Original scientific paper
UDC 635.63-026.613

THE EFFECT OF TECHNOLOGICAL PARAMETERS ON LOW-SALTED CUCUMBERS COLOR CHANGE UNDER USING LOW-TEMPERATURE NON-BRINE PROCESS OF MANUFACTURE

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Abstract

Food color is an important quality parameter. The overall impression of the product is made on the basis of visual sensation. Despite the subjectivity of color perception, color determines the attitude of the consumer to the product. During the processing of raw materials, irreversible color changes occur under the influence of various factors. Therefore, the preservation of the color of vegetable raw materials is an actual problem. Also, color evaluation is a pressing issue. In the food industry, food color is often analyzed qualitatively. This does not give a complete picture of the color difference of the analyzed samples. Currently, the CIE XYZ method is an alternative to the touch method for obtaining an objective color assessment.

As a result of the research, the effect of the cooling duration and additives (salt and spices) on the change in the green color of cucumbers was established. The content of natural pigments in 10 new cucumber varieties (bred by the Institute of Vegetable and Melon-Growing of the Ukrainian Academy of Agrarian Sciences) was studied by using the spectrophotometric method. The diffuse reflectance spectroscopy method (Techkon SP-810, Germany) was used in colour examination of the samples in the 400 - 700 nm range.

It was established that the dominant wavelength is within 510 ... 560 nm, which corresponds to the green region of visible light. In addition, the duration of cooling and the presence of additives makes a noticeable effect on the color purity and brightness of cooled cu cumbers. The samples cooled in 1 hour has the highest color purity and brightness. With an increase in cooling time up to 3 hours, color purity decreases by 18% and brightness by 15% in samples of cucumbers with salt and spices and color purity decreases by 17 and brightness by 16% in samples without additives. Thus, an increase in cooling time affects the color purity and brightness of the sample.

Spectrophotometric studies have shown that the proposed method for the production of low-salted cucumbers by a low-temperature non-brine process leads to color stabilization. Recipe components for the production of salted cucumbers are defined.

***Key words**: Cucumber, Color, CIE XYZ method, Reflection spectra, Low-temperature process, Non-brine process.*

1. Introduction

Cucumber is widely used food product. It is consumed in natural form, being canned, salted, stuffed, used in salads and drinks [1, 2]. Due to the pleasant aroma the cucumbers stimulate the appetite, promote the digestion of other products and improve the activity of the digestive glands. It has potential antidiabetic, lipid lowering and antioxidant activity [1, 3].

Cucumbers from open and protected ground differ in chemical composition. The fruits from the last one contain less dry substances and sugars. It is established that cucumbers contain sugar in the range of

1.2 - 2.65%. Cucumbers also contain 0.68% cellulose as carbohydrates and a small amount of starch, pectin substances (0.24%), hemicellulose (0.1%), and lignin. Cucumber fruits are poor in mineral elements, but their specific ratio induce the high consumer properties as no other vegetables (except radish) and fruits can compete with them here. They also contain B vitamins, biotin, nicotinic and ascorbic acid [4], and a wide variety of biologically active, non-nutritive compounds known as phytochemicals such as: alkaloids, flavonoids, tannins, phlabotannins, steroids, saponins among others [5].

They contain only 3 - 5% of dry substances with the energy content of 63 kJ. Therefore, cucumber is a valuable dietary and medicinal product [6]. It is good to be consumed by people with hypertensive and hypotonic disease, heart failure, gout, people suffering from excess weight, as well as this is a food for diabetics because of the content of zinc which contributes to the pancreas activity and insulin synthesis [4]. Gill *et al.*, [7], found that the methanolic extract of *C. sativus* seeds possessed significant ulcer potential, which could be due to the antioxidant activity.

Green color of cucumbers is due to the presence of chlorophylls. Carotenoids are found mainly in the peel. However, irreversible changes in color occur in the process of canning under the action of various factors, therefore the preservation of the color of vegetable raw materials is of importance [8, 9]. Methods of canning the vegetables and fruits can be different, however, none of the existing methods of processing of cucumbers can't preserve their natural color [10]. Changes of color from green to yellow-green in different shades are associated with the enzymatic and non-enzymatic degradation of chlorophyll. This process is accelerated by high temperature, acidic environment and light [11].

In assessing the quality of processed cucumbers, their color can be attributed to the main indicator which characterize their consumer properties [12]. It has been established that the problem of obtaining a quantitative characteristic of organoleptic indicators is important and relevant. This is especially true for the food products color which is often determined by the sensory method that does not allow one to fully obtain the color difference of product samples [13]. Among instrumental methods, the CIE XYZ method can serve as an alternative, since it allows to obtain an objective color assessment [14].

Modern production techniques of cucumber products differ by raw materials and by treatment approaches allow to simulate a product of a given quality. Despite this, the new methods have several disadvantages as a long fermentation period and a short shelf life as well as the destruction of the natural color of cucumbers and the loss of quality [15]. These disadvantages form the basis for further improvement of the production technology of cucumber products with a given composition and characteristics to improve consumer properties and expand the range.

The goal of this work was to study the effect of technological parameters in the production of low-salted cucumbers in a low-temperature salt-free way, on the color changes, which can preserve the natural color of the final product and significantly increase the storage conditions.

2. Materials and Methods

The natural pigments content was established by means of spectrophotometric techniques on SF-103 spectrometer (NPKF Aquilon, Russia) on the following samples: Smak, Miranda, Slobozhansky, Parker, Xana, and new varieties as: Ajax × Senator, Hannushka × Ajax, Regina × Parker, Gunnushka × Tournament, and Miranda × Parker, grown in the fields of the Institute of vegeculture and melon-growing of the Ukrainian Academy of Agrarian Sciences (Merefa). In order to do this, the samples were homogenized, and the pigments were extracted with an organic solvent. In the extract: carotenoids, chlorophyll *a*, chlorophyll *b* were determined by means of spectrophotometric method on SF-103 spectrometer (NPKF Aquilon, Russia). Pigment content was calculated as mg per 100 g wet weight.

For the low-temperature non-salted process, the samples were washed, and with the table salt were added: currant leaves, cherries, dill greens, bay leaf, allspice, and then whole mix was packed in vacuum container and frozen at -18 ^{0}C for 30 - 180 minutes. Every 30 minutes the selected samples were defrosted at room temperature for color measurement. Fresh cucumbers were used as a comparison samples (control).

Color estimation was carried out by means of the diffuse reflectance spectroscopy on Techkon SP-810, Germany. The reflection coefficients were measured in the range of 400 - 700 nm with a step of 10 nm. To calculate the characteristics of the chromaticity, reflection spectra of the test samples were mathematically processed by digitizing the dependence of the reflection intensity on the wavelength using the Grafula 3 v 2.10 package and then by approximating the experimental points using spline interpolation. Obtained data were used for calculation the CIE XYZ parameters such as the dominant wavelength (λd), "brightness" and "color purity". All mathematical calculations necessary for calculating color characteristics were performed by MathCAD 14.0.

3. Results and Discussion

Color is the important criterion for food quality. For vegetables and fruits it is formed by natural pigments.

According to research data, it has been established that carotenoids and chlorophylls are present in new varieties of cucumbers grown in the open field (Figure 1).

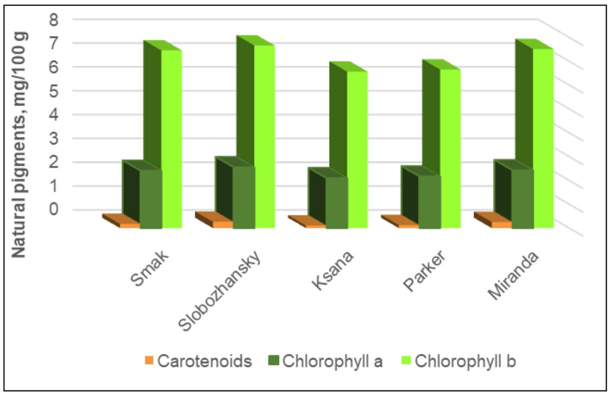

Figure 1. Content of natural pigments in cucumber varieties grown on the open field, mg/100 g

The total content of carotenoids is insignificant and is in the range of 0.109 - 0.265 mg/100 g. Chlorophyll pigment complex in cucumbers is presented by chlorophyll *a* and chlorophyll *b*. The content of chlorophyll *a*, depending on the variety, varies between 2.095 - 2.553 mg/100 g. Content of chlorophyll *b* in the studied varieties is almost 3 times higher than that of chlorophyll a: 6.562 - 7.6591 mg/100 g.

Study of natural pigments content in cucumber hybrids grown under cover has showed that the carotenoids are also found in insignificant amounts: 0.059 - 0.112 mg/100 g, but chlorophyll *b* content doesn't exceed 6.88 ± 0.36 mg/100 g (Figure 2).

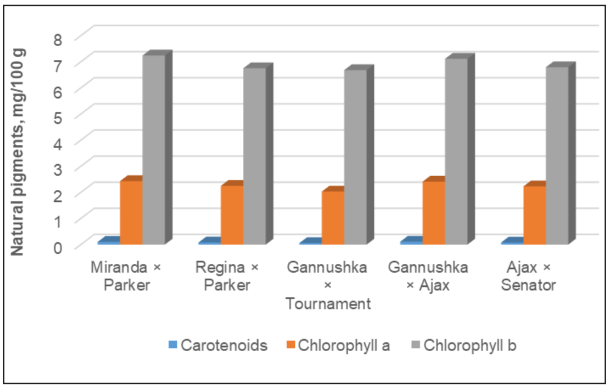

Figure 2. Content of natural pigments in cucumber hybrids, grown under cover, mg/100 g

Thus, the color of cucumbers is formed mainly due to the presence of chlorophyll *a* and chlorophyll *b* as carotenoids don't significantly affect the color of the studied samples.

Content of natural pigments allows to specify the nutritional value of cucumbers, but doesn't allow to fully determine their color which is an important indicator in assessing quality. The product must not only be of high quality but also safe. Safety is determined by the presence of toxic substances as: nitrates, toxic elements, radionuclides, mycotoxins and pesticides [16]. Our research has allowed to investigate the open ground cucumber varieties and their ability to accumulate nitrates in the following sequence: Smack> Miranda> Slobozhansky> Parker> Xana. Ranking of closed cucumber hybrids by this attribute is as follows: Ajax × Senator> Gannushka × Ajax> Regina × Parker> Gannushka × Tournament> Miranda × Parker. Obtained results show the amount of lead, mercury, arsenic, cadmium in all studied varieties and hybrids of cucumbers does not exceed the maximum permitted level.

The analysis of the obtained results by safety specs and the content of natural pigments, established that the varieties of Slobozhansky, Smak, Miranda and Miranda × Parker, Gannushka × Ajax hybrids were the best for the production of salted cucumbers.

Miranda × Parker hybrid fruits were selected to study the effect of the low-temperature non-salted method of the production of low-salted cucumbers on the color change as well as for the optimization of process parameters. Studied the fully developed fruits were: with the same length (9 - 10 cm), even, and with a dense surface of a green color.

In order to obtain the color values, they were calculated from the measured reflection coefficients. Obtained results showed the dominant wavelength (λ_d) of most samples is within 510 - 560 nm. This corresponds to the green region of visible light, since the color surface of the samples is perceived in its specific color due to the reflection of light with a specific wavelength as all other waves are absorbed. Visually, the color of the samples is estimated as green of different intensity (Table 1).

Table 1. Results of the determination of the color values of the hybrid Miranda × Parker samples

Samples	Freezing time, min	Dominant wavelength, λ_d	Color purity, %	Brightness, %
Control	0	510,7	53,91	29,07
Cucumbers with salt and spices:				
№ 1	30	527.9	63.42	38.97
№ 2	60	550.0	51.72	36.66
№ 3	90	557.5	38.93	25.25
№ 4	120	560.4	36.53	23.64
№ 5	150	566.5	38.04	24.32
№ 6	180	570.0	33.83	21.20
Cucumbers without additives:				
№ 7	30	522.1	59.08	23.74
№ 8	60	531.8	49.32	44.44
№ 9	90	550.4	38.90	25.11
№ 10	120	562.9	36.78	33.99
№ 11	150	563.5	49.83	35.12
№ 12	180	563.1	42.42	28.09

Legend: (Sr = 0.05, n = 5, p = 0.95)

Table 2. The natural pigment content in the studied samples of Miranda × Praker hybrid

Sample	Chlorophyll *a*	Chlorophyll *b*	Carotenoids
Fresh cucumber (control 1)	2.43	7.24	0.105
Low-salted cucumbers processed traditionally (control 2)	1.52	4.66	0.078
Low-salted cucumbers processed by means of non-salted low-temperature method	2.15	6.85	0.100

Legend: (Sr = 0.05, n = 5, p = 0.95)

Then the dominant wavelength of frozen cucumbers increases gradually compared with the control samples. At the same time the frozen samples with additives (salt and spice) have the higher values of λ_d compared with fresh cucumber samples. The λd value of the frozen cucumbers without additives didn't exceed 563.5 nm.

Increase of the freezing time above 90 minutes leads complete cover of a dense ice layer to the surface of cucumber samples. When defrosting, the water is released extracting various substances from leaves as the color of the extract varies from yellow to yellow-brown. The cucumbers get a brown tint, soft texture and lose their shape while pressed. Sample structure degradation can be explained by prolonged freezing. At the same time the water contained in fresh cucumbers up to 94% mainly in the free state freezes. Defrosting the ice crystals destroy the cell walls, which leads to a change in the morphological structure of the fruit and, consequently, to the deterioration of sensory characteristics, primarily appearance and body [17]. With the increase of freezing duration of samples with and without additives the "color purity" parameter gradually decreases as compared with the control ones. This is due to the fact that there is a change in the uniform green color of the samples as yellow and brown shades appear.

The "brightness" value of samples with additives is gradually reduced to 21.20% when compared with the control (38.97%). This is due to the fact that the leaves of currants, cherries, dill, bay leaf, and allspice emit tannins, which affect the color of the cucumbers skin, causing darkening. The frozen cucumber samples without additives, show an increase of this value as this is associated with the gradual destruction of chlorophyll. Thus, an increase of the freezing time affects the purity of the color and brightness of the samples.

Obtained data show that the maximum preservation of the cucumbers green color was established during the freezing with the addition of salt and spice for 60 minutes. Freezing duration for 30 minutes doesn't allow to obtain a finished salted product, since taste, smell and texture have not yet been formed although the color values are close to those of control samples.

We carried out the comparison of the natural pigments content in low-salted cucumbers obtained by low-temperature non-salted method against the control 1 (fresh cucumbers) and control 2 (low-salted cucumbers obtained by traditional technology) with the exposure at room temperature for 3 days (Table 2).

The results show that the traditional treatment of low-salted cucumbers leads to the chlorophyll *a* loss of 37.5%, chlorophyll *b* - 35.6%, and carotenoids - 25.7% which is 4 - 6 times more than with the low-temperature non-salted method.

4. Conclusions

- The color of the new varieties of cucumbers grown in open ground and hybrids of cucumbers grown under cover is formed due to the presence of chlorophylls while the content of chlorophyll *b* is almost 3 times higher than that of chlorophyll *a*. The total content of carotenoids is insignificant (0.059 - 0.265 mg/100 g) and doesn't significantly affect the color of the studied varieties and hybrids of cucumbers.

- Obtained color values of frozen Miranda × Parker hybrid cucumbers allowed to establish the optimal freezing mode as 60 minutes at -18 ^{0}C.

- It has been established that lightly salted cucumbers obtained by low-temperature, by salt-free method are as finished product with natural green color with no addition of the artificial dyes due to the preservation of natural pigments.

- New processing technique for production of salted cucumbers allows to expand the range of vegetable products with significant consumer preferences.

5. References

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