THE IMPACT OF THE FOOD PRODUCTION PROCESS IN THE PEJA REGION OF KOSOVO: THE CASE OF PI&KI BISCUITS OF EGI GROUP

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Abstract

The aim of the paper was to determine the influence of temperature and different amounts of sodium hydrogen carbonate on the texture and color of tea cakes obtained under laboratory conditions. Each mix varied according to the amount of sodium bicarbonate added, the granulation of the sugar, or the baking temperature. Product texture was analyzed daily using a texture analyzer and color was measured using a Minolta Chroma meter. After baking the tested samples, measurements were made of the length and height of the tea cakes, as well as the dynamics of changes in water activity and moisture content during baking. The results of texture analysis showed that an increased percentage of sodium bicarbonate decreases the strength of tea cakes, while at higher temperatures, strength and brittleness increase. In terms of color, the results showed that comparing the total color change of tea paste obtained from different blends and roasted at different temperatures, the least color change in most cases was the blend with the lowest percentage of sodium hydrogen carbonate.

Keywords: tea paste, texture, color, temperature, sodium bicarbonate
JEL classification: CODE,

1. Introduction

Tea biscuits are a food product made mainly from flour, sugar and fat. They can be of different shapes, sizes, with different fillings or accessories. Even today, tea pastries are considered typical representatives of flour flavors that are produced both in factories and at home. Lines for the production of tea biscuits are automated, although there are currently very few manufacturers who have fully automated the entire production process. One of the important characteristics is the responsibility of the production technologist, of course his ability to make high quality tea cakes and awareness of the potential of purchasing quality ingredients. In this topic, the influence of roasting temperature and different percentage of sodium bicarbonate on the change of texture and color of tea paste was monitored. The tea paste produced was obtained in laboratory conditions that differed in the baking temperature, the added amount of sodium bicarbonate, the type of fat and sugar. In parallel with the monitoring of the temperature and the tools for raising the dough, the moisture content and water activity were also monitored.

2. LITERATURE REVIEW

Raw materials for the production of tea biscuits.

Flour

Technological quality of flour, nutritional value, chemical composition and health status are determined by a number of chemical, physical, microbiological, rheological and other analytical methods. The aim is to determine in advance the ability of the flour to produce high quality commercial products. (Kent and Evers, 1994). In the production of tea pastries, the most commonly used flours are wheat flour T-400 and T-550. A very important feature of tea pastries is flour granulation, and the choice of flour according to its granulometric composition depends on the raw material of the dough and the method of mechanical processing. Such wheat flours have low protein content and flour texture and have a larger grain than durum cookie flour, and the reason for this is that using larger particles and low protein flour reduces the absorption power.

Chemical composition of wheat and flour

In the grain of wheat, the main groups of chemical compounds are carbohydrates, proteins, lipids, fibers and mineral substances. The endosperm, coat and embryo make up the structure of the wheat grain. With the technological process of milling, the gut gives bran, and the endosperm gives flour. (Arendt and Zannini, 2013).

Table 1. Average chemical composition of wheat grain (Koehler and Wieser, 2013)

Chemical composition	%
Proteins (Nx6.25)	11.3
Lipid	1.8
Carbohydrates	59.4
Dietary fiber	13.2
Minerals	1.7
Water	12.6

Water, proteins, starch, fats, pentosans and sugars are the most important components for flour quality during technological processing. The average chemical composition of flour for a given degree of grinding was obtained by grinding different wheat mixtures.

Table 2. Average chemical composition of flour (%) at different grinding levels

	% of the mixture			
Chemical composition	50	70	80	94-100
Minerals	0,46	0,62	0,80	1,7
Proteins	10,7	12,2	13,0	13,5
Lipoidit	1.1	1.5	1.8	2.3
Fiber	0,1	0,2	0,3	2,1
Starch and sugars	84	81	81	73

Most of the food that humans consume is in the form of starch, which is an excellent source of energy. Starch is found in plants in the form of grains and is known to be quantitatively the main component of the wheat grain. Starch granules of different origins differ in shape, size and general appearance. The difference between wheat starch grains and starch grains of other cereals can be observed by microscopic observation. By grouping the granules according to size, we obtain small, medium and large starch granules. The size of the starch granules actually has no effect on the quality of the flour. If wheat starch is heated with water, the starch grains swell and a colloidal suspension is formed, which is separated into two components, amylose and amylopectin. Grinding wheat grains leads to the gradual crushing of the endosperm and the destruction of the structure of large and small particles. The finer the grinding, the more damaged granules there are and the quality of the flour depends on the amount of damaged starch granules. Namely, damaged starch granules are a source of carbohydrates for the production of sugar, which is necessary during dough fermentation, while undamaged starch grains do not gelatinize at the temperature of dough fermentation. (Hoseney, 1994, Arendt and Zannini, 2013)

Sugars: In addition to starch, wheat flour also contains other carbohydrates such as monosaccharides, disaccharides, oligosaccharides and polysaccharides. The total percentage of sugar, but also the representation of individual sugars in wheat varies depending on the variety of wheat as well as the conditions of development. The percentage of sugar in the sprout is 16.2-16.9%, while the total percentage of sugar in the shell is about 5%.

Table 3. Average percentage of free sugars in wheat flour (MacArthur, L.A., D'Appolonia, B.I., 1979)

Sugar composition	%

Sucrose	0,47
Raffinose	0.31
Maltose	0.08
Fructose	0.03
Glucose	0.04

Hemicelluloses and pentosans: The terms hemicelluloses and pentosans are often used interchangeably, so they often seem to have no exact meaning. However, they together constitute the non-starch, non-cellulosic polysaccharide portion of the plant. Polysaccharides that have pentoses as their basic units are divided into pentosans that are soluble and those that are not soluble in water. Hemicellulosic substances are called pentose polysaccharides that are not soluble in water, while pentosans are pentose polysaccharides that are soluble in water. Soluble and insoluble pentosans have such a position of the hydroxyl group in water that they easily bind to water molecules. Their branched structure allows them to bind a large amount of water, which means that pentosans increase the water content of dough and produce products with a higher water content and slow down the aging tendency of bread products. (Hoseney, 1994)

Proteins: Proteins are complex chemical compounds with high molecular mass and are also the main component for determining the quality of flour in wheat grains. Proteins are represented in different ways in the wheat grain, so in the envelope of the wheat grain there is about 15%, while in the germ the proportion of proteins is between 17% and 27%. In the endosperm, depending on the type of wheat, there is 5-16% protein, although within the endosperm the percentage of protein increases from the center towards the aleurone layer. Wheat contains the following proteins:

- albumin
- globulin
- prolamin (gliadin)
- glutelin (glutenin).

It is thanks to prolamin and glutelin that wheat differs from other cereals. (Hoseney, 1994)

Lipids: The term lipid often includes fats and fat-like substances, of which 1.5-2.5% are in flour. Lipids are natural organic compounds that dissolve in fatty solvents, but also the most unstable compounds in the wheat grain. Although they are present in small amounts, lipids play an important role in the formation of the physical properties of the dough and to a large extent positively affect the technological quality of the flour. Flour from which lipids are extracted gives a dough that is less elastic and provides greater resistance to stretching. Although the percentage of lipids in flour is small, their functional properties are of great importance in the technological production based on flour. Flour lipids consist of: triglycerides, phospholipids and glycolipids. Phospholipids have a favorable effect on gluten, which holds more gas in the dough and the product itself acquires a larger volume and a better structure. Glycolipids and phospholipids bind to flour proteins and starch and affect their mobility and flexibility. (Gavrilović, 2003).

Pigments: Pigments are color carriers with different chemical compositions. In wheat and wheat products, they are found in very small amounts, and are usually yellow pigments: carotene, xanthophylls and flavones. (Pomeranz, 1988).

Mineral substances: Regarding mineral substances, it is important to mention that these are substances that support many vital functions in the body and play an important role in nutrition. The main mineral substances that the body needs are sodium, potassium, calcium, magnesium, iron, chlorine, sulfur and phosphorus, while the mineral substances present in flour are phosphorus, potassium, magnesium and calcium. How important minerals are in flour is shown by darker flours, which have more minerals and, at the same time, greater biological value. (England, 1998)

Water

According to the Ordinance on the health of drinking water, drinking water is all water that, in its original state or after treatment, is intended for drinking, cooking or food preparation, as well as water used in the production, processing and conservation. of products or substances intended for human consumption (MAŠVG, 2005). The water used during the technological production of certain products must be colorless, tasteless and odorless. If there is an increase in the acidity of the water or there are ammonia residues, this means that the water is polluted due to the decomposition of organic matter and therefore such water should not be used in the food industry. , nor in the production of tea pastes. If the water hardness is too high, ion exchangers are used, while filtration is used to remove mechanical impurities. Water is present in the dough in free and bound form. The amount of free water in the dough regulates the highly elastic properties of the dough. During boiling, the gluten proteins swell, until an equilibrium is reached between the osmotic pressure and the pressure between the gluten micelles. Flour with a certain composition of the raw material is able to create a dough with a minimum water content as well as with a water content higher than the value for the water absorption power of the flour. (Gavrilović, 2000)

Fats

Even before sugar, which was only known in the Middle Ages and was first used as a spice and only later as food, fats were used as ingredients in various products. (Handbook on Improvers and Other Raw Materials for Baking and Confectionery, 2007). At that time, the functional properties of fat were not thought about, although it was known since then that fat is highly nutritious and that it is a concentrated source of energy for human nutrition. The term fat covers a surprisingly large number of chemical substances, very differently structured, whose molecules are dominated by methylene-based chains, so their main property is poor solubility in polar solvents (water) and good solubility in non-polar solvents . (Handbook on Improvers and Other Raw Materials for Baking and Confectionery, 2007). Various fats can be used in the production of tea cakes, whether natural, hydrogenated or emulsified.

We know that apart from flour, the main raw materials used in the production of tea cakes are fat and sugar. Fats and oils are esters of higher saturated and unsaturated fatty acids and glycerol. There are different divisions according to which we divide fats and oils. Division according to chemical composition:

- Solids (fats),
- Liquid (oil),
- Grease with lubricating consistency.

Division by origin:

- animals,
- plant.

Vegetable fat

In a dough made of flour, water and fat, the fat is spread out in thin layers and binds through hydrophobic bonds to the hydrophobic bonds of proteins and flour. The fat has the ability to regulate the behavior of the dough through the properties of plasticity and the ability to absorb air bubbles. Nonpolar fat triglycerides act as softeners and affect dough consistency. (Gavrilović, 2000). The plastic properties of cooking fats have an important function during dough cooking. The solid phase of triglycerides affects the reduced strength of the structural organization of the gluten complex, while the liquid phase of triglycerides affects the mobility of the dough. Fat reduces dough shrinkage during mechanical processing because it reduces the tension that leads to deformation of the part of the dough shape. When kneading the dough, the order of adding the fat and water is important because it has been proven that the simultaneous addition of fat and water to the flour contributes to optimal dough development. The fat is dispersed between the flour particles, allowing water to enter and hydrate the protein and starch. As the heat increases during cooking, part of the fat, due to its plastic (especially shortening) properties, slowly passes into the liquid phase, which has a favorable effect on the hydration process. If the fat is not plastic enough, it will melt as the heat rises during cooking. The liquid phase is dispersed over the surface of the flour particles, which prevents water from coming into contact with the flour, which slows down the swelling of the gluten protein. In the dough, the fat is in contact with flour enzymes, drying agents, acids and other raw materials and a smaller or larger amount of water. This is precisely the reason why the dough is the environment in which the chemical change of the fat in the processes of hydrolysis or oxidation can take place. The consequence of this is the breakdown of the fat and at the same time the breakdown of the product itself, i.e. the tea paste. The chemical properties of the fat should not change during mixing, processing and baking. To prevent unwanted spoilage of the product, the fat must have the necessary stability and ability to be preserved throughout the technological process of production and stability of tea cakes and other similar products. (Gavrilović, 2000). H1: Biscuits contain healthy substances for human health.

Butter

Butter is a product obtained by extracting milk fat from the fatty phase of milk - cream. According to the Regulation on Lubricating Fats (Regulation on Lubricating Fats, NN No. 41/2012), milk fats are products in the form of a solid, plastic emulsion that is obtained exclusively from milk or other milk products. Butter is a product with a milk fat content of at least 80% and a maximum of 90%, water content of a maximum of 16% and a maximum of 2% nonfat milk solids. The butter production process can be continuous or discontinuous. The interrupted process is older and in this process butter is produced from sweet sauce and sour cream from the accumulation of fat globules. The continuous process of butter production is a newer process and with this process mostly butter is obtained from sweet cream. The energy value of 100 g of butter is about 700 kcal/3000 kJ. It contains fat-soluble vitamins such as A, D, E and K, and the provitamin of vitamin A, ß-carotene, from which the yellow color of butter originates. (Tratnik, 2012) Butter is certainly the most popular fat in the cookie industry, but due to its high price, it is used exclusively in the production of high-quality cookie products.

Sugars

Often, the name sugar actually refers to sucrose obtained from sugar beets or sugar cane. Sucrose is a non-reducing disaccharide whose main units are glucose and fructose. Glucose and fructose are linked to each other by carbonyl groups. (Afoakwa, E. O., 2010) It is common for raw sugar to contain 95% sucrose while refined table sugar contains approximately 99.8% sucrose. Table sugar contains at least 99.6% sucrose. (Micic, 1976).

During the kneading of the dough, the role of sucrose is to reduce the osmotic activity of the water, where the gluten swells more slowly, therefore the process of forming the dough is slower. During the mixing, strong resistances appear, which can be shown with a farinogram. If sucrose is present in a proportion of 15 to 30% of the flour, this affects the intake of a smaller amount of gluten in the dough. If the moisture content of the dough is below 25%, it is preferable to use powdered sugar whose maximum particle size is 100 µm. The advantage of powdered sugar is that it dissolves faster during the cooking of the dough. Finely ground powdered sugar, with particles of a maximum size of 30 µm, is used in the preparation of fat fillings. In fat filling for tea cakes, the fat is spread over the surface of the sugar particles and additives, which prevents moisture absorption and recrystallization of the sugar.

Growth tools

The idea of using baking powder instead of yeast is 150 years old, and Justus von Liebig was the first to solve this problem in Germany. He produced bread whose structure was filled with sodium carbonate and hydrochloric acid. This laid the foundation for the production of baking powder as well as other chemical growth agents. (Handbook on improvers and other raw materials for baking and confectionery, 2007) In the production of cookies and similar products, chemical and biochemical dough-raising agents are used as additives. The biochemical agent for dough growth is baker's yeast (Saccharomyces cerevisiae), while the most commonly used chemical agents are ammonium hydrogen carbonate and sodium hydrogen carbonate (sodium bicarbonate). The role of chemical leavening agents in cookie dough is manifold. Chemical agents change the pH of the dough medium, prevent the sticking of the dough, affect the change of the rheological properties of the dough, and because of all this it is possible for the individual dough to be thinned during mechanical processing. (Gavrilović, 2003) Sodium hydrogen carbonate (sodium bicarbonate, $NaHCO_3$) creates a smaller amount of carbon dioxide in dough and mass at about 60°C and without an acid carrier. Sodium hydrogencarbonate is a white crystalline powder, with a weak odor and a slightly alkaline-salty taste. (Gavrilović, 2003). Sodium carbonate (soda) is produced as a by-product. Sodium bicarbonate can be found on the market in different grains. It is very difficult to dissolve in water (coarser particles, >0.15 mm), so they can remain in the dough or mass and thus cause changes in the color of the center of the product. Finely ground sodium bicarbonate (particle size <0.15 mm in diameter) is used for doughs that are mixed for a short time (less than one minute). Sodium bicarbonate is added to the cookie dough in the amount of 2 to 6 g/1 kg of flour, hydrogen carbonate, etc. The main role of other additives such as salt is to correct the taste of the product, while the role of other raw materials is to obtain a homogeneous dough, to form a color, to adjust the balance of relative humidity, freshness and the roundness of the product's aroma. (Gavrilović, 2003) All raw materials in the composition of the dough for tea pastries must be determined, that is, their purpose, as well as their quality, must be determined. For this reason, it is necessary to use comparative methods. H2: Pi & Ki Biscuits consumption is very popular to the consumes.

3. HYPOTHESIS

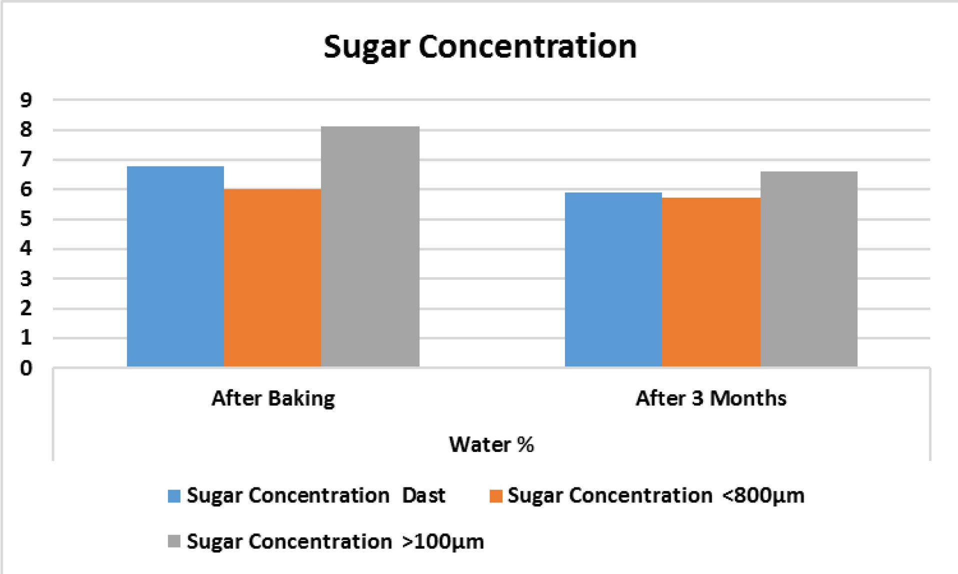
In the future food industry, preparation and production processes will be heavily automated, utilizing advanced technologies such as robotics, AI, and 3D printing. This automation will lead to increased efficiency, consistency, and customization options in food production industry while also reducing labor costs and minimizing human error. Additionally, there will be a greater focus on sustainable ingredients and production methods to meet the growing demand for environmentally friendly food products. As consumer preferences shift towards healthier options, there will be innovations in food recipes to include functional ingredients like probiotics, vitamins, and plant-based proteins, catering to diverse dietary needs and preferences. Furthermore, personalized food manufacturing may become more prevalent, allowing consumers to customize ingredients, flavors, and shapes through online platforms or in-store kiosks, thus enhancing consumer engagement and satisfaction.

4. METHODOLOGY

This research was carried out based on the review of the literature and Pi&Ki in Egi group - Zahaq Pejë. For this research, scientific works from various medical fields that have addressed the topic of the diploma have been taken as a source. Developing a robust methodology is crucial for conducting a research on preparation and production in the future food industry. We determine the type of qualitative and quantitative method through research approach experimental, survey, case study and literature review. We specify the scope of the objectives ensuring the alignment research problem.

5. FINDINGS

In the future food industry preparation and production processes are likely to undergo significant advancements to meet evolving consumer demands, improve efficiency, and address sustainability concerns. Here are some potential findings regarding the future of tea cakës production:



Graph 1: Average values of determination of water content depending on granulation of sugar after roasting and after 3 months of storage of tea paste samples, regardless of roasting temperature and $NaHC0_3$ content.

In the table 4: Change in activity and water content of tea cakes after baking and after storage depending on granulation of sugar, regardless of baking temperature and sodium bicarbonate content.

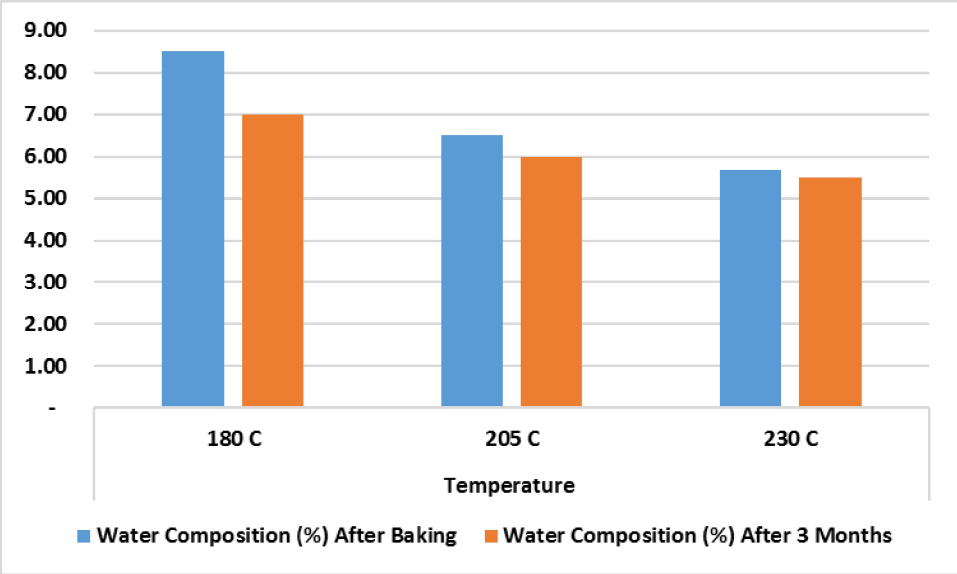
Sugar Concentration	Δ Proportion of Water (%)		Δ Activities	
Dast	0,38 ± 0,44	b	0,013 ± 0,010	a
<800µm	0,26 ± 0,28	b	0,012 ± 0,017	a
>1000µm	1,50 ± 1,55	a	0,020 ± 0,024	a

Data presented are mean values ± standard deviation; values marked with the same letter in the same column are not statistically different (p<0.5) according to Fischer's LSD least significant difference test.

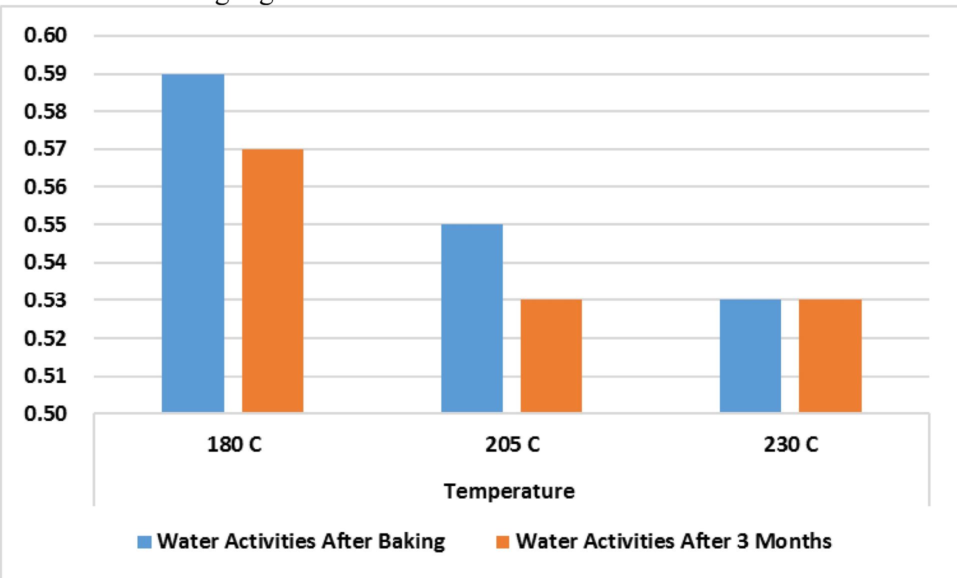
Table 5: Change in activity and water content of tea cakes after baking and after storage depending on sodium hydrogen carbonate content, regardless of sugar granulation and baking temperature.

NaHCO3 (%)	Δ Water (%)		Δ Activities	
0.67	0,80 ± 0,97	a	0,022 ± 0,024	a
1,11	0,76 ± 1,05	a	0,017 ± 0,016	a
1,56	0,58 ± 0,76	a	0,006 ± 0,005	a

Data presented are mean values ± standard deviation; values marked with the same letter in the same column are not statistically different (p<0.5) according to Fischer's LSD least significant difference test.



Graph 2: Average values of water content determination depending on the applied baking temperature, after baking and after 3 months of storage of tea cake samples, regardless of NaHCO3 content and sugar granulation.



Graph 2: Average values of water activity determination depending on the applied roasting temperature, after roasting and after 3 months of storage of tea paste samples, regardless of NaHCO3 content and sugar granulation.

Table 6: Change in activity and water content of tea cakes after baking and after storage depending on baking temperature, regardless of sodium bicarbonate content and sugar particle.

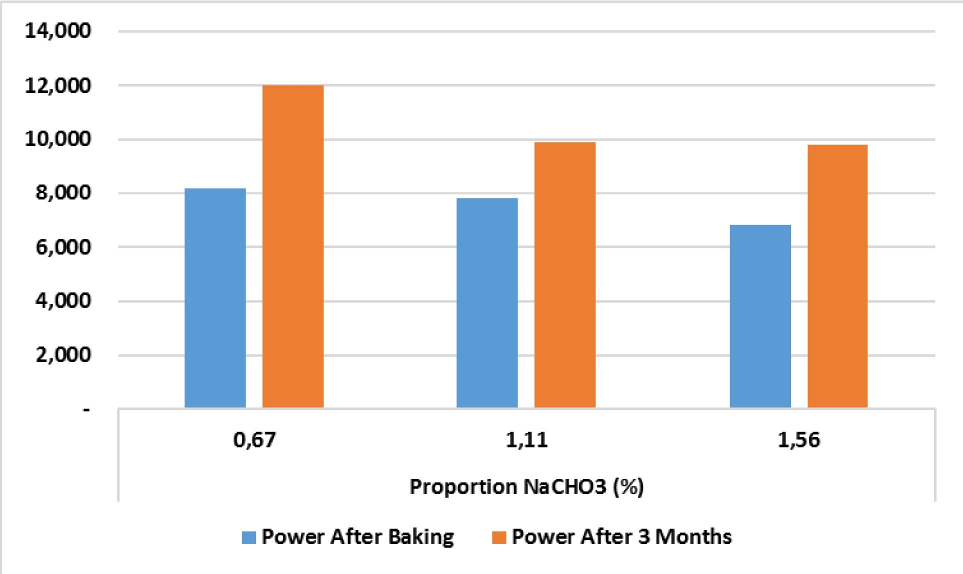
Temperature (C)	Δ Water (%)		Δ Activities	
180	1,41 ± 1,12	a	0,017 ± 0,021	a
205	0,48 ± 0,58	b	0,014 ± 0,017	a
230	0,26 ± 0,44	b	0,014 ± 0,016	a

Data presented are mean values ± standard deviation; values marked with the same letter in the same column are not statistically different ($p<0.5$) according to Fischer's LSD least significant difference test.

Table 7: Change in the parameters determined by the texture analysis of the tea paste after roasting and after storage depending on the sugar particles, regardless of the roasting temperature and the proportion of sodium bicarbonate.

Sugar Concentration	Δ Power (g)		Δ Fragility (mm)		Δ Cutting work (gsec)	
Dast	997 ± 2711	a	1,27 ± 0,41	a	7563 ± 3020	a
<800μm	1767 ± 1956	a	0,92 ± 0,61	a	5203 ± 2575	b
>1000μm	5224 ± 5225	b	0,50 ± 0,28	c	285 ± 588	c

Data presented are mean values ± standard deviation; values marked with the same letter in the same column are not statistically different ($p<0.5$) according to Fischer's LSD least significant difference test.



Graph 3: Average strength values depending on the proportion of NaHCO3, after roasting and after 3 months of storage of tea paste samples, regardless of roasting temperature and sugar granulation.

Table 8: Change in the parameters determined by the analysis of the structure of the tea paste after roasting and after storage depending on the proportion of sodium hydrogencarbonate, regardless of the sugar particle and the roasting temperature.

NaHCO3 (%)	Δ Strenght (g)		Δ Fragility (mm)		Δ Cutting work (gsec)	
0,67	3679 ± 1579	a	1,23 ± 0,21	a	-4080 ± 2751	a
1,11	2096 ± 2502	a	0,82 ± 0,57	ab	-4388 ± 2587	a
1,56	3060 ± 1725	ab	0,74 ± 0,77	b	-4581 ± 2328	a

Table 9: Change in the parameters determined by the analysis of the structure of the tea paste after roasting and after storage depending on the roasting temperature, regardless of the proportion of sodium bicarbonate and sugar granulation.

Temperature (C)	Δ Strenght (g)		Δ Fragility (mm)		Δ Cutting work (gsec)	
180	7967 ± 1832	a	1,75 ± 0,21	a	-424 ± 332	a
205	779 ± 1089	b	0,73 ± 0,15	b	-6351 ± 1362	b
230	88 ± 961	b	0,21 ± 0,26	c	-6275 ± 2280	b

Data presented are mean values ± standard deviation; values marked with the same letter in the same column are not statistically different ($p<0.5$) according to Fischer's LSD least significant difference test.

Table 10: Results of statistical analysis of changes in diameter, thickness and coefficient of expansion of tea cakes after baking and after storage depending on granulation of sugar, regardless of baking temperature and proportion of sodium bicarbonate.

Sugar Concentration	Δ Diameter (cm)		Δ Thickness (cm)		Δ Expansion Coefficient	
Dast	0,22 ± 0,09	a	-0,05 ± 0,019	a	4,47 ± 1,71	a
<800μm	0,17 ± 0,04	a	-0,07 ± 0,021	b	4,79 ± 1,18	a
>1000μm	0,11 ± 0,10	b	-0,080 ± 0,022	b	4,57 ± 1,55	a

Data presented are mean values ± standard deviation; values marked with the same letter in the same column are not statistically different ($p<0.5$) according to Fischer's LSD least significant difference test.

Table 11: Results of statistical analysis of changes in diameter, thickness and expansion coefficient of tea cakes after baking and after storage depending on the proportion of sodium hydrogen carbonate, regardless of sugar granulation and baking temperature.

NaHCO3 (%)	Δ Diameter (cm)		Δ Thickness (cm)		Δ Expansion Coefficient	
0,67	0,25 ± 0,15	a	-0,04 ± 0,01	a	4,14 ± 1,43	a
1,11	0,12 ± 0,11	b	-0,07 ± 0,03	b	4,77 ± 2.03	a
1,56	0,12 ± 0,05	b	0,07 ± 0,03	b	4,92 ± 1,00	a

Data presented are mean values ± standard deviation; values marked with the same letter in the same column are not statistically different ($p<0.5$) according to Fischer's LSD least significant difference test.

Table 12: Results of statistical analysis of changes in diameter, thickness and coefficient of expansion of tea cakes after baking and after storage depending on baking temperature, regardless of the proportion of sodium bicarbonate and sugar granulation.

Temperature (C)	Δ Diameter (cm)		Δ Tile (cm)		Δ Expansion Coefficient	
180	0,17 ± 0,06	a	-0,07 ± 0,03	b	5,16± 1,90	a
205	0,17 ± 0,04	a	-0,05 ± 0,02	a	4,11 ± 1,57	b
230	0,16 ± 0,09	a	-0,07 ± 0,02	b	4.56 ± 1,17	b

Data presented are mean values ± standard deviation; values marked with the same letter in the same column are not statistically different ($p<0.5$) according to Fischer's LSD least significant difference test.

6. DISCUSSION

The topic presents the results of the analysis of a total of 15 batches of tea paste mixtures (excluding preliminary research) and the following parameters were monitored: texture of tea pastes after baking and after storage, color change, then height and length of baking and stored tea pastes, and changes in size and water activity after roasting and storage. Figures 4 and 5 and table 3 show the results of determining the water content and activity of tea paste samples depending on the granulation of sugar after baking and storage. The statistically processed results of the change in water content after baking and storage of tea paste samples depending on sugar granulation, regardless of baking temperature and sodium hydrogen carbonate content (table 3) show that a statistically significant difference ($p <0.05$) the difference in water content was found between samples prepared with sugar granulation >1000 µm (S1000) and samples prepared with the other two granulated sugars (powdered sugar, SP and sugar granulation <800 µm, S800) . The samples prepared by SP and S800 are not statistically different throughout the storage time according to Fisher's LSD test of significant difference. The statistically processed results of the change in water activity, after ripening and storage, show that all the tested samples regarding sugar granulation (SP, S800, S1000) do not differ statistically significantly according to Fisher's LSD test with the least important difference. The results of monitoring the changes in the proportion and activity of water after baking and storage of the tea cake samples in relation to the different proportions of $NaHCO_3$ (Figure 6, Figure 7, Table 4) showed, after statistical analysis, no statistically significant difference ($p< 0.05$) according to Fisher's LSD test, the least significant difference. The change in water content after baking and storage of tea paste samples at different temperatures (Figure 8, Figure 9, Table 5) showed that there is a statistically significant difference ($p<0.05$) in the change in water content between the samples of baked at 180 °C and samples baked at 205 °C and 230 °C. Between the samples baked at 205 °C and 230 °C there is no statistically significant difference ($p<0.05$) for the values of water content change according to Fisher's LSD test of significant differences.

The results of the statistical processing of the water activity change showed that all tested samples statistically do not differ significantly according to the Fisher's LSD test, with the least significant difference considering the applied baking temperatures. The downward trend shown by the results of water content and activity during storage is in accordance with the results published by Antonio Piga and co-workers, where the samples were stored for 35 days also in PVC bags. Figures 10 and 11 and 12 show the data obtained from the determination of durability, brittleness and shear performance of the tested samples that were baked with different granulations of sugar (SP, S800, S1000) after baking and storage. From the results it is evident that the strength and brittleness increased, and the shear work decreased after storage. Statistical analysis of changes in parameters determined by texture analysis (table 6) showed that SP and S800 baked samples were not statistically significantly different from each other ($p<0.05$) according to Fisher's LSD test, the least significant difference in stability, depending on sugar granulation, regardless of sodium bicarbonate proportion and baking temperature, while samples baked with S1000 are statistically different from the other two according to Fisher's LSD test, the least significant difference in strength is independent of the percentage of sodium bicarbonate and baking. the temperature. The results presented in table 6 showed that the change in brittleness and cutting performance of the tested samples after 3 months of storage was statistically significant ($p<0.05$), according to Fisher's LSD test the least significant difference depends on the granulation of sugar applied to sample mixture, regardless of sodium bicarbonate proportion and baking temperature. Figures 13, 14 and 15 and table 7 show the results obtained from the measurement of strength, brittleness and shear work, as well as the results of statistical analysis of the change in strength, brittleness and shear work after storage in relation to different proportions of NaHCO3 . The results of determination of strength (Figure 13) and fragility (Figure 14) show an increase in the value of these parameters after storage. Statistical analysis (table 7) shows that the samples with 0.67% and 1.11% NaHCO3 are statistically different from each other ($p<0.05$) according to Fisher's LSD test, less significant in the change in strength, regardless of the applied annealing temperature. and granulated sugar. The highest values of strength change after 3 months of storage were shown by the samples with the lowest NaHC03 content. The results of the statistical processing of the change in fragility (table 7) show that the samples with 0.67% NaHCO3 and 1.56% NaHCO3 are statistically different according to Fisher's least significant difference LSD test.

The results of the statistical processing of the change in fragility (table 7) show that the samples with 0.67% NaHCO3 and 1.56% NaHCO3 are statistically different according to Fisher's least significant difference LSD test. The samples with the lowest NaHCO3 content (0.67%) had the highest values of brittleness change after storage, in relation to the NaHCO3 content, regardless of baking temperature and sugar granulation. The values of cutting work (Figure 15) depending on the proportion of NaHCO3 decreased after storage, and the statistical analysis of the change of cutting work depending on the proportion of NaHCO3, regardless of the baking temperature and sugar granulation, shows that all the tested samples are not statistically significantly different according to Fisher's LSD Least Significant Difference test at work cut. Figures 16 and 17 and 18 show the results of determination of strength, brittleness and work in shear in the tested samples depending on the baking temperature, after baking and after 3 months of storage, regardless of NaHCO3 content and sugar granulation. The samples annealed at 180 0C had the greatest stability after storage, and the results of the statistical analysis (table 8) showed that these samples differ statistically significantly ($p<0.05$) from the samples annealed at 205 0C and 230 0C, while the samples annealed at 205 0C and 230 0C are not statistically different from each other according to Fisher's LSD test, the least significant difference in strength considering the baking temperatures of the tea paste samples. Values for fragility (Figure 17) after 3 months of storage increased in all samples baked at different temperatures, and the highest value of change in fragility after storage (table 8) was the samples baked at 180 0C, while the increase minimal change in brittleness was observed from samples baked at 230 0C. The results of statistical analysis showed that all samples baked at different temperatures are statistically different from each other ($p<0.05$) according to Fisher's LSD test with the least significant difference in brittleness. The average values of cutting work depending on the baking temperature showed a decrease in the value of all tested samples after 3 months of storage (Figure 18). Samples annealed at 180 0C had the least change in shear work values after storage, and these samples are statistically significantly different from samples annealed at 205 0C and 230 0C according to Fisher's LSD test, the least significant difference, regardless of the percentage of sodium hydrogen carbonate and sugar granulation (table 8.). Figures 19 - 26 show the measurement results of length (d), height (h) and calculated coefficient of expansion of tea cakes after baking and after 3 months of storage. The results showed a decrease in height and an increase in length and coefficient of expansion after storage. The results of measuring the length, height and expansion coefficient of tea cakes depending on different sugar particles, after baking and after 3 months of storage, regardless of the proportion of $NaHCO_3$ and baking temperature, are shown in figures 19, 20 and 21, and the results of the statistical analysis of the change in length, height and expansion coefficient after storage in table 9. The statistical analysis showed that the samples prepared with granulated sugar SP and S800 are not statistically different from each other ($p<0.05$) and that they differ statistically significantly according to Fisher's LSD test of least significant differences from samples prepared with granulated sugar S1000 taking into account the change in length (diameter) of the samples after storage.

In addition, statistical analysis showed that after storage at a change in altitude, samples prepared with powdered sugar (SP) differ statistically ($p<0.05$) from samples prepared with S800 and S1000 sugar according to Fisher's LSD test with the least significant difference (table 9.) Statistical processing of the calculated results of the change in the coefficient of expansion of the tea cake after 3 months of storage shows that there is no statistically significant difference ($p<0.05$) according to the Fisher's LSD test, the most significant difference little important. in relation to sugar granulation, regardless of the proportion of $NaHCO_3$ and the baking temperature (table 9). Figures 22, 23, 24 show the results of the length, height and expansion coefficient of baked tea cakes depending on the different proportion of $NaHCO_3$, after baking and after 3 months of storage of the samples, regardless of the sugar particle and baking temperature . The results of the statistical analysis of the change in length, height and expansion coefficient of tea cakes after storage depending on the $NaHCO_3$ content are shown in Table 10. The largest change in length and the smallest change in height after storage were the cake of tea samples with the lowest concentration of $NaHCO_3$ (0.67%) and were statistically significantly different ($p<0.05$) from the samples with 1.11% and 1.56% $NaHCO_3$ according to Fisher's LSD test with the least difference important (table 10).

All samples with different proportions of $NaHCO_3$ were not statistically different from each other ($p<0.05$) according to Fisher's LSD least significant difference test regarding the change in expansion coefficient after storage (table 10). Figures 25, 26 and 27 show the results of the length, height and coefficient of expansion of baked samples of tea cakes depending on the baking temperature, after baking and after 3 months of storage of the samples, regardless of the content of $NaHCO_3$ and sugar particle . . The results of the statistical analysis in Table 11 showed that all the tested samples are not statistically significantly different from each other ($p<0.05$) according to Fisher's LSD test, the least significant difference in relation to the applied baking temperature in the change in length and expansion coefficient after storage, and that the samples baked at 205 °C are statistically different from the samples baked at 180 °C and 230 °C according to Fisher's LSD test, the least significant difference in height change after storage.

7. <u>CONCLUSION</u>

In conclusion, the future of preparation and production in the food industry is poised for significant transformation driven by technological advancements and evolving consumer preferences. After research and analysis of all the parameters of the tested tea paste samples, after 3 months of storage, the following conclusions were reached:

- The water content and activity after storage of the tested tea cake samples decreased.

- The change in water activity after storage was not statistically significant neither in the samples with different sugar particles, nor in the samples with different sodium hydrogencarbonate content, as well as taking into account the applied baking temperatures. The biggest change in water content was found in samples prepared with sugar with granulation over 1000 μm and those baked at 180 °C.

- Textural properties of strength and brittleness increased after storage, while shear work values decreased.

- The largest changes in strength and brittleness after storage had the samples with the lowest content of sodium hydrogen carbonate (0.67%) baked at 180 °C. Considering the granulation of sugar, the biggest difference in strength was shown by samples with sugar granulation over 1000 μm, and the biggest difference in brittleness by samples prepared with powdered sugar. - The calculated coefficient of expansion of the tea paste samples, as well as the measured length values increased after storage, while the height of the tea paste decreased due to all three parameters that changed during the preparation of the samples (granulation of sugar, sodium bicarbonate content and baking temperature).

- The changes in the length of the tea paste were the least in the samples prepared with powdered sugar, with the lowest sodium hydrogen carbonate content (0.67%) and the applied baking temperature of 180 °C. The biggest changes in height were recorded in the samples prepared with sugar granulation over 1000 μm.

- The statistical analysis of the change in the coefficient of expansion of the tea paste samples showed the absence of a statistically significant difference in relation to the granulation of sugar, the percentage of sodium bicarbonate and the three applied baking temperatures.

- The results of determining the total color change showed that with an increase in the baking temperature of the samples prepared with granulated sugar less than 800 μm, the difference in the total color change decreases, in all three tested concentrations of sodium hydrogencarbonate

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