Scientific Papers. Series B, Horticulture. Vol. LXVI, No. 2, 2022
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

# ORGANIC SOURDOUGH MINI BAGUETTE FORTIFIED WITH JERUSALEM ARTICHOKE FLOUR, FOR DIABETICS

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***Abstract***

*Fermentation of the dough with sourdough cause the improvement of the sensory and nutritional qualities of bakery products. Also, sourdough bakery products (in a longer fermentation process) are digested more slowly in the human body, which causes a lower glycemic impact on the human body. This paper presents the research results undertaken to obtain the organic sourdough mini baguette fortified with Jerusalem artichoke flour, for diabetics. This product has superior sensory qualities, high nutritional value, has antioxidant capacity and low glycemic index, being in the diet of diabetics. Thus, the mini baguette fortified with jerusalem artichoke flour, is distinguished by the content in mineral elements (K: 245.17-260.85 mg/100 g; Ca: 136.21-145.21 mg/100 g; Mg: 90.02-98.45 mg/100 g; Fe: 1.88-1.97 mg/100 g; Zn: 1.47-1.56 mg/100 g), total fiber (8.94-9.75 mg/100 g), total polyphenols (115.75-118.98 mg GAE/100 g). Also, this bakery product has antioxidant capacity (125.43-128.65 mg Trolox/100 g) and has low content in available carbohydrates (39.24-38.15%). The use of sourdough in the organic mini baguette composition ensures its freshness and microbiological stability for a period of at least 4 days. The use of sourdough as a natural fermentation agent and Jerusalem artichoke flour as a fortifying agent ensures a mini-baguette with superior sensory qualities, high nutritional value and antioxidant capacity, which can be used in the prevention and diet therapy of diabetes.*

***Key words****: diabetics, Jerusalem artichoke flour, mini baguette, organic, sourdough.*

## INTRODUCTION

Sourdough is the result of the fermentation of flour from cereals and pseudocereals or legumes, among others, through the action of microorganisms present in the preparation (Weckx et al., 2019). Some sourdoughs may also contain added microorganisms. Sourdoughs are stable ecosystems composed of lactic acid bacteria (LAB) and yeasts used in the production of bakery products (Zlateva et al., 2019). Traditionally, sourdough was used as a leavening agent, but today it is more and more used to improve the organoleptic characteristics of bakery products and to reduce the need for additives in their composition (Gänzle et al., 2016).

The sourdough fermentation process is based on the unique symbiosis between yeasts and lactic bacteria. The use of sourdough in bread composition cause the improvement of the aroma, the texture and the increase of the shelf life of the bread.

Bioaccessibility and bioavailability of nutrients are essential for ensuring optimal nutrition of the fermentation medium, but also for the quality of the final product and its beneficial effects on consumers health (Păcularu-Burada et al., 2020; Siepmann et al., 2018). Thus, the use of sourdough in the fermentation process of the dough to obtain bread can lower its glycemic index, improve the dietary fiber complex, release bioactive peptides and increase the absorption of minerals and bioactive compounds (vitamins, phenolic compounds) in the human body (Păcularu-Burada et al., 2020; Siepmann et al., 2018). At the same time, the microbial metabolism of the lactobacilli present in the dough cause the formation of compounds with nutritional value, such as peptides and amino acid derivatives (amino-butyric acid) as well as prebiotic exopolysaccharides (Păcularu-Burada et al., 2020; Chiș et al., 2019; Rashmi et al., 2020). Catana et al. (2018) obtained an assortment of minibaguette fortified with dehydrated fruits of

*Aronia melanocarpa*, using sourdough as a fermentation agent. This mini-baguette stands out for its sensory qualities, the content in mineral elements (Potassium: 10547 mg/kg; Calcium: 1598.57 mg/kg; Magnesium: 1095.44 mg/kg; Iron: 19.80 mg/kg), total polyphenols (197.91 mg GAE/100 g) and antioxidant capacity (2.64 mg Trolox Equivalents/g).

Also, Burnete et al. (2020) made an assortment of hypoglycemic bread, in which a type of natural yeast fortified with polyphenols and inulin was used as a fermentation agent. This bread is intended for diabetics, having a low carbohydrate content, high nutritional value and antioxidant potential (117.45-125.15 mg TE/100 g).

This paper presents the research results undertaken to obtain the organic sourdough mini baguette fortified with Jerusalem artichoke flour, for diabetics.

## MATERIALS AND METHODS

### Materials

To obtain the "Mini baguette fortified with Jerusalem artichoke flour" the following materials were used: organic sourdough, whole wheat flour, barley flour, Jerusalem artichoke flour, apple waste flour (*Jonathan variety*), seeds (sunflower, pumpkin, flax, white sesame, black sesame) milk, olive oil and sea salt.

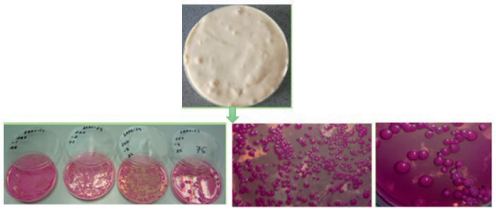

Figure 1. "Mini baguette fortified with Jerusalem artichoke flour"

For the control sample (C: "White mini baguette with natural sourdough") the following materials were used: organic sourdough, white wheat flour, white sesame and black sesame seeds, milk, olive oil and sea salt.

Organic sourdough was obtained and tested at the Human Nutrition Laboratory in IBA-Bucharest. Jerusalem artichoke flour was obtained within the Vegetable-Fruit Processing Pilot Experimental Station, from IBA Bucharest.

***Mini baguette-making***

To obtain the product "Mini baguette fortified with Jerusalem artichoke flour" three experimental variants (CDV1, CDV2 and CDV3) and the control sample were made (C: "White mini baguette with natural sourdough"). The variable factors were the levels of fortification with Jerusalem artichoke flour and apple waste flour (3%, 4% and 5%, relative to the amount of whole wheat flour in the product composition). The experimental variant CDV3 presents the minimum level of fortification (3%).

Figures 2 and 3 show the products "Mini baguette fortified with Jerusalem artichoke flour" (CDV3) and the control sample.


Figure 2. Product "Mini baguette fortified with Jerusalem artichoke flour" (CDV3) and control sample

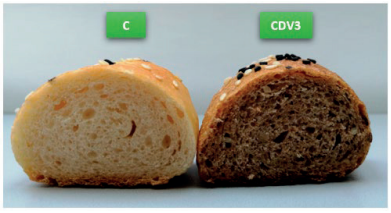


Figure 3. Product "Mini baguette fortified with Jerusalem artichoke flour" (CDV3) and control sample (in section)

To make the products, the biphasic process was applied, which ensures a high bioavailability of minerals and bioactive compounds and a better digestibility of proteins.

### Methods

***Statistical Analysis***

The organic sourdough mini baguette fortified with Jerusalem artichoke flour, for diabetics and Control sample were analyzed in triplicate. Mean and standard deviation are reported for each analytical parameter studied.

***Sensory analysis***
The sensory analysis was carried out using the descriptive method and by "Comparison method with unitary score scales" method (Burnete et al., 2020).
Instrumental color analysis was performed with a CM-5 colorimeter (Konica Minolta, Japan) equipped with SpectraMagic NX software.
Instrumental texture analysis was performed with Instron Texture Analyzer (model 5944, Illinois Tool Works Inc., USA) equipped with Bluehill 3.13 software.

***Physico-chemical analysis***
The physical-chemical analysis was carried out using the following methods: ACC 44-15A (moisture content), AOAC 979.09 (protein content), AOAC 963.15 (fat content), AOAC 923.03 (ash content) and AOAC 991.43 (total dietary fiber). The mineral elements were determined by atomic absorption spectrophotometry, after calcination of the samples. Energy value (kcal/100 g and kJ/100 g) were calculated according to the Commission Regulation no. 1169/2011 (European Commission, 2011).

***Total polyphenol content***
Total polyphenol content was performed by Folin-Ciocalteau spectrophotometric method, according to Horszwald and Andlauer (2011), with some modifications (Burnete et al., 2020).

***Antioxidant capacity***
Antioxidant capacity was performed by DPPH (1,1diphenyl-2-picryl hydrazyl) method, according to Horszwald and Andlauer (2011), with some modifications (Burnete et al., 2020).

***Microbiological analysis***
Microbiological analysis was performed according to SR ISO 21527-1:2009 (Yeasts and molds) and SR EN ISO 21528-1:2017 method (*Enterobacteriaceae*).

## RESULTS AND DISCUSSIONS

***Sensory analysis***
Following the sensory analysis, it was found that the product "White mini baguette with natural sourdough" has a pleasant, specific taste and aroma, an elastic, dense core, with uniform pores and a volume of 247 $cm^3$/100 g. The product "Mini baguette fortified with Jerusalem artichoke flour" made in the experimental versions CDV1 and CDV2, has an elastic, dense core, with uniform pores and a pleasant, specific taste and aroma, but has a low volume (CDV1 - V = 216 $cm^3$/100 g; CDV2 - V = 180 $cm^3$ /100 g) and after 2 days from the date of manufacture they have a hard texture. In contrast, the product made according to the experimental variant CDV3, presents appropriate sensory qualities and has a volume close to that of the Control sample (V = 243 $cm^3$/100 g). If the percentage of Jerusalem artichoke flour and apple waste flour increase, we noticed as a result a decrease in product volume and an increase in firmness (product texture). Thus, the product made according to the experimental variant CDV1, in which the level of fortification with Jerusalem artichoke flour and apple waste flour is 5%, shows, after one day from the date of manufacture, the highest value of firmness (12.82 N) and gumminess (4.03). Elasticity and cohesiveness recorded close values in the case of the Control sample and the three experimental variants. The products were packed in polypropylene foil.

Table 1. The textural properties of the product "Mini baguette fortified with Jerusalem artichoke flour", and the control sample C

| Product | Period (days) | Firmness (N) | Elasticity | Cohesiveness | Gumminess (N) |
|---|---|---|---|---|---|
| C | 1 | 6.03 ± 0.05 | 0.99 ± 0.02 | 0.43 ± 0.03 | 2.58 ± 0.28 |
| CDV1 | 1 | 12.82 ± 1.64 | 0.97 ± 0.00 | 0.32 ± 0.03 | 4.03 ± 0.78 |
| CDV2 | 1 | 8.47 ± 1.47 | 0.97 ± 0.00 | 0.37 ± 0.03 | 3.03 ± 0.73 |
| CDV3 | 1 | 6.10 ± 0.28 | 0.97 ± 0.00 | 0.40 ± 0.02 | 2.36 ± 0.23 |

The experimental data on the main instrumentally determined texture parameters (firmness, elasticity, cohesiveness, gumminess) are presented in Table 1, and compression curves are presented in Figures 4-6.

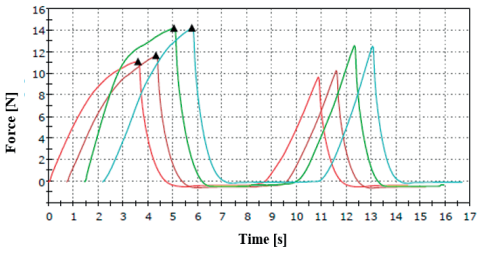


Figure 4. Compression curves for the product "Mini baguette fortified with Jerusalem artichoke flour" (CDV1)

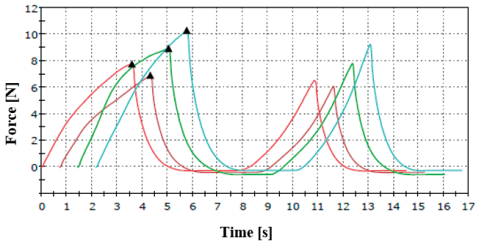


Figure 5. Compression curves for the product "Mini baguette fortified with Jerusalem artichoke flour" (CDV2)

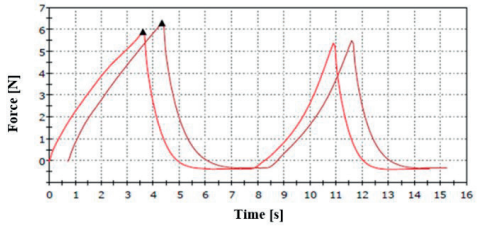


Figure 6. Compression curves for the product "Mini baguette fortified with Jerusalem artichoke flour" (CDV3)

Following the sensory analysis by a panel of 10 tasters, applying the "Comparison method with unitary score scales", the products received the following scores and qualifications: control sample C - 19.92 points ("very good" qualification), CDV1 - 17.76 points ("very good" qualification), CDV2 - 17.92 points ("good" qualification) and CDV3 - 19.76 points ("very good" qualification) (Figure 7).

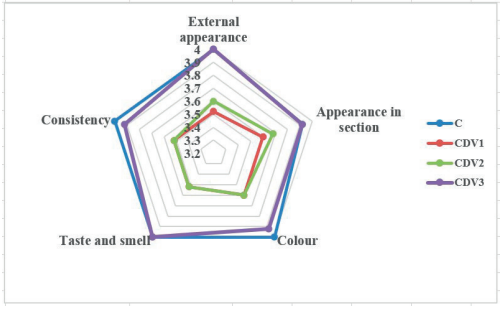


Figure 7. Sensory evaluation of the product "Mini baguette fortified with Jerusalem artichoke flour" (CDV1, CDV2 and CDV3) and of the control sample (C)

Following the instrumental analysis of the color the results showed that the product "Mini baguette fortified with Jerusalem artichoke flour" (CDV1, CDV2 and CDV3) recorded lower luminance values, compared to the control sample (C). The use of whole wheat flour in the composition of the product cause the darkening of its color, the minimum luminance value being registered in the case of the experimental variant CDV1, L* = 66.30 (Figure 8).

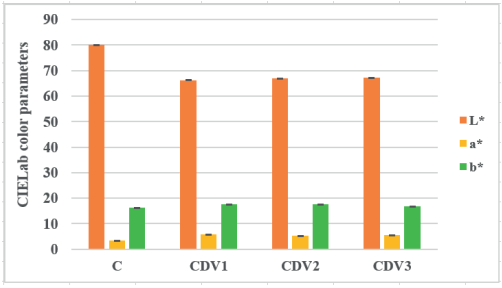


Figure 8. Color parameters of the product "Mini baguette fortified with Jerusalem artichoke flour" (CDV1, CDV2 and CDV3) and of the control sample (C)

Also, the product "Mini baguette fortified with Jerusalem artichoke flour" (CDV1, CDV2 and CDV3) has higher values of the color parameters a* and b*, compared to the control sample (C).

Corroborating the results of the sensory analysis with those of the instrumental analysis of the texture, in order to make the product "Mini baguette fortified with Jerusalem artichoke flour", the experimental variant CDV3 was chosen as the optimal variant.

### *Physico-chemical analysis*

Physico-chemical analysis of the product "Mini baguette fortified with Jerusalem artichoke flour" and of the control sample C is presented in Table 2.

Table 2. Physico-chemical composition of the product "Mini baguette fortified with Jerusalem artichoke flour" and of the control sample C

| Component | C | CDV1 | CDV2 | CDV3 |
|---|---|---|---|---|
| Acidity (degrees) | 3.8±0.01 | 4.38±0.01 | 4.30±0.01 | 4.20±0.01 |
| Moisture (%) | 32.88±0.82 | 33.16±0.83 | 33.54±0.84 | 33.05±0.83 |
| Ash (%) | 0.84±0.009 | 1.40±0.015 | 1.49±0.016 | 1.58±0.017 |
| Protein (%) | 9.65±0.08 | 11.60±0.10 | 11.78±0.10 | 12.15±0.11 |
| Fat (%) | 1.88±0.02 | 4.67±0.05 | 4.55±0.05 | 4.42±0.05 |
| Carbohydrates (%) | 54.75±0.04 | 49.17±0.02 | 48.64±0.02 | 48.80±0.02 |
| Available carbohydrates (%) | 53.94±0.03 | 44.18±0.01 | 43.93±0.01 | 44.37±0.01 |
| Total dietary fiber (%) | 0.81±0.01 | 4.99±0.09 | 4.71±0.09 | 4.43±0.08 |
| Energy value (kcal/100g) | 273 | 275 | 273 | 275 |
| Energy value (kJ/100g) | 1157 | 1161 | 1153 | 11560 |

Following the physico-chemical analysis, it was found that the product "Mini baguette fortified with Jerusalem artichoke flour" has a low carbohydrate content and stands out for its

protein, ash and total fiber content, compared to the control sample (C). These chemical characteristics of the product cause a quick and lasting satiety when consumed and a reduced glycemic impact, being beneficial in the diet of diabetics and obese people.

The product "Mini baguette fortified with Jerusalem artichoke flour" has protein, ash and fiber content, comparable to those reported by Odunlade et al. (2017) in the case of white bread, fortified (fortification level 1-3%) with leafy vegetable powders (protein: 9.50 to 13.93%; fiber: 1.81-4.00%), ash: 1.05 to 2.38%) .

The "Mini baguette fortified with Jerusalem artichoke flour" stands out for its content in mineral elements" (K, Ca, Mg, Zn, Cu and Fe). Their content in minerals is presented in Figures 9 and 10.

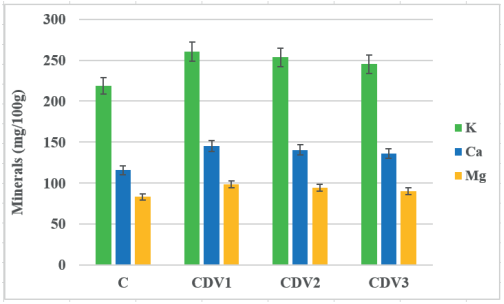


Figure 9. Mineral content (K, Ca and Mg) of the product "Mini baguette fortified with Jerusalem artichoke flour" and of the control sample C

The product made according to the experimental variant CDV1, has the highest content in potassium, calcium and magnesium (K: 260.85 mg/100 g; Ca: 145.21 mg/100 g; Mg: 98.45 mg/100 g). Bread and bakery products are an important source of macro and micro elements (Odunlade et al., 2017; Szymczycha-Madeja, 2017). In the human body, minerals have structural, catalytic and regulatory functions. Thus, they activate enzymes and regulate fluid pH for metabolic reactions and cellular osmotic exchanges (Gharibzahed et al., 2017).

The product "Mini baguette fortified with Jerusalem artichoke flour" has a lower calcium and magnesium content than bread fortified with leafy vegetable powders (Ca: 250-330.5 mg/100 g; Mg: 157.5-179 mg/100 g). Instead, this product has a significantly higher mineral content compared to that reported by Torrinha et al. (2019) in the case of some types of bread, made from wheat flour, in Europe (K: 74-205 mg/100 g; Ca: 19.2-45.9 mg/100 g; Mg: 20-32.4 mg/100 g).

The product "Mini baguette fortified with Jerusalem artichoke flour" made according to the experimental version CDV1, has the highest content in iron, zinc and copper (Fe: 1.97 mg/100 g; Zn: 1.57 mg/100 g; Cu: 1.01 mg/100 g).

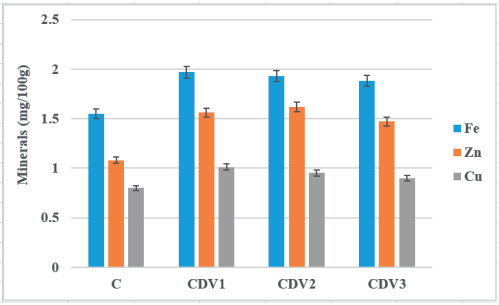


Figure 10. Mineral content (Fe, Zn and Cu) of the product "Mini baguette fortified with Jerusalem artichoke flour" and of the control sample C

The product "Mini baguette fortified with Jerusalem artichoke flour" has the iron and zinc content higher or comparable to that reported by Torrinha et al. (2019) in the case of some types of bread, made from wheat flour, in Europe (Fe: 1-2.2 mg/100 g; Zn: 0.27-1.59 mg/100 g). The Fe content of the product "Mini baguette fortified with Jerusalem artichoke flour" is higher compared to that reported by Zlateva et al. (2019), in the case of bread fortified with Spirulina powder (fortification level 2%): 1.59 mg/100 g .

***Total polyphenol content***

Due to the valuable ingredients used in the composition of the "Mini baguette fortified with Jerusalem artichoke flour", the product stands out for its content in total polyphenols (Figure 11).

The product made according to the experimental variant CDV1, has the highest content in total polyphenols (129.56 mg GAE/100 g), about 1.8 times higher than the Control sample (C). The total polyphenol content of the product "Mini baguette fortified

with Jerusalem artichoke flour" (CDV1, CDV2 and CDV3) is lower than that reported by Catană et al. (2018), in the case of the "Minibaguette with Aronia" product (197.91 mg GAE/100 g), but higher than that reported by Saharan and Jood (2021) in the case of bread fortified with Spirulina: 85 mg GAE/ 100 g (fortification level 2%) and 119 mg GAE/100 g (fortification level 4%).

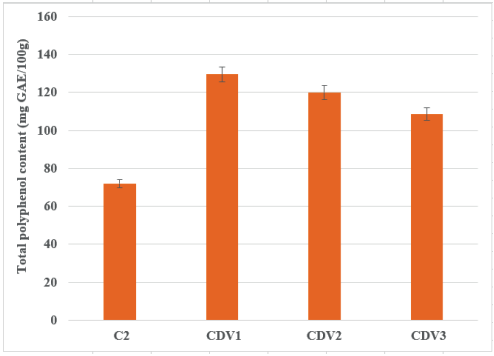


Figure 11.Total polyphenol content of the product "Mini baguette fortified with Jerusalem artichoke flour" and of the control sample C

Bread and bakery products (buns, baguettes, mini baguettes, croissants, etc.) are important foods in the human diet. Therefore, their enrichment in polyphenols is of real interest. Polyphenols have direct antioxidant and anti-inflammatory effects in the human orgasm, contributing to the prevention of conditions caused by oxidative stress. At the same time, recent scientific evidence mentions that polyphenols and their metabolites inhibit the growth of pathogenic bacteria in the colon (Aravind et al., 2021).

***Antioxidant capacity***

Due to its complex biochemical composition, the product "Mini baguette fortified with Jerusalem Jerusalem artichoke flour" (CDV1, CDV2 and CDV3) has antioxidant capacity. (Figure 12).

The highest value was recorded in the case of the experimental variant CDV3: 135.67 mg Trolox/100 g. The product made according to this experimental variant have a higher antioxidant capacity compared to that reported by Burnete et al. (2020), in the case of the product "Hypoglycemic bread with antioxidant potential" (125.15 mg Trolox /100 g).

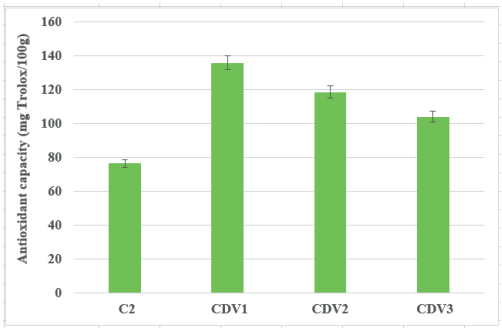


Figure 12. Antioxidant capacity of the product "Mini baguette fortified with Jerusalem artichoke flour" and of the control sample C

The antioxidant capacity of the product "Mini baguette fortified with Jerusalem Jerusalem artichoke flour" (CDV1, CDV2 and CDV3) is lower than that reported by Catană et al. (2018), in the case of the product "Minibagette with Aronia" (264 mg Trolox/100 g).

***Microbiological analysis***

The microbiological analysis of the product "Mini baguette fortified with Jerusalem artichoke flour" and the Control sample (C) is presented in Table 3.

The microbiological analysis revealed that the product complies with the provisions in force even 7 days after the date of manufacture. The microbiological stability of the product is due to polyphenols that have an antioxidant and antibacterial effect (Bouarab-Chibane et al., 2019) and the lactic acid bacteria from organic sourdough, which has antimicrobial and antifungal properties (Bartkiene et al., 2019).

Table 3. Microbiological analysis of the product "Mini baguette fortified with Jerusalem artichoke flour" and of the control sample C

| Product | Microbiological indicator | | | | | |
|---|---|---|---|---|---|---|
| | Yeasts and molds (CFU/g) | | | *Enterobacteriaceae* (CFU/g) | | |
| | 24h | 5 days | 7 days | 24h | 5 days | 7 days |
| C | < 10 | - | - | < 10 | - | - |
| CDV1 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 |
| CDV2 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 |
| CDV3 | < 10 | < 10 | < 10 | < 10 | < 10 | < 10 |

Corroborating the results of the microbiological analysis with the results of the sensory analysis and the results of the instrumental analysis of the texture, the shelf life of the product "Mini baguette fortified with Jerusalem artichoke flour" was set at 4 days.

## CONCLUSIONS

The product "Mini baguette fortified with Jerusalem artichoke flour" made with organic sourdough presents superior sensory characteristics, being evaluated by a panel of 10 tasters with a score of 19.76 points ("very good" qualification).

The product "Mini baguette fortified with Jerusalem artichoke flour" has a low content in available carbohydrates (44.37%) and stands out for its content in proteins, total fibers, mineral elements (K, Ca, Mg, Fe, Cu, Zn), total polyphenols and antioxidant capacity, being beneficial in the diet of diabetics, obese people, as well as people with conditions caused by oxidative stress.

Thanks to polyphenols and lactic acid bacteria, the product "Mini baguette fortified with Jerusalem artichoke flour" shows microbiological stability, having a shelf life of 4 days.

## ACKNOWLEDGEMENTS

This work was achieved through Core Programme (PN 19 02), supported by the Ministry of Research, Innovation and Digitalization, contract 22N/2019, project no. PN 19 02 02 01.

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