Dr hab. inż. Katarzyna SZWEDZIAK, Prof. PO[1]
Department of Biosystems Engineering and Chemical Processes
Opole University of Technology, Poland
Prof. Dr hab. Inż. Petr DOLEŻAL[2]
Department of Animal Nutrition and Forage Production (FA), Mendel University in Brno
Czech Republic
Mgr inż. Dominika KOTYSZ
mgr inż. Anna GUMENIUK

THE USE OF GLUTEN-FREE FLOURS FOR THE PRODUCTION OF GLUTEN FREE FOOD®

Zastosowanie mąk bezglutenowych do produkcji żywności bezglutenowej®

Key words: gluten-free flours, millet flour, buckwheat flour, quinoa flour, quality, food, food production, gluten-free diet.

The article analyzes selected quality parameters of millet, buckwheat and quinoa flour. In order to determine the quality indicators, the water content and titratable acidity were determined for each type of flour. The study showed that buckwheat flour has the characteristics most similar to that of wheat flour. Based on the organoleptic evaluation carried out among the respondents, it can be concluded that buckwheat flour products are pleasant to the taste and smell. Manufactured products made of gluten-free flours have a specific consistency, which is due to the inability to produce a gluten mesh.

Słowa kluczowe: mąki bezglutenowe, mąka jaglana, mąka gryczana, mąka z komosy ryżowej, jakość, żywność, produkcja żywności, dieta bezglutenowa.

W artykule dokonano analizy wybranych parametrów jakościowych mąki jaglanej, gryczanej i mąki z komosy ryżowej. W celu określenia wskaźników jakości przeprowadzono oznaczenie zawartości wody oraz kwasowości miareczkowej dla każdego rodzaju mąki. Badania wykazały, że mąka gryczana ma najbardziej zbliżoną charakterystykę do mąki pszennej. Na podstawie przeprowadzonej oceny organoleptycznej wśród ankietowanych, można stwierdzić że wyroby z mąki gryczanej są przyjemne w smaku oraz w zapachu. Wyprodukowane wyroby z mąk bezglutenowych charakteryzują się specyficzną konsystencją, co jest spowodowane niemożnością wytworzenia siatki glutenowej.

INTRODUCTION

A gluten-free diet consists in replacing traditional products made of cereals containing gluten proteins with their gluten-free counterparts, naturally gluten-free or where gluten has been eliminated in a technological manner. Today there are tons of gluten-free products available to replace confectionery, flour and wheat bread. The high availability of these products and their diversity still generate the problem of balancing such a gluten-free diet and the costs incurred [9, 11]. A gluten-free diet has become very popular because it contributes to weight loss. However, the unjustified exclusion of gluten from one's diet causes negative changes in the human body, including a deficiency of iron, minerals and B vitamins [7, 9]. The exclusion of gluten from the diet has become very popular, but it is seen more as a trend than the diet supporting the treatment of disease. The elimination of gluten proteins from the diet without a reason leads to a deficiency of B vitamins, iron and valuable minerals [9].

Nevertheless, the best method for treating celiac disease is to maintain a gluten-free diet for life [3, 4, 6, 11]. According to legal regulations, gluten-free products must have special labels, such as crossed ear, the content of gluten proteins cannot exceed 20 mg per 1 kg of the product. Wheat grains can be subjected to complex technological processes to remove gluten proteins, but it is impossible to get rid of it 100%, therefore some foodstuffs obtained by this method may contain minimal gluten protein residues [7, 8, 9, 11].

One of the gluten-free cereals is buckwheat, distinguished by a high content of resistant starch, which allows for combining dietary fibers and probiotics. It improves the condition and efficiency of the large intestine, and lowers the level of glucose in the blood. Thanks to the insoluble substances, the gallbladder is cleansed. The risk of the formation of kidney stones is then reduced. The intestine is released and its walls are strengthened. Despite the improvement in appetite, a gradual reduction in excess weight begins, which is why buckwheat flour is also used in diarrhea. Buckwheat is considered as a very healthy and beneficial component of the diet [3, 4, 5, 6]. The starch contained in buckwheat flour has a white color and does not change color during thermal treatment [1, 2].

Adres do korespondencji:- Corresponding author: Katarzyna Szwedziak, Opole University of Technology, Faculty of Production Engineering and Logistics, Departament of Biosystem Engineering and Chemical Processes, ul. Mikołajczyka 5, 45-271 Opole, e-mail:k.szwedziak@po.edu.pl

Millet is also classified as a gluten-free cereal and is the starting material for the production of millet flour. It is enriched with minerals that are essential for our body, such as potassium, magnesium, iron or silica, which are rarely found in cereal preparations [10]. Millet grains contain vitamins B1, B6, B2, biotin and pantothenic acid. The parameter that distinguishes millet from among others is the ability to alkalize the human body. It also has a diuretic effect, strengthens the kidneys, and supports the functions of the stomach and pancreas. It prevents the growth of bacteria in the mouth. Products made from millet flour can be used in the diet of people suffering from thrush, also helps with diarrhea, diabetes and indigestion.

Quinoa is classified as the most nutritious grain used in food, with a rich chemical composition [12]. The protein found in Quinoa is often compared to that of cow‘s milk because it has similar nutritional values. The amount of lysine, methionine and cysteine is much greater than in other grains and legumes. It is also worth noting that it contains valuable oils containing beneficial fatty acids and vitamin E [12]. Its grains contain abundant amounts of minerals such as: magnesium, copper, phosphorus and manganese [13].

PURPOSE AND SCOPE OF WORK

The aim of this study was to evaluate the properties of selected quality parameters of millet flour, buckwheat flour and Quinoa flour used for the production of gluten-free food. The scope of the work included the determination of acidity and water content in individual flours. Additionally, pancakes recipes using gluten-free flours were developed, pancakes were produced, a research questionnaire was formulated and an organoleptic evaluation was performed. Based on the research, the results were analyzed and conclusions were drawn.

RESEARCH METHODOLOGY

Chemical and organoleptic tests were performed to determine the quality and suitability for consumers. The research material consisted of three types of flour: millet flour, buckwheat flour; quinoa flour. Water content and potential acidity were determined. Total humidity was determined using a balance dryer. 3 g of material was measured for individual flours and the drying process was carried out at 105° C, during 15 minutes.

In order to determine the acidity of individual flours, 5 g of flour were weighed out and transferred to a conical flask. 100 cm^3 of distilled water at 20° C were measured in a measuring cylinder. 10 cm^3 from a measuring cylinder were added to the sample and mixed thoroughly with a glass rod to break up any flour lumps. While stirring, the mixture was made up with the remainder of the distilled water. The samples were allowed to stand for 5 minutes, 3 drops of an alcoholic phenolphthalein solution was added and titrated with 0.1 M NaOH solution until a pink color appeared for about 1 minute.

Fig. 1. A sample millet flour before determination the water content.
Rys. 1. Próbka mąki jaglanej przed oznaczeniem zawartości wody.
Source: Own study
Źródło Opracowanie własne

Fig. 2. A sample of buckwheat flour before determining the water content.
Rys. 2. Próbka mąki gryczanej przed oznaczeniem zawartości wody.
Source: Own study
Źródło: Opracowanie własne

Fig. 3. A sample of quinoa flour before determining the water content.
Rys. 3. Próbka mąki quinoa przed oznaczeniem zawartości wody.
Source: Own study
Źródło: Opracowanie własne

Fig. 4. Determination of acidity of millet flour.
Rys. 4. Oznaczenie kwasowości mąki jaglanej.
Source: Own study
Źródło: Opracowanie własne

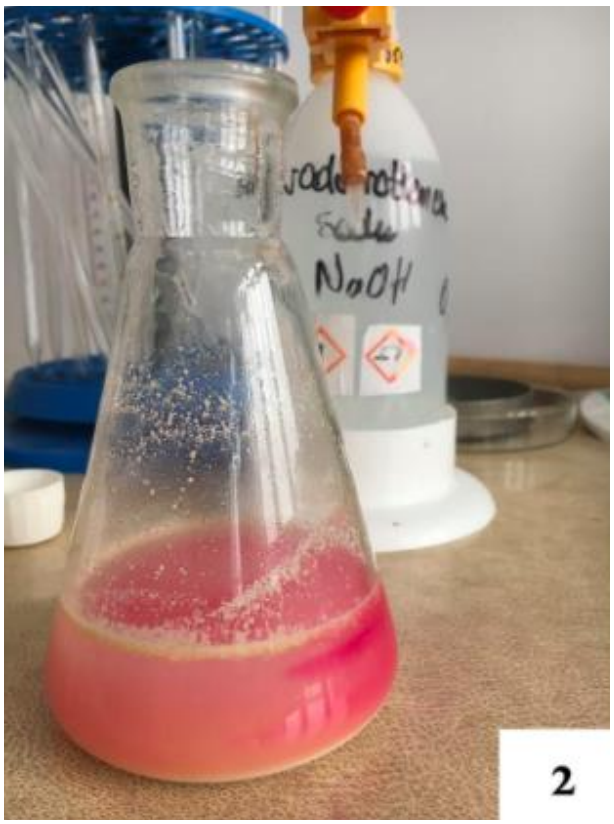

Fig. 5. Determination of the acidity of buckwheat flour.
Rys. 5. Oznaczenie kwasowości mąki gryczanej.
Source: Own study
Źródło: Opracowanie własne

Fig. 6. Determination of acidity of quinoa flour.
Rys. 6. Oznaczenie kwasowości w mące quinoa.
Source: Own study
Źródło: Opracowanie własne

The results of water content determination for individual flours were interpreted in accordance with the formula:

$$X = \frac{m1 - m2}{m1} \times 100\% \quad (1)$$

where: x – total humidity [%]
m1 – mass of the sample before drying [g]
m2 – mass of the sample after drying [g]

The interpretation of the acidity determination results for individual flours was performed in accordance with the formula:

$$X = 20 * a * n \quad (2)$$

where: a – volume of standard 0.1 M sodium hydroxide solution [cm³],
n – NaOH molarity,
X – flour acidity in degrees,
20 – acidity conversion factor in degrees

The degrees of acidity correspond to the number of cm³ of 0.1 M NaOH solution used to titrate the acids contained in 100 g of flour.

The organoleptic evaluation of millet, buckwheat and Quinoa flour was carried out in processed form. According to the recipe, pancakes were produced. Each batch of pancakes was made of the same amount of flour. The additional ingredients were: eggs, milk, baking powder, salt, honey, brown sugar, rapeseed oil. The following quality characteristics were assessed: texture, smell, color, external appearance and taste. The test was carried out in two stages: immediately after

Fig. 7. Dough consistency: 1 – millet flour dough; 2 – buckwheat dough; 3 – Quinoa flour dough.
Rys.7. Konsystencja ciasta: 1 – ciasto z mąki jaglanej; 2 – ciasto z mąki gryczanej; 3 – ciasto z mąki quinoa.
Source: Own study
Źródło: Opracowanie własne

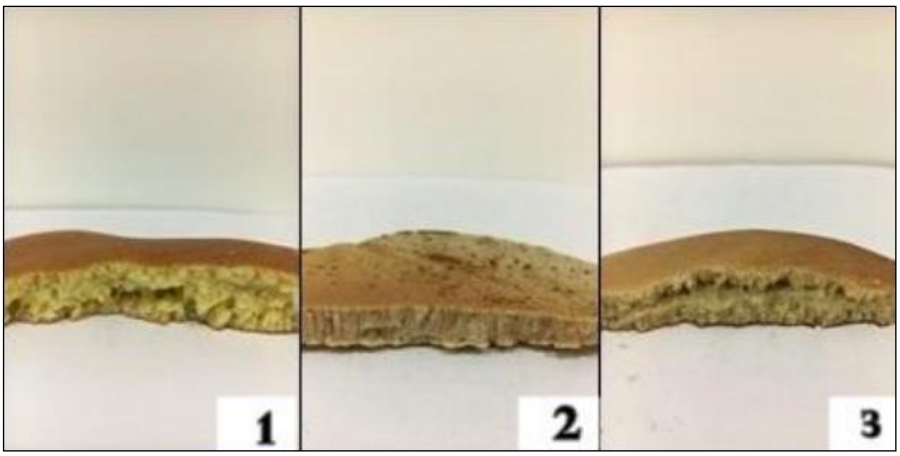

Fig. 8. Pancake texture in cross-section: 1 – made of millet flour; 2 – from buckwheat flour; 3 – with Quinoa flour.
Rys.8. Faktura naleśnikowa w przekroju: 1 – z mąki jaglanej; 2 – z mąki gryczanej; 3 – z mąki quinoa.
Source: Own study
Źródło: Opracowanie własne

preparation and after cooling. Selected features were assessed using the five-point method. The evaluation was made by 15 people, including 8 women and 7 men aged 20–30.

ANALYSIS AND DISCUSSION OF THE RESULTS

Based on the research, the obtained results were summarized and analyzed.

Water contents for millet, buckwheat and quinoa flour

Millet flour had the greatest ability to evaporate water, the moisture index of which was at the highest level. Buckwheat flour had similar parameters to millet flour. Quinoa flour was characterized by the lowest water evaporation capacity.

Titratable acidity of millet, buckwheat and quinoa flour

The titratable acidity is equal to the total concentration of acidic hydrogen atoms that are present in the test sample also in the form of hydronium ions H_3O^+, and both in undissociated form, where they are neutralized by reaction with bases. It is conditioned by the presence of organic acids, acidic salts, acid anhydrides and other chemical compounds. After the acidity determination of millet, buckwheat and Quinoa flour, you can notice a significant difference in the obtained results. Millet flour has the lowest acidity among the three tested samples because it meets the characteristics of basic substances. Its acidity was 0.4, while buckwheat flour showed the highest acidity between the three tested samples, which was 3.8, but compared to wholemeal flour, which contains more bran with higher acidity, and is 8, it has a much lower value. Sample 3 from Quinoa, as well as millet flour, is characterized by a weak acidity equal to 1, which proves the alkaline characteristics of the tested sample.

Organoleptic evaluation of millet, buckwheat and quinoa flour products

Features such as color, taste, smell, texture and external appearance were assessed organoleptically. The mean for each quality index was determined, and the results were summarized in the form of a graph.

Millet flour pancakes were characterized by a specific color. They were slightly sweet in taste, but their aroma was faint. Texture evaluation indicated dry, but external appearance was positive.

Pancakes prepared from buckwheat flour, according to the respondents, were distinguished by a very good taste, while the color was dark, uncharacteristic. The smell was intense but pleasant, peculiar to buckwheat. The texture was judged to be rubbery, but the external appearance was positively assessed by the testers.

Pancakes made of quinoa flour stood out among others because of their bitter taste and porous texture. They have an intense grain scent, a characteristic color and are positively assessed in terms of external appearance.

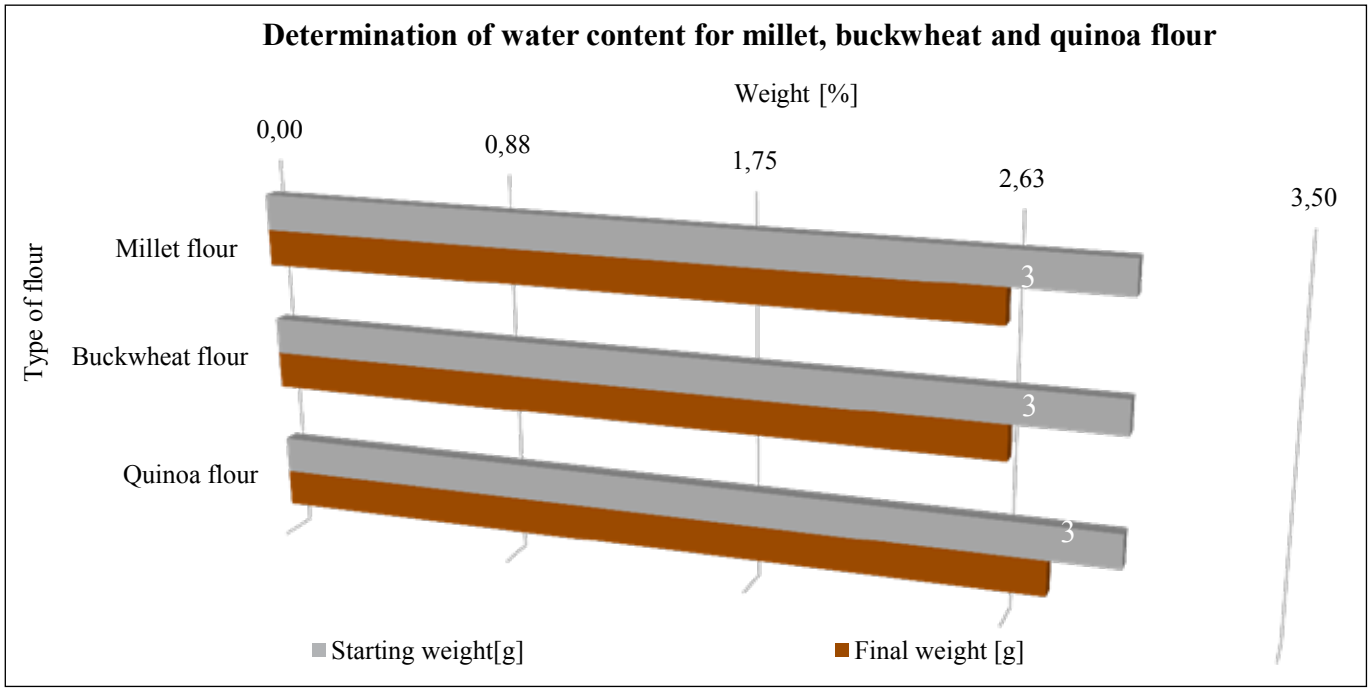

Fig. 9. Determination of water content for millet, buckwheat and quinoa flour.
Rys.9. Oznaczenie zawartości wody w mące z prosa, gryki i quinoi.
Source: Own study
Źródło: Opracowanie własne

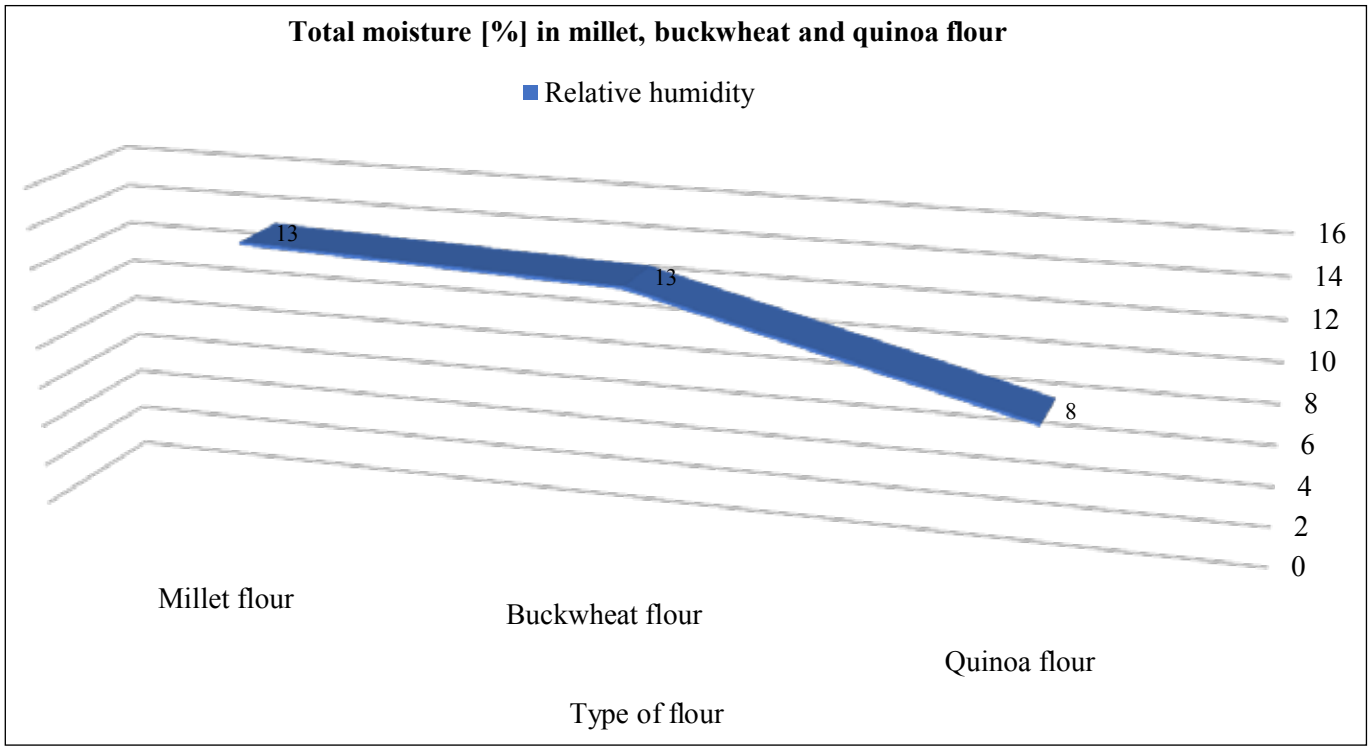

Fig. 10. Total moisture for millet, buckwheat and quinoa flour.
Rys. 10. Wilgotność całkowita w mące jaglanej, gryczanej i quinoa.
Source: Own study
Źródło: Opracowanie własne

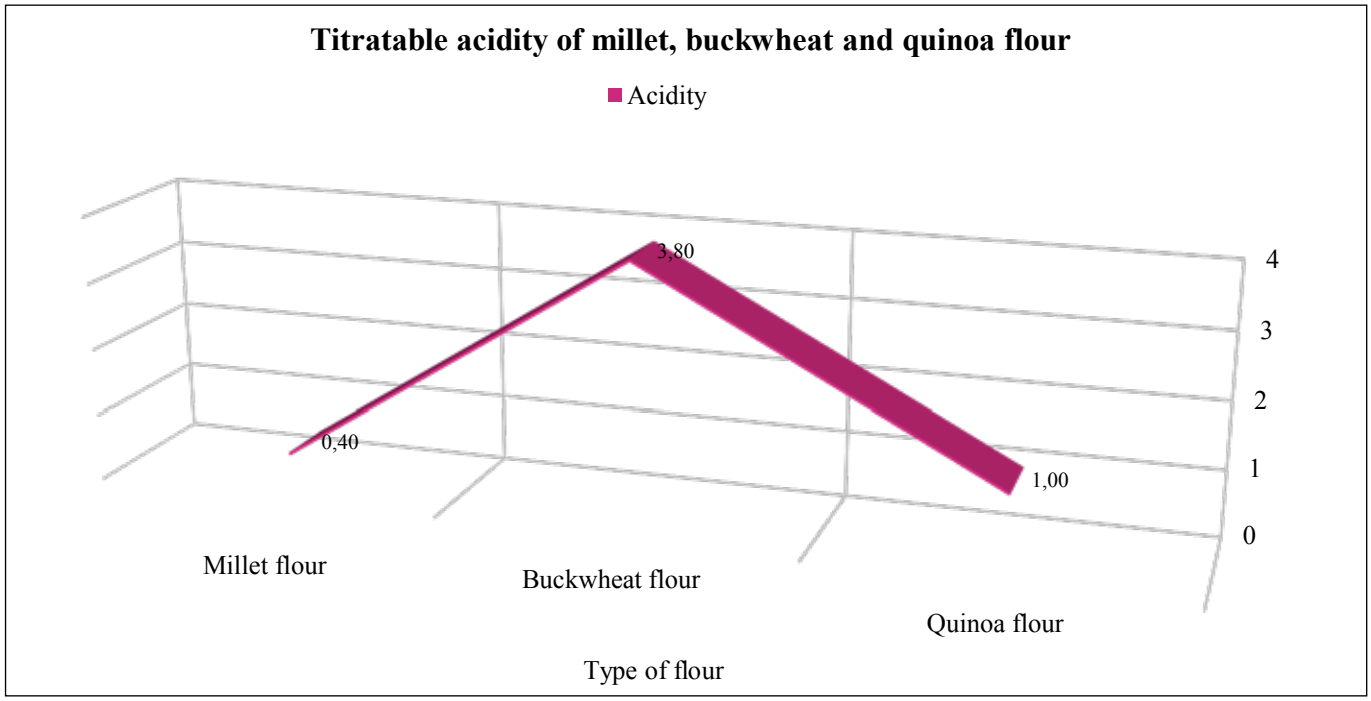

Fig. 11. Titratable acidity of millet, buckwheat and quinoa flour.
Rys. 11. Kwasowość mąki jaglanej, gryczanej i quinoa.
Source: Own study
Źródło: Opracowanie własne

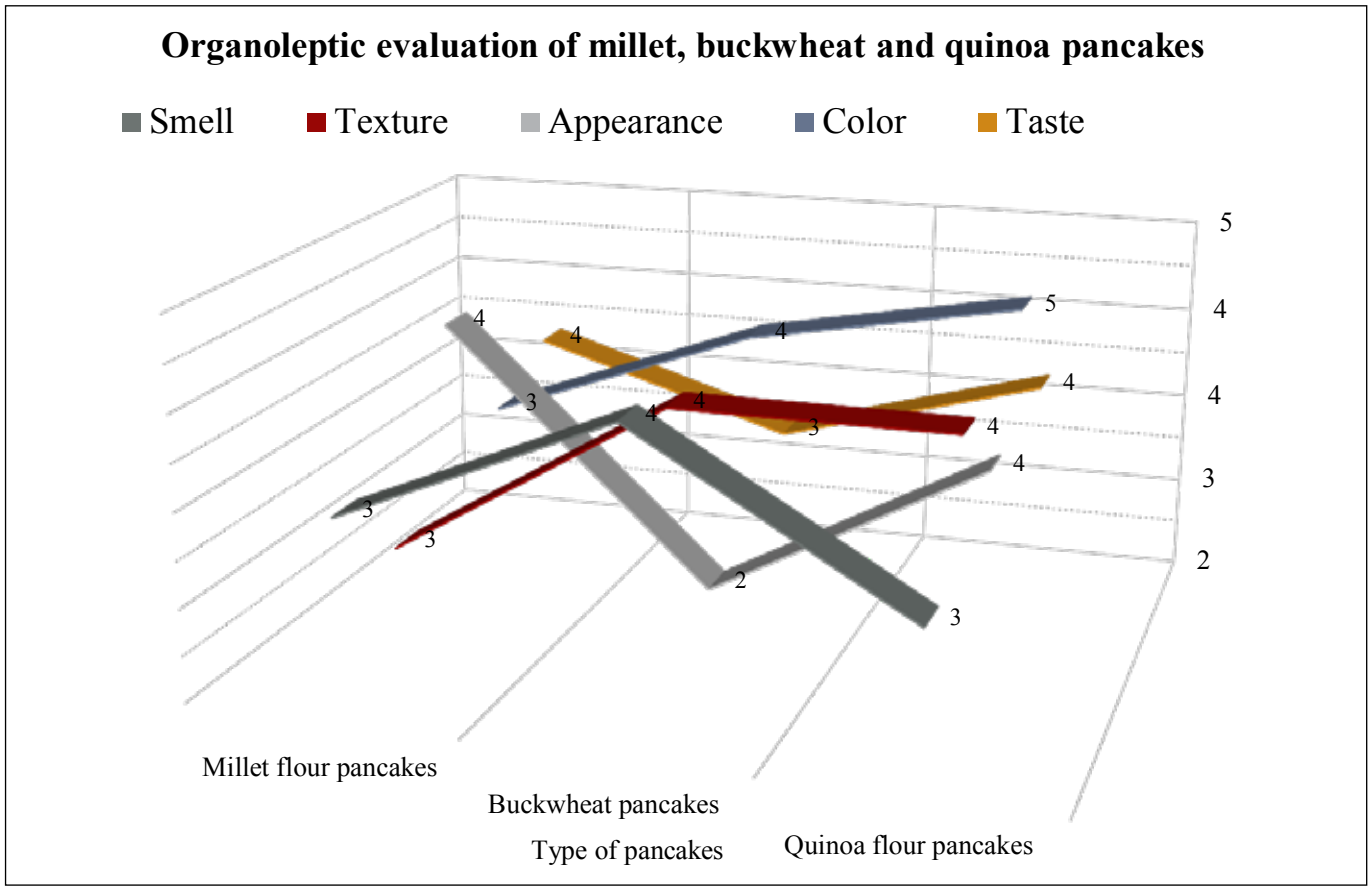

Fig. 12. Organoleptic evaluation of pancakes made of millet, buckwheat and quinoa flour.
Rys.12. Ocena organoleptyczna naleśników z mąki jaglanej, gryczanej i quinoa.
Source: Own study
Źródło: Opracowanie własne

CONCLUSIONS

Based on the conducted research, it can be concluded that:

1. Millet flour had the highest water content index.
2. All tested flours were alkaline.
3. In the organoleptic assessment, the products in the form of pancakes were best assessed when used in the production of millet flour.
4. The moisture of the flour has a significant influence on the texture of the dough.

WNIOSKI

Na podstawie przeprowadzonych badań można stwierdzić, że:

1. Najwyższym wskaźnikiem zawartości wody charakteryzowała się mąka jaglana.
2. Wszystkie testowane mąki miały odczyn zasadowy.
3. W ocenie organoleptycznej najlepiej oceniano produkty w postaci naleśników z mąki jaglanej.
4. Wilgotność mąki ma istotny wpływ na konsystencję ciasta.

REFERENCES

[1] **ARCHANA SS, A. KAWATRA. 2001.** „Białko in vitro i strawność skrobi z prosa perłowego (Pennisetum glaucum L.), na którą mają wpływ techniki przetwarzania". Nahrung / Food 45 (1): 25–7.

[2] **BLACK J.L., C. ORFILA. 2011.** "Impact of coeliac disease on dietary habits and quality of life". J. Hum. Nutr. Diet. No. 24.

[3] **BROWNLEE IA. 2011**. "The physiological roles of dietary fibre". Food Hydrocoll 25(2): 238–250.

[4] **DZIEDZIC K., D. GÓRECKA, J. KOBUS-CISOWSKA, M. JESZKA. 2010**. „Możliwości wykorzystania gryki w produkcji żywności funkcjonalnej". Nauk. Przyr. Technol. 4(2): 1–7.

[5] **GĄSIOROWSKI H. 2008**. „Gryka". Prz. Zboż.-Młyn. 10: 15–17.

[6] **GÓRECKA D, M. HĘŚ, K. SZYMANDERA-BUSZKA, K. DZIEDZIC. 2009.** "Contents of selected bioactive components In buckwheat groats". Acta Sci. Pol. Technol. Aliment. 8(2): 75–83.

[7] **NIEWINSKI M. M. 2008.** "Advances in Celiac Disease and Gluten-Free Diet". Journal of the American Dietetic Association, Volume 108, Issue 4, April 2008, Pages 661–672.

[8] **PIECHOTA M. 2021.** „Nowa moda czy konieczność? – kilka słów o diecie bezglutenowej". Tutoring Gedanensis 6(2)/2021 (4–11) ISSN 2451–1862.

[9] **STEMPIŃSKA K., M. SORAL-ŚMIETANA. 2006.** „Składniki chemiczne i ocena fizykochemiczna ziarniaków gryki – porównanie trzech polskich odmian". Żywność. Nauka. Technologia. Jakość. 2 (Supl.): 348–357.

[10] **STEMPIŃSKA K., M. SORAL-ŚMIETANA. 2006.** „Składniki chemiczne i ocena fizykochemiczna ziarniaków gryki – porównanie trzech polskich odmian". Żywność. Nauka. Technologia. Jakość. 2 (Supl.): 348–357.

[11] **SWORA E., H. STANKOWIAK-KULPA, M. MAZUR. 2009.** „Dieta bezglutenowa w chorobie trzewnej". Nowiny Lekarskie 78, 5–6: 324–329.

REFERENCES

[1] **ARCHANA SS, A. KAWATRA. 2001.** „Bialko in vitro i strawnosc skrobi z prosa perlowego (Pennisetum glaucum L.), na ktora maja wplyw techniki przetwarzania". Nahrung / Food 45 (1): 25–7.

[2] **BLACK J.L., C. ORFILA. 2011.** "Impact of coeliac disease on dietary habits and quality of life". J. Hum. Nutr. Diet. No. 24.

[3] **BROWNLEE IA. 2011.** "The physiological roles of dietary fibre". Food Hydrocoll 25(2): 238–250.

[4] **DZIEDZIC K., D. GORECKA, J. KOBUS-CISOWSKA, M. JESZKA. 2010.** „Mozliwosci wykorzystania gryki w produkcji zywnosci funkcjonalnej". Nauk. Przyr. Technol. 4(2): 1–7.

[5] **GASIOROWSKI H. 2008.** „Gryka". Prz. Zboz.-Mlyn. 10: 15–17.

[6] **GORECKA D, M. HES, K. SZYMANDERA-BUSZKA, K. DZIEDZIC. 2009.** "Contents of selected bioactive components In buckwheat groats". Acta Sci. Pol. Technol. Aliment. 8(2): 75–83.

[7] **NIEWINSKI M. M. 2008.** "Advances in Celiac Disease and Gluten-Free Diet". Journal of the American Dietetic Association, Volume 108, Issue 4, April 2008, Pages 661–672.

[8] **PIECHOTA M. 2021.** „Nowa moda czy koniecznosc? – kilka slow o diecie bezglutenowej". Tutoring Gedanensis 6(2)/2021 (4-11) ISSN 2451-1862.

[9] **STEMPINSKA K., M. SORAL-SMIETANA. 2006.** „Skladniki chemiczne i ocena fizykochemiczna ziarniakow gryki – porownanie trzech polskich odmian". Zywnosc. Nauka. Technologia. Jakosc. 2 (Supl.): 348–357.

[10] **STEMPINSKA K., M. SORAL-SMIETANA. 2006.** „Skladniki chemiczne i ocena fizykochemiczna ziarniakow gryki - porownanie trzech polskich odmian". Zywnosc. Nauka. Technologia. Jakosc. 2 (Supl.): 348–357.

[11] **SWORA E., H. STANKOWIAK - KULPA, M. MAZUR. 2009.** „Dieta bezglutenowa w chorobie trzewnej". Nowiny Lekarskie 78, 5-6: 324–329.

[12] **UKKOLA A., K. KURPPA, P. COLLIN, H. HUHTALA, L. FORMA, L. KEKKONEN, M. MÄKI, K. KAUKINEN. 2012.** "Use of health care services and pharmaceutical agents in coeliac disease: a prospective nationwide study". B.M.C. Gastroenterol., 12,136: 10.1186/1471-230X-12-136.

[13] **YUAN FU. 2009.** "Preparation of Antioxidant Peptides from Buckwheat Albumin by Enzymatic Hydrolysis" [Text] / Fu Yuan, Zhang Meili, Wen Houjuan // Food Science, Vol. 30 (15): - P. 142–147.

[12] **UKKOLA A., K. KURPPA, P. COLLIN, H. HUHTALA, L. FORMA, L. KEKKONEN, M. MAKI, K. KAUKINEN. 2012.** "Use of health care services and pharmaceutical agents in coeliac disease: a prospective nationwide study". B.M.C. Gastroenterol., 12,136: 10.1186/1471-230X-12-136.

[13] **YUAN FU. 2009.** "Preparation of Antioxidant Peptides from Buckwheat Albumin by Enzymatic Hydrolysis" [Text] / Fu Yuan, Zhang Meili, Wen Houjuan // Food Science, Vol. 30 (15): - P. 142–147.