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DEVELOPMENT OF PEANUT QUALITY CRITERIA FOR DETERMINATION OF ITS RATIONAL USE

Introduction. *The world industrial producers cultivate the four main varieties of peanuts (Spanish, Valencia, Virginia, and Runner), which have different types and subspecies, whose names may vary in some countries. These varieties differ in structure, chemical composition, nutritional and biological value, as well as in the areas of industrial use.*

Problem Statement. *At present, there is no scientific approach to the rational use of peanuts in specific technologies of food industry, which would take into account its varietal properties and chemical composition. The development of such a technique will significantly reduce the loss of raw materials, improve the quality of peanut processing products, and increase the efficiency of production.*

Purpose. *To make a cluster analysis to find ways for rational use of peanut varieties adapted for cultivation in Ukraine and to develop appropriate recommendations for the food industry.*

Materials and Methods. *Nineteen varieties of peanuts have been used in the collection of the Institute of Oilseeds of the NAAS of Ukraine (Zaporizhzhia). The cluster analysis method has been used to process the research results and to classify the peanut varieties.*

Results. *Peanut quality criteria have been developed for choosing an optimal usage (protein content and its biological value, lipid and oleic acid content, oxalate index, and content of contaminants). Depending on the usage, the peanut varieties have been classified into the three groups: for manufacturing peanut oil, for processing into peanut paste, and for manufacturing halva, chocolates, cakes, and snack products. The recommendations allow different manufacturers to choose an optimal usage and to use peanuts for producing high quality products in a more efficient way.*

Conclusions. *The developed quality criteria can be used as basis for the definition and development of the principles of rational use of peanuts given their specific properties and are useful for technologists, commodity researchers, breeders, geneticists, pharmacologists, physicians, and so on. The rational use of peanut varieties will contribute to the manufacture of competitive high-quality products and increase the profitability of enterprises.*

Keywords: peanuts, quality criteria, peanut products, and cluster analysis.

Balanced diet with essential nutrients is one of the most relevant problems of humanity in the third millennium. Nowadays, there is reported a global acute shortage of complete protein, polyunsaturated fatty acids, vitamins, mineral substances, food fibers, and other nutrients. And peanut is a very good source of these elements. Peanut fat contains about 20% of saturated fatty acids and 80% of unsaturated acids where the largest share belongs to oleic and linoleic acids [1].

Protein composition of peanut kernels is presented by glutenins and globulins, namely, arachin and conarachin. The biological value of the peanut protein is linked to the contain of essential amino-acids that are necessary for human life activity, but cannot be synthesized by the body itself. According to the literature data, the peanut protein amino-acid composition is mainly repre-

sented by such amino-acids as arginine, glycine, leucine, alanine, and methionine. Other amino-acids occur in small amounts [2].

In addition to that, peanut is a source of vitamins, minerals, polyphenols, phytosterols, and other biologically active substances, which make peanut an indispensable product for proper and healthy nutrition.

However, at the same time, peanuts contain some harmful substances having anti-nutritional and toxic effects (oxalic acid and its salts, allergens, enzyme inhibitors, nitrates, salts of heavy metals, radionuclides, and mycotoxins).

There are four main peanut varieties that are globally cultivated in agricultural industry (*Spanish*, *Valencia*, *Virginia*, and *Runner*). They have different types and subspecies. However, their names in some countries may vary. These varieties differ in structure, chemical composition, nutritional and biological value, and the areas of use.

The chemical composition of peanuts depends on variety, maturity level, location and conditions of cultivation, season, processing and storage conditions, as well as on diseases and contaminations. Since peanut is a favorite cultivar in many countries of the world, these problems have been well researched by scientists [3—5]. Unfortunately, in Ukraine, peanuts are not used to the full excent, but the crop breeders have conducted a huge job to adapt this useful cultivar for growing it on Ukrainian fields. By the way, varieties of Ukrainian selection have been recorded in the State Register.

The chemical composition of peanut beans used in Ukraine has been studied by Russian researchers [2, 6, 7] who established a quantitative ratio of the main substances in peanut varieties like *Krasnodarets 13*, *Krasnodarets 14*, *Kalina*, and *Rositsa*. The amount of amniotic shell of peanut beans for these varieties is 2.0—3.5%, moisture content in the kernel is 6.0—7.5%, protein content is 15.4—30.2%, lipids content is 48.0—50.8%, disaccharides content is 4.7—5,1%, starch content is 4.1—4.7%, fiber content is 1.3—2.3%, pectic acid content is 2.9—3.5%, pentosan content is 1.7—2.1%, and ash content is 2.0—2.2%. The lipids and proteins are mostly localized in the kernels, although the lipid complex of the shell is characterized by a high content of free fatty acids. The amino-acid composition of the proteins contains 8 essential and 10 nonessential amino-acids, which makes it closer to the that of animal albumen. The kernels contain some minerals and vitamins (B_1 and E).

Due to the rich chemical composition, peanut kernel is widely used in different sectors of food industry for manufacturing healthy nutrition products.

About 40% of the worldwide peanut crop is processed into paste (peanut butter), 20% is used for confectionery products, 10% goes for peanut oil, 10% is used for snacks, and the rest is processed into other products [8].

There are two main types of paste: a homogeneous creamy mass and a paste with added pieces of peanuts (crunchy peanut butter). Besides, this product can have different caloric value and peanut content. In general, it contains 90% of peanuts and 10% of sweeteners (sugar, honey, syrup), flavors, preservatives, emulsifiers, and/or stabilizers (hydrogenated vegetable fats), which enable to prevent its separation and to increase its shelf life [9]. Nowadays, peanut butter is very popular in English-speaking countries and their former colonies: Canada, USA, Australia, UK, South Africa, New Guinea, New Zealand, the Bahamas, the Philippines, and the Netherlands. Usually, a typical American breakfast includes peanut butter in its pure form spread on a slice of white bread or on a sandwich with jam. Also, it is widely used in baking industry as a semiproduct for manufacturing crackers and pastry products with peanut flavor.

In confectionery industry peanut is a raw material for the manufacture of chocolates, halva, caramel toppings, ice creams, oriental sweets, wafer rolls, and cakes [10—13].

Coated peanut kernels have a wide popularity worldwide. A variety of components can be used

for coating: powdered sugar, honey, dry milk, cocoa powder, caramel and so on [14—16].

As snacks, peanuts are available fried with addition of vegetable oil or deep-fat fried in a crispy shell. The composition of the shell can include flour (wheat, corn, rice), modified starches, salt, sugar, dyes, spices, fermented soy paste, antioxidants, and flavor intensifiers [17—19]. Due to its effective properties, peanut butter is widely used in cosmetics, medicine, and food industry.

Also, peanut is used as a multifunctional additive to baked goods, lactose-free milk beverages, cheese products, dairy desserts, and sweetened condensed milk products. However, the creation of poly-functional peanut products in Ukraine is quite limited and there are no benchmarks for the rational use of peanut in the specific technologies of food industry that would take into consideration its varietal properties and specific chemical composition. The solution of this problem will enable expanding the range of peanut-containing healthy foods and increasing the economic efficiency of its processing for food purposes by means of the rational use of raw materials.

The goal of our research is to find the ways of the rational use of peanut varieties adapted for the cultivation in Ukraine in food industry.

In order to solve this problem, the following tasks shall be performed:

- to systemize the results of a comprehensive research of the chemical composition and the ability of different peanut varieties to accumulate the contaminants;
- to analyze the requirements for raw materials depending on various technological purposes;
- to establish the criteria of peanut quality for selecting the usage.

Nineteen peanut varieties from the collection of the Institute of Oilseed Crops of the NAAS of Ukraine (Zaporizhzhia) (*Krasnodarets 13*, *Krasnodarets 14*, *Krasnodarskiy 14*, *Krasnodarskiy 15*, *AR 1*, *AR 2*, *AR 3*, *AR 4*, *AR 5*, *AR 6*, *UNDOC 14*,

Table 1

Characteristics of the Chemical Composition of Peanuts of Different Varieties, % ($n = 3, p \geq 0.95, \varepsilon \leq 5$)

Variety	Humidity	Protein	Fat	Sugar	Starch	Cellulose	Pectin substances	Ash
Krasnodarets 13	9.6	23.8	35	6.7	9.8	4.3	6.4	3.2
Krasnodarets 14	3.3	22.5	54	3.0	5.9	3.2	4.3	2.8
Krasnodarskiy 14	3.3	20.0	59	2.6	4.6	2.9	4.1	2.6
Krasnodarskiy 15	3.6	23.0	52	3.0	7.1	3.3	4.0	2.9
AR 1	3.0	22.5	58	4.2	3.7	2.5	2.7	2.5
AR 2	3.0	19.6	57	2.3	7.8	3.4	3.0	2.8
AR 3	3.3	22.3	53	3.8	7.8	2.8	3.2	2.7
AR 4	3.3	24.1	54	3.7	5.8	2.3	3.1	2.8
AR 5	3.3	21.9	55	3.2	6.2	2.5	4.3	2.6
AR 6	3.5	24.7	56	2.8	3.9	3.3	2.0	2.8
VNDIOK 14	6.7	24.2	48	4.1	5.6	3.2	4.6	2.7
VNDIOK 15	3.0	22.1	57	3.1	6.1	2.8	2.3	2.6
Pink Large	3.0	17.6	58	3.6	6.9	3.6	3.1	3.0
Pale Pink 1	9.4	24.2	34	8.0	9.7	4.2	6.3	3.1
Pale Pink 2	3.1	23.4	56	2.6	4.3	3.2	3.9	2.5
Pale Pink 3	3.6	21.2	54	4.5	5.6	3.5	3.8	2.8
Dark Red	3.6	26.8	54	2.0	3.8	2.9	3.1	2.9
Crimson	6.3	24.2	55	3.8	2.9	2.2	1.9	2.7
Klinsky	3.2	23.4	54	3.9	4.3	3.2	4.3	2.7

UNDOC 15, *Pink Large*, *Pale Pink 1*, *Pale Pink 2*, *Pale Pink 3*, *Dark Red*, *Crimson*, and *Klinskiy*) have been experimentally studied.

The general chemical composition of the peanut varieties adapted to cultivating in Ukraine has been studied [20—26] and given in Tables 1—4.

In order to process the information received from the research and to divide the peanut varieties by usage, the method of cluster analysis has been used [26, 27]. The general algorithm for dividing the studied peanut varieties into functionally similar groups in terms technological processing can be represented as follows. The information on the "ideal characteristics" of the groups into which the whole database must be divided has been collected and input into PC. The required number of groups is determined by the pilot analysis. Also, the data on the real performance of the varieties obtained during the research process are input. The data are to be divided into groups for the purpose of further study.

For each "ideal" representative of the group, the maximum deviation $\rho_{i,\ max}$ from the "ideal" value has been identified:

$$\rho_{i,\max} = \sqrt{\sum_{j=1}^{k}\left(\frac{a_j - \Delta_j}{a_j}\right)^2}. \qquad (1)$$

where $\Delta_j = 0.5\Delta_{j,\ \max} \times \Delta_{j,\max}$ is the maximum deviation limit of *j*-"ideal" index analyzed.

Thus, if the condition $\rho_i \le \rho_{i,\ \max}$ is met, then representative and may be included into this group for the research.

Having analyzed expression (1), one can see that the allowed value ρ_i is within limits $0 \le \rho_{\max}$. Thus, the smaller is the value ρ_i, the closer is the object of research to the aggregate of the index that is considered "ideal".

The objects studied using to the formula given above have been analyzed by the Mathcad program using the appropriate software [28].

The main constituents of peanut are fat (34—59%) and protein (17.6%—26.8%). Carbohydra-

Table 2

Peanut Vitamin and Mineral Composition, mg/100 g ($n = 3$, $p \ge 0.95$, $\varepsilon \le 5$)

Variety	Vitamins						Mineral substance						
	B_1	B_2	PP	E	β-carotene	With	Na	K	Ca	P	Mg	Mn	Fe
Krasnodarets 13	0.58	0.07	14.22	6.21	—	5.3	26	736	100.0	360	175	1.94	4.01
Krasnodarets 14	0.64	0.12	13.87	7.72	0.03	4.2	22	650	99.0	356	182	2.20	5.02
Krasnodarskiy 14	0.74	0.08	12.89	9.45	—	4.7	21	694	86.4	358	152	1.77	3.60
Krasnodarskiy 15	0.82	0.09	12.70	6.87	—	5.8	23	658	75.0	354	154	1.99	3.49
AR 1	0.75	0.13	13.67	7.88	0.02	5.3	23	660	98.0	347	174	1.93	2.18
AR 2	0.62	0.14	13.75	7.32	0.01	5.7	24	702	98.0	398	161	2,55	4.08
AR 3	0.60	0.08	13.82	6.42	—	4.9	23	656	98.0	388	178	2,02	3.90
AR 4	0.74	0.11	14.84	7.34	0.04	4.2	23	730	85.0	302	172	2.28	2,50
AR 5	0.68	0.14	14.39	7.04	—	5.6	25	732	75.0	325	172	2.07	3.25
AR 6	0.80	0.15	12.66	7.68	0.02	4.3	23	700	89.0	380	171	1.74	2.59
VNDIOK 14	0.88	0.09	13.19	6.34	0.02	5.7	20	694	102.0	386	185	2.42	4.12
VNDIOK 15	0.79	0.14	14.82	8.95	0.04	6.0	19	674	90.0	336	184	1.98	2.09
Pink Large	0.72	0.09	13.22	9.05	—	4.4	25	734	62.0	322	152	1.73	2.68
Pale Pink 1	0.60	0.10	12.41	6.00	0.05	4.2	23	722	87.0	357	180	1.76	3.21
Pale Pink 2	0.68	0.15	14.22	7.90	—	4.5	21	698	106.0	388	188	2.65	3.91
Pale Pink 3	0.76	0.13	13.20	7.66	0.01	4.0	18	705	92.9	345	170	1.69	4.02
Dark Red	0.78	0.10	13.63	7.58	0.03	5.5	20	687	86.0	333	188	2.27	3.00
Crimson	0.75	0.08	14.28	7.87	—	5.7	22	683	65.4	340	164	2.41	2.74
Klinsky	0.65	0.09	13.60	6.12	—	5.3	20	702	92.0	376	168	1.93	4.54

Table 3

Amino Acid Composition of the Protein of the Studied Peanut Samples, g/100 g protein ($n = 3$, $p \geq 0.95$, $\varepsilon \leq 10$)

Amino acid	*Krasnodarets 13*	*Krasnodarets 14*	*Krasnodarets 14*	*Krasnodarets 15*	*AR 1*	*AR 2*	*AR 3*	*AR 4*	*AR 5*	*AR 6*	*VNDIOK 14*	*VNDIOK 15*	*Pink Large*	*Pale Pink 1*	*Pale Pink 2*	*Pale Pink 3*	*Dark Red*	*Crimson*	*Klinsky*
	Essential amino acids																		
Valine	4.2	4.9	3.2	3.0	5.8	6.0	4.2	6.4	3.2	5.0	3.1	4.8	2.0	3.7	5.1	3.0	3.5	5.0	5.4
Leucine	4.6	5.3	6.5	6.1	8.9	5.4	4.2	5.8	5.4	9.3	4.9	5.4	7.4	4.3	5.1	4.4	5.1	5.7	4.3
Isoleucine	2.9	2.5	1.5	3.0	4.4	1.2	2.7	2.0	1.1	4.9	2.6	2.9	3.2	2.2	2.3	2.1	1.5	2.6	2.7
Lysine	5.3	2.5	1.3	3.0	3.5	1.6	1.5	4.6	2.7	2.2	5.0	3.9	4.0	2.7	2.3	3.4	1.8	2.3	2.7
Methionine	0.8	1.4	1.0	1.5	0.6	0.8	1.1	1.8	1.1	1.3	0.6	1.0	2.4	0.5	1.4	0.7	0.8	1.4	1.6
Phenylalanine	4.2	3.2	3.9	4.4	7.0	3.2	3.1	5.8	4.8	4.7	3.5	3.9	4.4	2.7	2.8	3.7	3.8	5.4	3.8
Tryptophan	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.0	1.0
Threonine	4.8	4.6	3.5	1.7	2.4	2.8	3.1	2.9	3.2	2.2	2.0	4.8	2.0	3.7	2.8	3.0	3.5	1.4	4.3
Total	**27.9**	**25.4**	**21.9**	**23.7**	**33.6**	**22**	**20.9**	**30.3**	**22.5**	**30.6**	**22.7**	**27.7**	**26.4**	**20.8**	**22.8**	**21.3**	**21.1**	**24.8**	**25.8**
	Nonessential amino acids																		
Aspartic acid	9.1	9.3	12.5	10.2	8.4	9.6	13.0	7.3	10.5	7.7	8.6	9.7	11.1	12.4	10.1	9.6	12.7	8.8	12.4
Serine	6.4	5.8	5.2	5.1	3.9	6.0	4.04	2.9	4.7	2.8	4.9	4.4	3.2	4.4	4.3	4.7	5.0	3.6	5.4
Glutamic acid	16.7	14.4	21.0	19.0	17.9	19.0	19.2	15.7	21.0	16.4	17.8	17.0	17.2	21.0	18.3	19.5	19.0	20.9	17.2
Proline	6.9	7.1	9.5	8.0	4.2	11.5	10.9	6.6	9.0	10.0	11.9	8.2	11.9	10.8	10.1	10.8	10.6	9.8	8.1
Glycine	9.1	7.1	6.5	5.1	7.0	6.8	7.2	6.3	6.4	4.4	6.2	6.3	6.3	6.2	5.6	6.6	7.5	6.2	5.4
Alanine	6.4	5.0	4.5	4.0	5.0	4.0	7.6	6.6	4.3	3.8	3.8	4.8	3.2	3.8	5.6	4.0	4.9	4.5	5.4
Histidine	2.3	1.8	2.6	2.1	3.9	4.8	1.5	4.6	2.7	2.2	2.2	1.9	3.2	2.5	1.7	3.0	2.2	2.6	4.6
Arginine	10.9	17.7	9.4	15.0	9.5	12.0	11.2	13.3	11.0	15.7	16.0	14.0	11.9	14.4	11.3	11.9	10.9	9.7	8.7
Cystine	1.4	2.5	2.7	1.1	1.0	1.2	1.0	1.1	1.2	1.3	1.1	2.4	1.0	1.0	3.1	1.1	1.0	1.1	2.7
Tyrosine	2.6	2.8	3.5	3.2	4.0	2.4	2.7	4.6	4.3	4.4	3.1	3.4	4.4	1.9	4.7	3.4	3.3	4.5	2.7
Total	**71.8**	**73.5**	**77.4**	**72.8**	**64.8**	**77.3**	**78.34**	**69**	**75.1**	**68.7**	**75.6**	**72.1**	**73.4**	**78.4**	**74.8**	**74.6**	**77.1**	**71.7**	**72.6**

tes are represented by mono and disaccharide (2.0—8.0%), starch (2.9—9.8%), fiber (2.2—4.3%), and pectin substances (1.9—6.4%). The moisture content is insignificant and is about 3.0—9.6%. A specific feature of the vitamin composition is a high content of liposoluble vitamin E (6.0—9.45 mg/100 g) and water-soluble B1 (0.58—0.88 mg/100 g), and PP (12.41—14.84 mg/100 g). Minerals are mainly represented by potassium (650—736 mg/100 g), magnesium (152—188 mg/100 g), phosphorus (302—398 mg/100 g), manganese (1.69—2.65 mg/100 g), and iron (2.09—5.02 mg/100 g). Also, there is a small amount of sodium and calcium. The studied varieties of peanuts are a source of phytosterols, with β-sitosterol prevailing. Also, there have been found campesterol, stigmasterol, Δ5-avenasterol, Δ7-stigmasterol, Δ7-avenasterol, and one sample had a tiny quantity of cholesterol. The total content of steroids varies between 172.7—604.6 mg/100 g and is the highest for variety AR 6. The content of phytosterols in the studied peanut varieties meets the daily value at 58—202%. Glutamic acid (14.4—21.0 g/100 g protein) prevails in the amino acid composition of the peanut protein. Methionine (1.0—3.1 g/100 g protein) and cystine (0.5—2.4 g/100 g protein) have the least share in the peanut protein. As regards the amino acid composition of the protein of the studied varieties, there has been reported a significant (3—4 times) discrepancy in the content of some amino acids (isoleucine, lysine, and threonine), which can be explained by the varietal specificity of their biochemical composition. The calculated amino acid score, its discrepancy coefficient, and the biological value have shown that the highest biological value (72—77.2%) has been recorded for the varieties *Pale Pink 1*, *Pale Pink 3*, *VNDIOK 14*, *VNDIOK 15*, and *Krasnodarets 13*. These varieties are the most balanced in amino acid compo-

Table 4

Fatty Acid Composition of the Studied Peanut Varieties fat ($n = 3$, $p \geq 0.95$, $\varepsilon \leq 10$)

Variety	Fatty acids name and content, g/100 g							
	Lauric	Myristic	Palmitic	Palmitoleic	Stearic	Oleic	Linoleic	Linolenic
Krasnodarets 13	traces	traces	1.95	0.07	0.84	15.24	12.81	0.04
Krasnodarets 14	0.05	0.25	2.50	0.10	1.29	22.09	25.10	0.05
Krasnodarskiy 14	0.09	0.22	2.69	0.11	1.42	29.44	23.73	0.06
Krasnodarskiy 15	0.06	0.30	2.40	0.10	1.25	26.20	18.10	0.05
AR 1	traces	0.70	3.85	0.12	1.39	22.79	25.65	0.06
AR 2	0.17	0.76	2.67	0.11	1.37	30.57	17.83	0.06
AR 3	traces	traces	4.20	0.11	1.27	23.87	19.89	0.05
AR 4	traces	traces	6.47	0.11	1.30	29.59	12.95	0.05
AR 5	0.39	0.14	3.65	0.11	1.32	24.74	21.08	0.06
AR 6	0.10	0.17	2.00	0.11	1.34	15.35	33.38	0.06
VNDIOK 14	traces	traces	2.88	0.10	1.15	22.63	17.49	0.05
VNDIOK 15	0.06	0.24	2.78	0.11	1.37	27.78	21.14	0.06
Pink Large	0.23	0.76	4.58	0.12	1.39	22.91	24.44	0.06
Pale Pink 1	traces	traces	2.13	0.07	0.79	14.08	12.79	0.03
Pale Pink 2	0.10	0.27	2.73	0.11	1.34	25.50	23.23	0.06
Pale Pink 3	0.10	0.33	2.85	0.11	1.30	23.05	22.63	0.05
Dark Red	0.26	1.22	8.08	0.11	1.30	25.28	14.16	0.05
Crimson	0.11	0.47	3.03	0.11	1.32	21.78	24.62	0.06
Klinsky	0.06	0.27	2.49	0.11	1.30	21.29	24.89	0.05

sition as compared with others. The main components of the fatty acid composition are palmitic, oleic, and linoleic acids, which underlie the biological value of these peanut varieties. The peanut variety *AR 2* has the largest oleic acid content (30.57 g/100 g). *AR 6* has the highest content of linoleic acid (33.38 g/100 g). The lowest content of these acids is reported for *Pale Pink 1* (14.08 g/100 g and 12.79 g/100 g, respectively).

The content of toxic substances (heavy metals salts), radionuclides of cesium and strontium, aflatoxins, and nitrates in the studied varieties of peanut is within the limits of permissible concentrations. All the studied peanut varieties are characterized by an increased ability to accumulate oxalic acid and its salts (139—252 mg/100 g) and a high oxalate index (1.5—3.7), which indicates the antinutritive properties of peanuts and limits the circle of their consumers. In order to reduce the content of toxic and anti-nutritive substances, the authors have suggested a method for thermal processing of peanuts (hydrothermal treatment for 30—40 min followed by roasting at a temperature of 120 °C, for 30—35 min), which reduces the content of oxalic acid and its salts by 67.2—76.0% and the content of copper salts by 28.8%—38.0%. Protein digestibility is raised by 20 mg of tyrosine.

To group the peanut varieties depending on the usage, the requirements for raw materials during their processing have been established:

- for oil production: the content of fat and oleic acid shall range from medium to maximum, depending on variety; the content of salts of heavy metals, radionuclides, aflatoxin B1 shall be lower than the MPL;
- for peanut butter production: the protein content shall range between medium and maximum, depending on variety; the biological value of protein shall be medium, depending on variety (the recipe of these products includes ingredients that contain protein and can improve the biological value of the final product); depending on variety, the content of salts of heavy metals shall vary from the lowest to that exceeding the MPL by 30% (inasmuch as the suggested method of heat hydrothermal therapy reduces the content of these contaminants by 28.8—38.0%); the content of radionuclides and aflatoxin B1 shall be lower than the MPL; the oxalic index shall not exceed 3.2 (during the hydrothermal treatment by the suggested method, the loss of oxalic acid reaches 67.2—76.0%, which enables to reduce the oxalic index down to ≤ 1);
- for the production of halva, candies, cakes, jelly, snacks: the protein content varies from medium to maximum, depending on variety; the biological value of protein ranges from medium to maximum, depending on variety; depending on variety, the content of salts of heavy metals shall vary from the lowest to that exceeding the MPL by 30%; the content of radionuclides and aflatoxin B1 shall be lower than the MPL; the oxalic index shall not exceed 3.2.

Table 5

Criteria of Peanut Quality for Selecting the Usage

Criterion		Production		
		oil	peanut butter	halva, candy, cakes, jelly, snacks
Protein content, %		—	22.7— 26.8	22.7—26.8
Fat content, %		53—60	—	—
The content of oleic acid, %		21.2—30.6	—	—
Biological value of protein, %		—	54—64	59.2—77.2
Oxalic index		—	1.5—3.2	1.5—3.2
Radionuclides, Bq/kg	^{137}Cs	< 70	< 70	< 70
	^{90}Sr	< 10	< 10	< 10
Salts of heavy metals, mg/kg	Zn	< 100	< 130	< 130
	Cd	< 0.1	< 0.13	< 0.13
	Pb	< 0.5	< 0.65	< 0.65
	Cu	< 15	< 19.5	< 19.5
Aflatoxin B_1, mg/kg	< 0.005	< 0.005	< 0.005	3.38

Table 6

Classification of the Studied Peanut Cultivars by Usage

Line of Use	Cultivar
Oil	*Krasnodarets 14, Krasnodarskiy 14, Krasnodarskiy 15, AR 1, AR 3, AR 5, UNDOC 15, Pink Large, Pale Pink 3, Dark Red, Crimson, Klinskiy*
Peanut butter	*Krasnodarets 14, AR-3, AR 4, Pale Pink 2, Dark Red, Crimson, Klinskiy*
Halva, candy, cakes, jelly, snacks	*Krasnodarets 13, Krasnodarsky 15, UNDOC 14, UNDOC 15, Pale Pink 1, Dark Red, Klinsky*

The content of nitrates is not taken into account since peanut is a low nitrate product and this factor is not normed.

Thereafter, for each group, the proprietary criteria have been created.

The quality criteria for selecting the peanut varieties for further processing are shown in Table 5.

Using the cluster analysis, the studied varieties have been classified depending on the usage (Table 6).

The analysis of Table data shows that among the experimental varieties *Dark Red* and *Klinsky* are universal ones. They can be used in any technology. The best varieties for oil production are *Krasnodarets 14*, *Krasnodarskiy 14*, *Krasnodarskiy 15*, and *AR 1*. The best varieties for peanut butter production are *Krasnodarets 14*, *AR 3*, *AR 4*, and *Pale Pink 2*. The best varieties for confectionery and snacks production are *Krasnodarets 13*, *Krasnodarsky 15*, *VNDIOK 14*, and *VNDIOK 15*.

Therefore, peanut quality criteria for selecting the ways of use have been developed. They are as follows the protein content and biological value, fat and oleic acid content, oxalic index, and the content of contaminants (radionuclides, salts of heavy metals, and aflatoxin B1). This has enabled to create the rational guidelines of peanut usage. The following varieties have been selected for oil production: *Krasnodarets 14*, *Krasnodarskiy 14*, *Krasnodarskiy 15*, and *AR 1*. For peanut butter production, the most suitable peanut varieties are *Krasnodarets 14*, *AR 3*, *AR 4*, and *Pale Pink 2*. *Krasnodarets 13*, *Krasnodarsky 15*, *VNDIOK 14*, and *VNDIOK 15* are recommended for confectionery and snack products. Peanut varieties of Ukrainian selection, *Dark Red* and *Klinsky* are suitable for all purposes.

This approach enables not only to determine the usage of peanut varieties adapted to cultivation in Ukraine, but also to obtain environmentally safe products of healthy nutrition with high biochemical parameters.

The created quality criteria will underlie the principles of peanut usage depending on its specific properties to be developed by specialists in various fields (technologists, merchandisers, breeders, geneticists, pharmacologists, physicians, etc.). The rational use of peanut varieties will enable manufacturing competitive high-quality products and increasing the profitability of production.

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РОЗРОБКА КРИТЕРІЇВ ЯКОСТІ АРАХІСУ ДЛЯ ВИЗНАЧЕННЯ ШЛЯХІВ ЙОГО РАЦІОНАЛЬНОГО ВИКОРИСТАННЯ

Вступ. У світовому промисловому виробництві культивують чотири основні сортотипи арахісу — 'Спеніш', 'Валенсія', 'Вірджинія' та 'Раннер', які мають різні типи та підвиди, назви яких в деяких країнах можуть варіювати. Ці сортотипи різняться будовою, хімічним складом, харчовою та біологічною цінністю, а також напрямами промислового використання.

Проблематика. На сьогодні відсутній науковий підхід щодо раціонального використання арахісу в конкретних технологіях харчової промисловості, який враховував би його сортові властивості й специфічність хімічного складу. Розробка методики дозволить значно знизити втрати сировини, покращити якість продуктів переробки арахісу та збільшити ефективність виробництва.

Мета. Використання кластерного аналізу для пошуку шляхів раціонального використання сортів арахісу, адаптованих до вирощування в Україні, та розробка відповідних рекомендацій для харчової промисловості.

Матеріали й методи. Використано 19 сортів арахісу колекції Інституту олійних культур УААН (Запоріжжя). Для обробки результатів досліджень та розподілу сортів арахісу застосовано метод кластерного аналізу.

Результати. Розроблено критерії якості арахісу для вибору напряму використання (вміст протеїну та його біологічна цінність, вміст ліпідів та олеїнової кислоти, оксалатний індекс, вміст контамінантів). Застосування їх дозволяє розподіляти сорти арахісу на три групи: для виробництва олії, для переробки в арахісову пасту, для халви, цукерок, тортів та снекової продукції. Розроблені рекомендації дозволяють підприємствам різного спрямування більш раціонально обирати та використовувати арахіс для отримання продукції високої якості.

Висновки. Розроблені критерії якості є базисом для визначення та розробки принципів раціонального використання арахісу відповідно до його специфічних властивостей та можуть слугувати технологам, товарознавцям, селекціонерам, генетикам, фармакологам, медикам. Раціональне використання сортів арахісу сприятиме виробництву конкурентоздатних продуктів високої якості та підвищенню рентабельності підприємства.

Ключові слова: арахіс, критерії якості, продукти з арахісу, кластерний аналіз.

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РАЗРАБОТКА КРИТЕРИЕВ КАЧЕСТВА АРАХИСА ДЛЯ ОПРЕДЕЛЕНИЯ ПУТЕЙ ЕГО РАЦИОНАЛЬНОГО ИСПОЛЬЗОВАНИЯ

Введение. В мировом промышленном производстве культивируют четыре основных сортотипа арахиса — 'Спениш', 'Валенсия', 'Вирджиния' и 'Раннер', которые имеют различные типы и подвиды, названия которых в разных странах могут варьироваться. Эти сортотипы отличаются строением, химическим составом, пищевой и биологической ценностями, а также направлениями промышленного использования.

Проблематика. Сегодня отсутствует научный подход относительно рационального использования арахиса в конкретных технологиях пищевой промышленности, который учитывал бы его сортовые свойства и специфичность химического состава. Разработка методики позволит значительно снизить потери сырья, улучшить качество продуктов переработки арахиса и повысит эффективность производства.

Цель. Использование кластерного анализа для поиска путей рационального использования сортов арахиса, адаптированных для выращивания в Украине, и разработка соответствующих рекомендаций для пищевой промышленности.

Материалы и методы. Использовано 19 сортов арахиса коллекции Института масличных культур УААН (г. Запорожье). Для обработки результатов исследований и распределения сортов арахиса использовали метод кластерного анализа.

Результаты. Разработаны критерии качества арахиса для выбора направления использования (содержание протеина и его биологическая ценность, содержание липидов и олеиновой кислоты, оксалатный индекс, содержание контаминантов). Применение их позволяет распределять сорта арахиса на три группы: для производства масла, для переработки в арахисовую пасту, для халвы, конфет, тортов и снековой продукции. Разработанные рекомендации позволяют предприятиям различной направленности более рационально выбирать и использовать арахис для получения продукции высокого качества.

Выводы. Разработанные критерии качества являются базисом для определения и разработки принципов рационального использования арахиса в согласовании с его специфичными свойствами и могут служить технологам, товароведам, селекционерам, генетикам, фармакологам, медикам. Рациональное использование арахиса способствует производству конкурентоспособных продуктов высокого качества и повышению рентабельности предприятия.

Ключевые слова: арахис, критерии качества, продукты из арахиса, кластерный анализ.