INVESTIGATION OF THE INFLUENCE OF WEATHER CONDITIONS OF THE VEGETATIONAL PERIOD FOR THE FORMATION OF THE NUTRIENT VALUE OF CAULIFLOWER

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Abstract

The influence of weather conditions of the vegetation period on the formation of the food value of cauliflower was studied.

Weather conditions of the vegetation period influenced the formation of the food value of cauliflower. More dry substances 8,4–15,5 % depending on a hybrid accumulated in a drying and hot 2017 year. The content of dry substances in heads of early ripen hybrids of cauliflower during 2015–2017 was within 6,1–10,9 % depending on a hybrid. In 2016 and 2017 there accumulated more of them. The more total content of sugars, saccharose formed in heads of cauliflower in 2015 and 2017. The content of ascorbic acid in early ripen hybrids was higher in 2015, which weather conditions in the period of ripening of heads were less drying comparing with other ones.

It was established, that the main sign-indicator is the content of dry substances that directly correlated with weather conditions of the vegetation period. The content of dry substances in heads of early ripen hybrids has a strong reverse connection with an air humidity in the period of head formation: r=–0,8 0,93, and also strong direct connections with a sum of precipitation and HTC of the vegetation period. The content of dry soluble substances has a strong reverse connection with an air humidity: r=–0,7–0,97.

There was elaborated a regression equation that helps to prognosticate the total content of sugars, saccharose, reducing sugars in cauliflower heads depending on dry soluble substances.

It was established, that the duration of the vegetation period in hybrids, studied in average for three years, was not equal and varied from 72 days in a hybrid of Livingston F1 (control) to 83 days in hybrid Kul F1.

Keywords: cauliflower, content of components of chemical composition, ascorbic acid dry substances.

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1. Introduction

The quality of vegetables is a complicated totality of parameters that determine their appropriateness for consumption fresh, processing or storage during a certain period without worsening commodity and consumption properties. The estimation of fresh vegetable products is realized by an outlook, consistence and also food and biological value, conditioned by the content of carbohydrates, vitamins, mineral substances [1].

Cauliflower contains the essential amount of vitamins, which consumption favors strengthening of the organism, increases its working capacity and resistance to harmful effects of the environment and diseases. The composition of cauliflower heads includes vitamin C (41,6–180 mg/100 g), vitamins of B group B (B_1, B_2, B_3), PP, A (0,5–1,6 mg/100 g), K (4 mg/100 g). Cauliflower also has the high content of vitamin P (22–111 mg). Its heads contain calcium (25–89 mg), iron (0,6–1,3 mg). Phosphorus and calcium in cauliflower are mainly in a form of soluble salts. Sugars are presented by glucose (1,0–2,7 % for dry substance), fructose (0,5–1,7 %) and saccharose (1,1–1,3 %), there are also xylose, maltose and raffinose in little amounts. The content of a dry substance is from 8,0 to 11,7 % [2].

The quality of fresh vegetables forms at ripening under the influence of genetic features of a variety and weather conditions, formed at planting [3].

It is known, that all biochemical and physiological changes at ripening of vegetables are conditioned by the coordinated expression of gens, connected with ripening, which encode enzymes, participating in biochemical and physiological processes [4–6].

Requirements of vegetable cultures to environmental conditions during vegetation are unequal. Especially, there are needed an increased soil humidity and moderate temperature for germination of seeds, and, on the contrary – a moderate humidity and increased temperature, sunshine – at fruiting.

The aim of the study was to analyze the influence of an average day temperature and hydrothermal coefficient of the vegetation period on the formation of components of the chemical composition of different cauliflower hybrids, to determine a dependency between the content of dry soluble substances with one of dry ones, sugars, sachharose, reducing sugars, ascorbic acid. The obtained results may be used for determining the content of certain components of the chemical composition without realizing laboratory analyses.

2. Materials and methods of the study of the influence of weather conditions of the vegetation period on the formation of components of the chemical composition of cauliflower

The flied experiments were realized at an experimental field in the Eastern part of the Left Bank forest-steppe of Ukraine at the territory of the Kharkiv district using drop irrigation. The laboratory experiments – at the department of fruit and vegetable storage of KNAU, named after V. V. Dokuchaev. The climate of the district, where these studies were realized, is moderate continental with an unstable humidification and air temperature. A soil type at the experimental field is typical chernozem, weakly washed, little-humus, heavily loamy on carbonate loess.

The studies were realized with early ripen cauliflower hybrids: Livingston F_1, Kul F_1, Opal F_1, (control – Livingston F_1), spread in Europe.

The term of planting of seedlings of early ripen hybrids is a first decade of May. The way of planting is seedlings (seedlings are planted with four-five true leaves). The way of placing of plants is ribbon with a placing scheme (40+100) ×50 cm. The density of plants is 28,6 thousand units/he. The experiments were repeated four times. The experiment is two-factor: there were studied the influence of A factor – hybrid peculiarities, B factor – conditions of the vegetation period. The area of each sowing plot is 21 m^2. The placing of variants is systematic. Accounts and observations of meteorological parameters (average day temperature, amount of precipitation, air humidity) were realized in the experiment. Commodity products were distributed in standard and non-standard ones. The content of certain components of the chemical composition: dry soluble substances; sugars: reducing ones and saccharose; ascorbic acid was determined in standard products.

The total content of sugars was determined by the photocolorimetric (ferrocyanide) method [7]. The content of saccharose was determined by the difference between the total content of sugars and reducing ones, multiplied by coefficient 0,95 [7–9].

The characteristic of the cauliflower studied hybrids:

Livingston F_1 (**Fig. 1**). The vegetation period counts 55–60 days. The hybrid has a snowhite head and the high homogeneity level in ripening. A plant is compact with the strong root system. It is fit for being realized fresh. It is recommended for planting and collecting at the beginning of summer and also by a conveyer at autumn harvesting [10].

Fig. 1. Cauliflower hybrid Livingston F_1

Kul F_1 (**Fig. 2**). The vegetation period lasts 60–65 days. The hybrid has a good snow-white head. The good self-opening is typical. The hybrid has high homogeneity level in ripening. A plant is compact. It is fit for being realized fresh. It is recommended for planting and collecting at the beginning of summer and also by a conveyer at autumn harvesting [10].

Fig. 2. Cauliflower hybrid Kul F_1

Opal F_1 (**Fig. 3**). It is intended for planting in hothouses and also for getting extremely early products in open soil under a perforated film and argofiber. It has no competitors in ripening terms (within 55 days for the moment of planting seedlings). Racemes are solid, compact, snow-white, with a mass from 0,6 to 1,5 kg. The recommended planting density – 35–40 thousand plants for 1 he [10].

Fig. 3. Cauliflower hybrid Opal F_1

Dry substances are divided in soluble and insoluble in water. The content of insoluble dry substances in fruit-vegetable products is little, in average 2–5 %. Some of them are in fact not assimilated by the human organism, but it doesn't mean that they are useless food components.

The content of soluble dry substances in cauliflower heads is from 5 to 18 %. Their summary amount is determined by a refractometer. Carbohydrates, nitrogen substances, acids, tanning and other substances of the phenol nature, soluble forms of pectins and vitamins, enzymes, mineral salts and so on are related to them. The most part of this group of compounds is presented by carbohydrates, mainly sugars [11].

A saccharose molecule is easily hydrolyzed under the influence of enzymes and water ions, creating glucose and fructose. In the technology this process is called inversion, and the mixture of equimolar amounts of glucose and fructose – inverted sugar or reducing sugars.

The content of reducing sugars in the vegetable material is determined by the interaction between sugars and copper-alkaline reagent. Copper oxide is created at that. The obtained residue was separated using filtration through a glass filter No. 3 (pores 40) or No.4 (pores 16) and dissolved in the saturated solution of ammonium chloride, heated to 35…37 °C. The optical density of the solution was determined by a spectrophotometer at wave length 590 nm and the concentration and content of reducing sugars in the vegetable material were calculated [12].

3. Results of the study of the influence of weather conditions of the vegetation period on the formation of components of the chemical composition of cauliflower

It is known, that the formation of a harvest of any culture, including cauliflower, takes place already at the initial phases of growth and development of plants and depends on many factors, included in the planting technology.

It was established, that weather conditions of the vegetation period influence ripening of cauliflower heads. 2015 may be considered as a moderately drying (HTC =0,7). In average the vegetation of period of cauliflower hybrids in average lasted 75 days. The period of mass ripening in 2015 was in the third decade of July that is by 10–15 days earlier comparing with 2016. The vegetation period of 2016 was enough provided with moisture (HTC=1,1), under such condition cauliflower hybrid plants became technically ripen in 80 days. The vegetation period of plants in 2017 (HTC=0,4) may be characterized as very drying: lack and irregularity of precipitation, air temperature constantly exceeded many year average indices. Such conditions allowed to get a cauliflower harvest in 77 days after planting seedlings.

Thus, it was established, that the duration of the vegetation period in the studied hybrids was not equal for three years of the studies and varied from 72 days in the hybrid Livingston F_1 (control) to 83 days in the hybrid Kul F_1. The duration of the vegetation period of the hybrid Opal F_1 didn't essentially differ from the control variant. Weather conditions of the vegetation period essentially influenced the formation of the cauliflower food value. More dry substances 8,4–15,5 % depending on a hybrid accumulated in drying and hot 2017. The content of dry substances in heads of early ripen cauliflower hybrids during 2015–2017 was within 6,1–10,9 % depending on a hybrid. They accumulated more in 2016 and 2017. The more total content of sugars and saccharose formed in cauliflower heads in 2015 and 2017.

Vitamin C is a strong antioxidant. A bound form of ascorbic acid – ascorbigen was detected in cauliflower vegetables. It is an indole derivative of ascorbic acid. Ascorbigen was mostly detected in young plants and their growing parts. The high content of ascorbigen is typical for representatives of the crucifer family, especially all cabbage types [17, 18].

The content of ascorbic acid was higher in early ripen hybrids in 2015, which weather conditions in the ripening period of heads were less drying comparing with other ones.

Carbohydrates are the main energetic material. Widespread carbohydrates – saccharose, fructose, glucose – are easily and almost completely assimilated by the human organism that conditions the essential role of fruit-vegetable products in nutrition. At storage of fruit-vegetable products simple saccharides are synchronously used for supporting after-harvest metabolism that becomes a cause of a changing concentration of soluble saccharides at storing vegetable products [13–16].

Based on the data bank, there was elaborated a regression equation, which can prognosticate the total content of sugars (1), saccharose (2), reducing sugars (3) in cauliflower heads depending on the content of dry soluble substances.

$$Y=-0,361x^2+2,193x+8,521, \quad (1)$$

$$Y=0,027x^2-0,653x+5,008, \quad (2)$$

$$Y=-0{,}031x^2+0{,}83x-2{,}753. \quad (3)$$

For the present methods of variation statistics are widely used at biometric studies and analysis of empirical data. Especially, bases of construction of variation series, properties of the general and partial totality of values, laws of variants distribution. The correlation and regression analysis of empirical observations play an important role [19, 20] P.V. Terentiev formulated a rule of the optimum, according to which an optimal environment must be considered as such, where the correlation of a variable group of the vegetable organism's growth with weather conditions is equal to null. The base of this method is a connection between signs, not chaotic, but by groups. Signs, included in one group are stronger connected with each other than with ones of other groups. Each group has a sign-indicator, stronger connected with other signs of own group. P. V. Terentiev denoted this phenomenon by the term correlation pleiad".

The analysis of the correlation connection between separate signs demonstrated (**Fig. 4**) that the main sign-indicator is the content of dry substances that directly correlated with weather conditions of the vegetation period. It was established that there is the direct medium connection between the content of dry substances in cauliflower heads and HTC, amount of precipitation and average day temperature r=0,62,r=0,62 and r=0,45 respectively (**Fig. 4**).

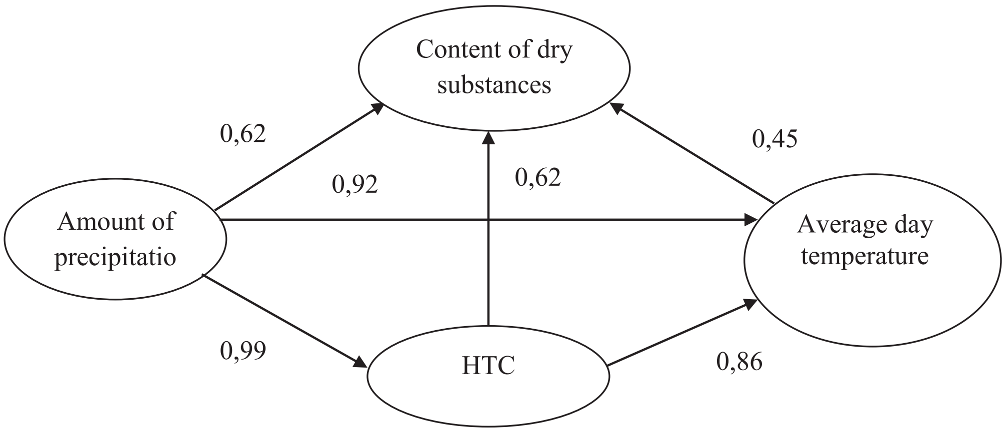

Fig. 4. Correlation pleiad of the dependency of the content of dry substances in cauliflower heads of Livingston F_1 hybrid on conditions of the vegetation period

4. Conclusions

It was established, that the main sign-indicator is the content of dry substances that directly correlated with weather conditions of the vegetation period. The content of dry substances in heads of early ripen hybrids has a strong reverse connection with an air humidity in the period of head formation: r=–0,89…–0,93, and also strong direct connections with a sum of precipitation and HTC of the vegetation period. The content of dry soluble substances has a strong reverse connection with an air humidity: r=–0,78…–0,97.

There was elaborated a regression equation that helps to prognosticate the total content of sugars, saccharose, reducing sugars in cauliflower heads depending on dry soluble substances.

Depending on the content of dry soluble substances one can prognosticate the total content of dry substances, sugars, saccharose, reducing sugars in cauliflower heads. The regression equations give a possibility to determine the content of certain components of the chemical composition without laboratory analyses. So, the research results may be used by producers for cultivating high-quality products and also in the further work for studying hybrids and varieties of any vegetable cultures, because it is impossible to cover the whole assortment in the one study.

Familiar studies have been already conducted on broccoli and Brussels cabbage, and this one is their continuation. Further prospective research directions are to combine the

studies of the influence of weather conditions of the vegetation period of cauliflower on its storage term.

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