

## CHANGES IN CHEMICAL COMPOSITION OF SPICY PEPPERS IN CONTROLLED PRODUCTION OF POWDERED PEPPER

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### Abstract

In this research were used fresh and dried spicy varieties of peppers (*Capsicum annum spp.*): *horgosh*, *hajaks* and *gorogled*. For production of grounded bukovec and powdered pepper were used a mixture of all varieties of spicy peppers. Drying was performed at processing plant, with tunnel oven drier, under controlled conditions.

Product's quality were examined with standard analytical methods, by determining: water, proteins, fats, sugars (HPLC), ash, total acids, vitamin C, separately for each varieties of fresh and dried spicy peppers. On grounded bukovec and powdered peppers also were determine ash insoluble in HCl, ether extract and capsanthin. It was established increment of dry matters content (for 78,668%) between fresh and dried peppers. During production of grounded bukovec and powdered peppers, fat content was significantly increased (for 14.042%), due milling of peppers with seeds, releasing fats, which with the pigments from peppers, produce intensive red color. Final products have characteristic color, taste and aroma, without foreign matters.

Examination of quality, microbiological safety (ISO methods), pesticides (GC) and heavy metals (AAS) at final products, indicate that they are met the legal requirements for quality and safe products.

**Key words:** *Pepper, drying, powdered pepper, control, chemical composition.*

### 1. Introduction

Pepper (*Capsicum annum spp.*) is an important vegetable, because of its high biological value

(Markovic and Vracar [1]). In a recent few years has increased its recognition due to the large number of varieties that are widely used in diet and processing industry (Harris [2]). Peppers, depending on the variety and purpose of production, are used in their physiological or technological maturity, in fresh or processed condition, while spicy varieties of peppers are used for the production of minced spicy pepper (Markovic and Vracar [1]).

Spicy varieties of peppers have a meaty pericarp and higher content of dry matter, unlike other varieties of peppers (Niketic-Aleksic [3]). Besides carbohydrates, proteins, fats, organic acids, mineral substances and vitamins, peppers are rich in colored matters. As the most important colored matters in fruits of pepper are carotenoids. On the basis of the amount of carotenoids in grounded and powdered pepper, it is estimated its quality (Markovic [4]). As a dominant carotenoid is capsanthin, especially present in mature red peppers (Vracar *et al.* [5]). The fruits of peppers contain carotenoids as a natural antioxidant and also vitamin C, which is present in relatively high amounts in mature fruits (Simal *et al.* [6]).

Product quality is often under direct influence of the technology of drying, i.e., the conditions of air drying (Simal *et al.* [6]), which significantly affects on the stability of the pigments (Eleyinmi *et al.* [7]). The most suitable temperature of drying is 60-70 °C that gives maximum value of coloration and the longest retention time of the color. The natural presence of sugars can cause partly caramelisation by heating, which affects the taste and aroma of spicy ground pepper. (Govindaraj [8]). If is not applied the required temperature, moisture content can be high, which will

affect flavor and color. Optimum moisture content is 8% (Moor [9]).

Powdered spicy pepper is the product obtained by milling of mature, dried fruits of pepper (*Capsicum annum* L. var. *longum*, *grossum*, *abreuiatum*, *typicum* etc). Pericarp is finely ground with seeds. Powdered spicy peppers in our country and in many other countries have been used for a long time as a universal and irreplaceable spice, with red color and good power of coloring (Ljubisavljevic [10]). Grounded bukovec is a traditional product that is obtained from the dried spicy peppers that are grounded together with the seed, in granulation of 1,5-3 mm. Powdered spicy pepper and grounded bukovec are spices that enhance the smell and taste of food (Markovic [4]).

Powdered peppers can be: sweet, semi-sweet and hot, it is divided into three classes (extra delicacy, delicacies and ordinary red pepper), which differ in color, ash and moisture content. Peppers of extra and first class are used to getting the best quality of powdered pepper (sweet and semi-sweet). The best powdered pepper is sweet, extra delicacy, no hot, with strong intense red color and up to 8% moisture (Govindaraj [8]).

Food preserved by heating should be microbiologically stable and provide protection that will prevent from development of microorganisms (Lelieveld *et al.* [11]).

## 2. Materials and Methods

In this paper were used three varieties of spicy peppers (*horgosh*, *gorogled* and *hajaks*), originating from the vicinity of Negotino and Demir Kapija, Macedonia. The technology of production the dried pepper, grounded bukovec and spicy powdered pepper was performed at the plant for production of spicy pepper "Sika" Przhdevo, Demir Kapija.

The facility is located, adjusted and maintained in accordance with the operations that are performed in it. All parts of equipment that are coming into contact with the peppers are made of materials, permitted for use in the food industry. Manufacturing operations and food control, regularly and systematically were implemented.

The spices varieties of peppers are harvested at full technological maturity, when peppers fruits get an intense red color, which is a prerequisite for producing of spicy peppers. (Niketic-Aleksic [3]). During the purchase was performed inspection and classification of peppers, when were selected peppers that are appropriate for the variety, fully healthy and without damage, with uniform dark red color.

In order to determine quality properties of pepper, we approached to the examination of their chemical composition, whereby were determined: total dry

matter, with oven method, on 105 °C, drying up to constant weight; Kjeldahl method for proteins, Soxhlet method for fats, HPLC method for sugar, gravimetric methods for ash, at 550 °C, titrimetric method for total acids by using 0,1M solution of NaOH and titrimetric iodometric method for determination of vitamin C.

Technological process includes the following operations: receiving, inspection, storage, washing, inspection, remove waste, remove the excess moisture, cutting, inspecting, installing on perforated plates and wagons, drying, inspection, cooling and packaging.

Drying was performed in tunnel oven drier. The material for drying should be evenly distributed at perforated plates. Airflow of heated air at the tunnel oven drier is in opposite direction of the material placed on wagons. With regulators for expel of saturated air and by using with data loggers, continuously were controlled the temperature and relative humidity during drying, which is one of the most important factors for successful drying (Juhas [12]).

The temperature at tunnel oven drier was regulated automatically, and the drying process lasts 12 hours. At the beginning of drying, temperature should be lower than 80 °C for fresh pepper, so at the final stage, the drying temperature is below 60 °C. Dried peppers were cooled for a period of half an hour, at a room with controlled temperature and relative humidity.

On dried peppers were examined their chemical composition, using the previously mentioned analytical methods. Thereby were determined following parameters: water, dry matter, ash, total acids, proteins, fats, sugars and vitamin C.

In the process of producing grounded bukovec and spicy powdered pepper was used a mixture of three varieties of dried peppers (*hajaks horgosh* and *gorogled*). Technological procedure continues with: inspection of dried peppers, grinding, granulation (3-5 mm and 1.5-3 mm) and packaging. For the production of powdered spicy red pepper, after the crushing process, takes place: milling, granulation (0.25-0.45 mm) and packaging.

At mill, the seeds are finely grounded with mesocarp of pepper. During milling, grounded pepper is heated, releasing the oil from seeds, which reacts with the pigments of dried pepper, producing an intense red color (Govindaraj [8]). Grounded bukovec and powdered pepper should be stored in conditions of controlled temperature of 5-8 °C and relative humidity of 55-65%, protected from light, pests and rodents. Each finished product should be aligned with its prescribed parameters in products specifications (Lelieveld *et al.* [11]).

Grounded bukovec and powdered spicy pepper, by using abovementioned analytical chemical methods

were examined the following parameters: water, dry matter, ash, ash insoluble in HCl, by gravimetric method (using muffle oven, at a temperature of 550 °C), total acids, proteins, fats, sugars and vitamin C, ether extract, using the gravimetric method and capsanthin by using spectrophotometer. To estimate the microbiological safety were used standard ISO methods, for control of following species of bacteria: *Salmonella*, *Enterobacteriaceae*, *Clostridium perfringens*, *Staphylococcus* coagulase positive, yeasts, molds and number of mesophilic aerobic bacteria.

The presence of heavy metals was determined by using AAS (atomic absorption spectrophotometry), and by using gas chromatography was determined presence of pesticides residues, as organochlorine (lindane, aldrin, dieldrin, HCH (alpha + beta), HCB) and organophosphorus (malathion, parathion, parathion-methyl, fosalone, forate, pirimiphos-methyl, penitroton, chlorpyrifos-methyl).

Examinations of chemical composition, organoleptic properties, microbiological safety, the presence of pesticide residues and heavy metals were performed at certified accredited laboratories, at the Institute of Public Health, Skopje and at the laboratory of the Department for processing of fruits and vegetables, Faculty of Agricultural Sciences and Food, Skopje, Macedonia.

### 3. Results and Discussion

The results of examinations and comparison of quality characteristics of fresh and dried peppers (*horgosh*, *hajaks* and *gorogled*), are presented in Table 1.

**Table 1. Comparison of quality characteristics of fresh and dried peppers fruits of following varieties (*horgosh*, *hajaks* and *gorogled*)**

Quality characteristics	<i>Horgosh</i> fresh	<i>Horgosh</i> dried	<i>Gorogled</i> fresh	<i>Gorogled</i> dried	<i>Hajaks</i> fresh	<i>Hajaks</i> dried
Water (%)	88.814 ↑	9.605 ↑	88.174	9.01	86.517 ↓	8.885 ↓
Dry matters (%)	11.186 ↓	90.395 ↓	11.826	90.99	13.483 ↑	91.115 ↑
Ash (%) on d.m.	8.234 ↑	6.099 ↓	8.084	6.816 ↑	6.653 ↓	6.407
Total Acids (%)	0.177 ↓	0.953 ↓	0.212	1.162	0.276 ↑	1.381 ↑
Fats (%) on d.m.	6.38 ↓	1.797 ↓	6.824 ↑	2.328 ↑	6.623	2.131
Proteins (%) on d.m.	13.749 ↓	8.016 ↓	16.244 ↑	11.741 ↑	14.144	10.358
Fruktose (%)	4.276	17.894 ↑	4.202 ↓	14.695	4.686 ↑	13.078 ↓
Glukose (%)	3.172 ↓	14.416 ↑	3.496	12.893	4.143 ↑	11.452 ↓
Vitamin C (mg/100g)	65.236 ↓	326.926 ↑	68.427	263.744	69.038 ↑	228.645 ↓

From Table 1 may be concluded that there is a big difference in water content and total dry matter in fresh and dried peppers. Because of these differences,

there are differences in content of other chemical compounds, entering into composition of total dry matters, especially fats, proteins and ash, which are expressed through the dry matters. It can be concluded that, fresh and dried peppers from the variety *horgosh* have the highest water content 88.814% and 9.605% respectively, and the lowest dry matter content of 11.186% and 90.395% respectively.

Among fresh peppers, the variety *hajaks* is characterized by the highest content of dry matter 13.483%, with the highest content of sugars (fructose 4.686% and glucose 4.143%), total acids (0.276%) and also, the highest content of vitamin C (69.038 mg/100 g). The *gorogled* variety has the highest fat content (6.824% on d.m.) and proteins (16.244% on d.m.).

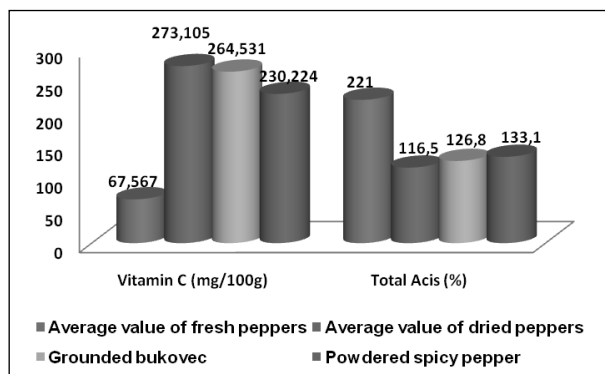
Among dried peppers, the variety *hajaks* had the highest content of dry matter 91.115%, and total acids 1.381%. The variety *gorogled* was characterized by the highest ash content (6.816% on d.m.), fats (2.328% on d.m.) and proteins (11.741% on d.m.). The variety *horgosh* was characterized by the highest content of sugars (fructose 17.894% and glucose 14.416%) and vitamin C (326.926 mg/100 g).

After the analysis of grounded bukovec and spicy powdered pepper, a comparison of quality properties was performed. The obtained values are compared with the values provided under Macedonian regulations. In Table 2 is presented a comparison of the nutritional values of grounded bukovec and powdered spicy peppers.

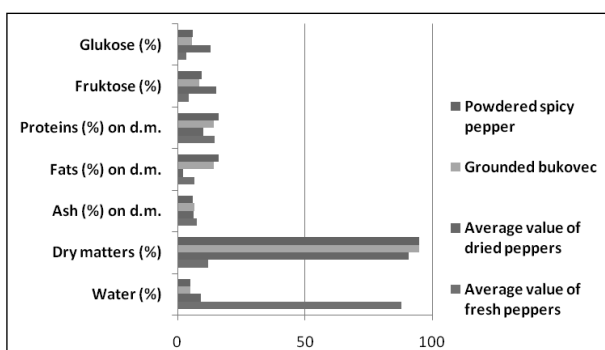
**Table 2. Comparison of nutritional composition of grounded bukovec and powdered spicy pepper**

Quality characteristics	Grounded bukovec	Powdered spicy pepper
Water (%)	4.980	5.068
Dry matters (%)	95.020	94.932
Fats (%)	13.547	15.310
Fruktose (%)	8.712	9.467
Glukose (%)	5.561	6.024
Proteins (%)	13.434	15.223
Vitamin C (mg/100g)	264.531	230.224
Total Acids (%)	1.268	1.331

From Table 2 can be concluded that there is no great difference between the nutritional value, whereby all ingredients are slightly higher in powdered spicy pepper, except vitamin C, which slightly was reduced, and the reason is the process of grinding and the instability of vitamin C on oxygen.



a) micronutrients



b) macronutrients

**Figure 1. a) and b) - Comparison of nutritional components, macronutrients and micronutrients in all stages of processing fresh pepper varieties**

From Figure 1 it can be notice how each of the peppers nutritional properties had been changing during the technological process, which takes place through the following stages: fresh peppers → dried peppers → grounded bukovec → powdered spicy peppers. Because for production of grounded bukovec and powdered spicy pepper were used a mixture of three varieties of peppers (*hajaks*, *horgosh* and *gorogled*), the values for each of the quality characteristics are taken as the mean value of the three varieties. The most notable changes in nutritional properties has between fresh and dried peppers, whereby the content of dry matter due drying had increased for 78.668%. It can be notice a large differences in fat content, between fresh and dried peppers, because of water loss during the drying process, and also between dried and ground peppers, due the presence of seeds in grounded bukovec and powdered spicy pepper, where are concentrated most of the fats present in the peppers. For micronutrients may be noted that in fresh peppers was significantly smaller amount of vitamin C (66.567 mg/100 g), while in the dried is the highest 273.105 mg/100 g. During further processing up to grounded bukovec and powdered spicy pepper, the content of vitamin C was reduced to 264.531 mg/100 g and 230.224 mg/100 g respectively, due to sensitivity of vitamin C on grounding and milling operations.

After determination of quality characteristics of the grounded bukovec and powdered spicy peppers, at the Table 3 are presented the results, and they are compared with the prescribed values for quality.

**Table 3. Comparison of quality parameters**

Product	Water (%)	Ash (%)	Ash insoluble in HCl (%)	Capsanthin (g/100g)	Ether extract (%)
<i>Grounded bukovec</i>	4.98	6.534	0.158	0.2	7.8
<i>Powdered spicy pepper</i>	5.068	5.931	0.147	0.32	8.57
<i>Delicates extra powdered spicy pepper - Delicates extra powdered *</i>	11	7	0.3	0.37	14
<i>Delicates extra powdered spicy pepper - Delicates *</i>	11	7	0.3	0.3	14
<i>Sweet red powdered spicy pepper*</i>	11	7.5	0.55	0.2	16
<i>Light red powdered spicy pepper*</i>	11	8.5	0.85	0.12	17

\*(Markovic [4])

From Table 3 we can conclude that the obtained products grounded bukovec and powdered spicy peppers are in accordance with the prescribed parameters of quality (Markovic [4]).

European quality standard of spicy pepper is regulated by Rule European Spice Associations Specifications of Quality Minima for Herbs and Spices, by which the ash content up to 10% ash insoluble in HCl content up to 2% and water content up to 11% (Markovic [4]).

Among the finished products may be noted microbiological contamination by: bacteria such as *Bacillus cereus*, *B. subtilis* and *Clostridium perfringens*, (Smith [13] and Baxter and Halzapfel [14]), yeasts and aflatoxins produced by *molds* such as *Aspergillus flavus*, *A. glaucus* and *A. niger* (Flannigan and Hui [15]). Microbiological analysis of all final products, dried pepper, grounded bukovec and powdered spicy peppers are regularly necessary to make it, in order to determine their microbiological safety.

There have been made examinations on: bacteria *Enterobacteriaceae*, *Salmonella*, *Clostridium perfringens*, mesophilic aerobic bacteria, *Staphylococcus* coagulase positive, molds and yeasts. The results from examinations indicate that the final products are in accordance with regulations (Official Gazette of R. M. No. 78/2008 [16]).

Were made examinations on heavy metals, cadmium, lead and arsenic in all final products, dried pepper, grounded bukovec and powdered spicy peppers. The

obtained values indicate that they are lower than those prescribed under the regulations (Official Gazette of R. M. No. 118/2005 [17]). According to same regulations (Official Gazette of R. M. No. 118/2005 [17]) were the values obtained during examinations of residues of organophosphorus pesticides and organochlorine pesticides.

#### 4. Conclusions

According to the performed analyzes for determining the quality properties of raw materials and final products, can be concluded:

- For the fresh peppers, the variety hajaks is characterized by the highest content of dry matter (13.483%), sugars (fructose 4.686% and glucose 4.143%), total acids (0.276%) and vitamin C (69.038 mg/100 g), while the variety gorgled has the highest fat content (6.824%) and protein (16.244%), expressed on dry matter.
- Among dried peppers, the variety horgosh, which in fresh state has the lowest content of dry matter (11.186%), during process of drying, the amount of dry matters had mostly increased, even for 79.21%, afterward has the highest value of water (9.605%), sugars (fructose 17.894% and glucose 14.416%), and vitamin C (326.926 mg/100 g). The highest dry matters (91.115%) have the variety hajaks, but the highest content of fat (2.328%), protein (11.741%), expressed on dry matter has the variety gorgled.
- It can be concluded that by process of drying, due to significant loss of water, comes to concentration of nutritional ingredients. Controlled conditions of production, temperature, humidity and time of drying, do not allow up to significant loss of nutritional ingredients, caused by caramelisation of sugars, oxidation of vitamin C and color matters.
- During production of grounded bukvecot and powdered spicy pepper, comes to reduction in the water content for about 4.1%, due to process of grounding, grinding and milling, when also comes to reduction in the content of vitamin C for 8.58 mg/100 g and for 42.9926 mg/100 g. In these products we found a significant increase in fat content, which is especially expressed in powdered spicy peppers (for about 14.042%), due to grinding the seeds, from which fats were released.
- According organoleptic analysis, it can be concluded that peppers from the grounded bukovec have typical red color, without side impurities, with a pleasant flavor and aroma. Powdered spicy pepper is with a characteristic intense red color, pleasant and typical odor, with sweet fruity aroma, pleasant characteristic taste and without the presence of foreign matters.

- By monitoring the technological processes and regular laboratory analysis, can be concluded that the obtained products and processes are designed to ensure that the final product meet the expectations of the consumer, within the prescribed expiring date and the expected use and to provide that products will meet the requirements for microbiological, chemical, physical, safety and sensory quality.

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