties showed significant differences between samples with and without added sugar. Higher values were found in the samples with added sugar at 43% moisture, 26% water activity and 62% ash. This may have been influenced by the structure of the pectin formed with the sugar. Fruit pastilles with and without added sugar have fewer calories than traditional sweets.

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