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OPTIMIZATION OF GROATS PRODUCTION AT PROCESSING OF SPELT GRAIN

Currently, the demand for high biological and nutritional value is increasing. This is due to popular methods of healthy nutrition distributed among consumers. The purpose of the article is to determine the optimal mode of peeling and water-heat treatment of spelt grain during the production of cereal products. The process of obtaining cereal products was simulated in laboratory conditions and included main processes of cereal production: water-heat treatment, peeling, separation of peeling products and control of finished products. Experiments were carried out in accordance with current requirements and standards. Statistical processing of the experimental results and mathematical modeling were carried out using Excel and Statistica 10.

With a probability of 95% it can be argued about the reliable and positive effect of water-heat treatment of spelt grain for the production of cereal products. The peeling duration determines the greatest impact on cereal output and the overall culinary assessment. The low temperature modes of water-heat treatment during cereal production are not able to change grain structure enough for a noticeable effect on the culinary assessment. It is proved that the peeling time causes the greatest influence on the yield. Grain moisture before peeling has less impact. The duration of softening influences the yield the least but its impact is true. The trend of the influence of grain processing parameters for polished meal was similar to the groats output. The optimum regime during cereal production should be grain moisture of 15.5–16.0%, the duration of softening for 60 minutes and the peeling time of 140 seconds. In the recommended mode, you can get a cereal product with a total culinary assessment of 8.0–8.5 points. Groats output after the specified mode was 88.6%. It has been proved by studies that moisture absorption processes of spelt grain change like moisture absorption processes of traditional wheat. This leads to the possibility of using standard equipment and technological solutions in the grain mills for the processing of peeled spelt grain. The slightest effect of the duration of softening causes the expediency of additional research on processes of cereal production at factories of different productivity to establish the economic feasibility of water-heat treatment.

Key words: *water-heat treatment, spelt wheat, peeling, culinary assessment.*

Formulation of the problem. Groats, as well as bakery products, are traditional food. Due to cereals, you can satisfy the body requirements with irreplaceable amino acids, vitamins, micro-and trace elements. The increase in the popularity of cereal products over the last decade is due to the popularization of healthy nutrition and the active development of biological plant growing. Cereal products with high fiber and non-traditional raw materials are in great demand. Despite the similarity of spelt grain to soft wheat, spelt shells are connected strongly with grains which are not separated during threshing. This necessitates the additional peeling of spelt grain. Taking into account the peculiarities of ear structure and grains, the existing modes of grain processing of traditional wheat into cereals need to be scientifically substantiated.

Analysis of recent research and publications. In the countries of Europe and the United States, in the last decade, consumers' interest in bakery, flour confectionery, pasta and cereals made of *Triticum monococcum*, *Triticum dicoccum* and *Triticum spelta* [1]. Spelt grain is important for selection and improving the quality of traditional wheat [2; 3]. The obtained hybrids give an opportunity to expand significantly the range of food products and improve their quality [4]. The use of hybridization for less commonly used wheat strains from Swiss bank of genes, in particular the ancient wheat forms, made it possible to select samples that differ significantly in terms of quality from the modern varieties. This provides an opportunity for more profound improvement of food properties of future hybrids and the management of their quality [5].

The renewal of interest in aristulated wheat is due to their high nutritional value, suitability for organic farming and the selective and genetic improvement of soft wheat. Significant interest in spelt wheat is also due to higher yields, compared with other aristulated wheat varieties. According to technological properties, spelt wheat flour is most similar to soft wheat flour. In addition, aristulated wheat varieties absorb more mineral elements from the soil, so they contain more ash than modern soft wheat varieties [6].

Bakery products made of spelt grain with the addition of spiced aromatic raw materials, in particular amaranth, have high consumer properties. It is proved that the quality of such products is high for a long shelf life (up to 6 days) [7]. The low yield of spelt grain causes a high cost of its cultivation which significantly increases the price of finished raw materials. Despite this, the population of Europe prefers this raw material, since it has proven its positive effect on the immune system of the body and there are recommendations for use in dietary nutrition [8].

The volumes of grain production in Ukraine have increased significantly. Therefore, its processing on cereal products is promising. This is due to lower material content of cereal plants compared to flour-grinding complexes, the possibility of efficient processing of grain at low productivity enterprises and lower requirements for technological properties of raw materials. Taking into account qualitative properties of spelt grain, one can develop an effective marketing strategy for a small and medium-sized grain mill.

One of the main processes of cereal production is water-heat treatment and grain peeling. During the processing of wheat grain, increasing the duration of peeling causes the gradual erosion of surface layers containing the main amount of fiber and dietary fiber. Grain moisture and softening contributes to the controlled change in technological properties with fixation at an optimum level. The positive effect of water-heat treatment during the processing of durum and soft wheat grain has been proved and corresponding processes are used in the industry [9]. The heat effect on caryopsis is interesting when using hot air conditioning. It is found that the organoleptic characteristics of cereal products can be improved as a result of roasting or steaming due to irreversible processes in the raw material as a result of such treatment [10].

The **purpose** is to determine the optimal mode of peeling and water-heat treatment during the development of spelt whole cereal. **Tasks** are to analyze the information about spelt grain; to specify the effect of moisture, the duration of softening and peeling on spelt cereal output and their quality; to substantiate the mode of processing spelt grain for cereal products.

Research materials and methods. The research was conducted in the laboratory of Department of Technology of Grain Storage and Processing of Uman NUH. Spelt grain of Zoria Ukrainy variety, grown under the conditions of Right Bank Forest Steppe of Ukraine, was used for experiments. The predecessor is full fallow. Fertilizer application is nitrogen (120 kg/ha), phosphorus and potash (60 kg/ha). Quality indicators are vitreousness (98%), grain unit (720 g/l), falling number (320 s), gluten deformation index (60 units), protein content (20%), starch (61%) and humidity (13.0 ± 0.2%). The technological scheme of obtaining cereal products in laboratory conditions was simulated in accordance with the requirements of the rules of organization and maintenance of the technological process in cereal factories [11].

Softening was carried out in metal cylinders. Peeling was on УШЗ-1 laboratory peeling machine (round speed 3000 rpm) and separation of peeling products was in РЛУ-1 laboratory sieve. Obtained products were weighed on electronic scales with accuracy of measurement to hundredths of particles.

The study was conducted in four repetitions that were randomized in time. Statistical processing of the experimental results and mathematical modeling were carried out using Excel and Statistica 10. During statistical processing, correlation and regression analysis were used. The obtained functional dependencies were checked for the absence of autocorrelation by the method of the Darbin-Watson statistics. Culinary evaluation was carried out in accordance with methods. Since the tasting evaluation can have a subjective character, an important factor is the indicator of the competence of the commission. Golubkov method with modifications was used to determine the competence of the commission.

Results of the research and their discussion. The variation of the output data of cereals was recorded as a result of grain peeling at the moisture content from 13.0 to 14.5% without water-heat treatment which was greater than the variation of the results of analytical repetitions (Coef. Var. = 0.18–1.14). Coefficients of the variation of cereal output depending on the moisture (0.61-1.74%) were smaller in comparison with coefficients of cereal variation depending on the duration of peeling (6.07–6.37%) (table 1).

Results of descriptive statistics show that the change in the duration of peeling at the moisture from 13.0 to 14.5% caused more variations in the data relative to the average number compared with the initial humidity. Sometimes the variation was less than

the variation of analytical repetitions. In addition, there was a positive tendency to increase cereal output as a result of an increase in moisture to 14.5%.

Therefore, it was advisable to investigate the effect of additional moisture and the duration of its softening on the cereal output (table 2).

Coefficients of variation of obtained samples at the moisture from 15.0 to 16.0%, the duration of softening from 30 to 120 minutes and the same peeling modes were from 0.05 to 0.79%. That is, fluctuations of the output depending on water-heat treatment were insignificant and smaller compared to the corresponding fluctuations in moisture of 13.0–14.5%. Also, output values varied to lesser degree depending on the duration of peeling (Coef. Var. = 4.7–4.9%). However, the tendency to increase the output for increasing moisture from 15.5 to 16.0% was maintained. The positive trend was due to an increase in the duration of softening.

Thus, with the help of primary statistical processing, the influence of peeling parameters on cereal output is determined. The difference in data fluctuations relative to the average value obtained with and without the use of water-heat treatment gives the possibility of the assumption of the positive impact of water-heat treatment on the production of spelt cereal products. However, variations in all cases were insignificant which makes it impossible for a reliable trend.

Table 1

Effect of moisture and peeling time on the yield of groats

Peeling time, sec	Humidity,%			
	13,0	13,5	14,0	14,5
20	94,5±0,4	94,9±0,5	95,6±0,8	96,1±0,2
40	93,8±0,4	94,2±0,2	95,0±0,2	95,8±0,3
60	93,0±0,8	93,7±0,2	94,2±0,4	95,2±0,4
80	89,5±0,5	89,8±0,4	90,0±0,4	90,8±0,5
100	86,9±0,7	87,3±0,5	89,3±0,5	90,1±0,4
120	86,2±0,5	87,9±0,5	88,1±0,5	89,0±0,7
140	83,0±0,7	83,7±0,8	85,1±0,2	86,1±0,8
160	81,9±0,5	82,1±0,4	82,8±0,3	83,5±0,7
180	79,0±0,5	79,7±0,8	80,1±0,8	81,0±0,5

Table 2

Effect of moisture, duration of drip irrigation and the length of peeling on the output of groats

Peeling time, sec	Humidity,%			Peeling time, sec	Humidity,%		
	15,0	15,5	16,0		15,0	15,5	16,0
The duration of the irrigation – 30 min				The duration of the irrigation – 90 min			
20	97,8±0,7	97,9±0,7	97,7±0,5	20	97,9±0,7	98,0±0,7	97,9±0,8
40	96,9±0,7	97,0±0,4	96,8±0,2	40	97,1±0,8	97,1±0,8	96,9±0,8
60	96,0±0,6	95,9±0,5	95,8±0,6	60	96,2±0,8	96,2±0,8	96,0±0,6
80	93,5±0,8	93,8±0,8	93,7±0,8	80	93,8±0,8	93,1±0,7	92,9±0,5
100	91,6±0,7	91,7±0,8	91,3±0,5	100	92,0±0,7	90,7±0,7	90,8±0,5
120	89,8±0,4	89,9±0,4	89,7±0,6	120	90,3±0,7	90,0±0,7	89,9±0,5
140	88,2±0,4	87,9±0,4	87,7±0,2	140	88,6±0,2	87,9±0,4	87,7±0,7
160	87,3±0,5	86,9±0,2	86,8±0,7	160	87,4±0,8	87,2±0,8	87,0±0,5
180	85,1±0,8	85,0±0,4	84,9±0,7	180	85,5±0,2	84,9±0,7	84,8±0,3
The duration of the irrigation – 60 min				The duration of the irrigation – 120 min			
20	98,0±0,7	97,8±0,2	97,5±0,3	20	97,7±0,4	98,2±0,7	98,0±0,7
40	97,1±0,7	96,9±0,4	96,6±0,3	40	96,7±0,7	96,9±0,5	96,8±0,5
60	96,3±0,7	96,0±0,3	96,1±0,7	60	95,9±0,5	96,0±0,8	95,9±0,4
80	93,7±0,8	94,1±0,7	93,9±0,5	80	93,7±0,8	92,6±0,4	92,8±0,6
100	91,8±0,4	91,3±0,6	91,0±0,3	100	91,8±0,5	91,3±0,8	91,1±0,4
120	90,0±0,3	89,8±0,4	89,5±0,8	120	90,0±0,3	90,2±0,3	90,0±0,7
140	88,4±0,7	87,9±0,8	87,7±0,8	140	87,7±0,5	87,5±0,7	87,4±0,5
160	87,0±0,7	87,2±0,4	87,0±0,4	160	87,2±0,2	86,8±0,8	86,6±0,8
180	85,3±0,8	85,1±0,3	85,0±0,3	180	85,3±0,5	84,2±0,2	84,5±0,8

In a regression analysis, the proportion of the factor's influence on the target function is conveniently determined using Pareto charts. The peeling duration had the greatest effect on cereal output since the standardized effect estimation (SEE) was 94.90521 (fig. 1).

Optimization of the cereal production process was carried out on the basis of functions 4, 5 and 6. The level of cereal output was the maximum value and, on the contrary, semolina output was the minimum one. The overall culinary estimation was at the level of more than 8 points which corresponds to the good value. The optimum regime during cereal production should be considered as follows: moisture grain content of 15.5–16.0%, the duration of softening of 60 minutes and the duration of peeling of 140 s (fig. 2).

In the recommended mode, you can get the cereal product with a total culinary estimation of 8.0–8.5 points. Cereal output under the specified mode is 88.6%. It is obvious that the importance of the influence of water-heat treatment on the parameters of cereal production will increase with increasing productivity of the plant.

Conclusions. As a result of generalizing information on spelt grain, its high biological value and safety for a person has been proved. Taking into account a number of valuable features, spelt grain is highly recommended for processing on dietary foods. Cereal production is recognized as the most competitive for the processing of small batches of spelt grain.

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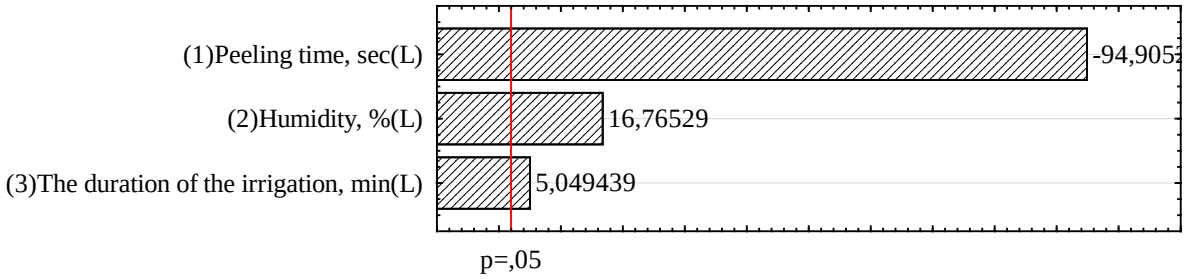

Fig. 1. Standardized Effect Estimate (Absolute Value)

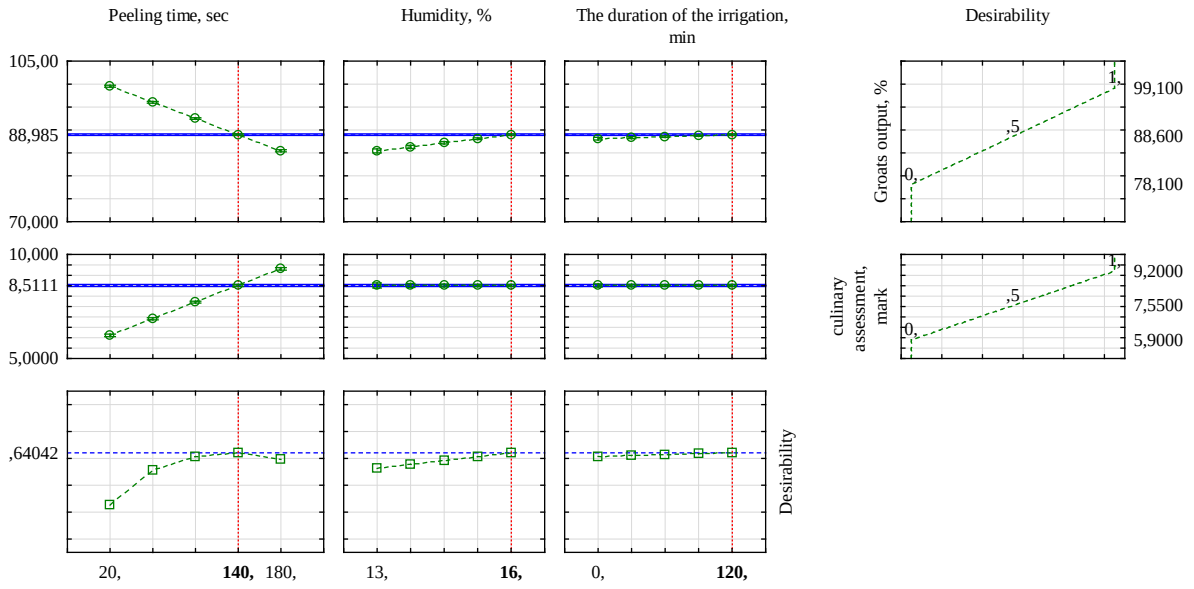

Fig. 2. Profiles for Predicted Values and Desirability

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Любич В.В., Третякова С.О., Мельник Д.С. ОПТИМІЗАЦІЯ ПРОЦЕСУ ВИРОБНИЦТВА КРУПИ ЦІЛОЇ ІЗ ЗЕРНА СПЕЛЬТИ

Нині збільшується попит на продукти харчування високої біологічної та поживної цінності. Це зумовлено популярними методиками здорового харчування, що поширюються між споживачами. Мета статті полягає у встановленні оптимального режиму лущення та водо-теплового оброблення зерна спельти під час виробництва круп'яних продуктів. Процес отримання круп'яних продуктів був змодельований в лабораторних умовах і включав основні процеси круп'яного виробництва: водо-теплове оброблення, лущення, розділення продуктів лущення, контроль готової продукції. Експерименти проводили відповідно до чинних вимог та стандартів. Статистичне оброблення результатів експериментів і математичне моделювання проводили за допомогою програми Ecxel та Statistica 10.

З ймовірністю 95% можна стверджувати про достовірно позитивний вплив водо-теплового оброблення зерна спельти під час виробництва зернових продуктів. Тривалість лущення впливає найбільший вплив на вихід зернових продуктів і загальну кулінарну оцінку. Низькотемпературні режими водо-теплового оброблення під час виробництва зернових продуктів не здатні змінити структуру зерна настільки, щоб істотно вплинути на кулінарну оцінку. Доведено, що найбільший вплив на вихід крупи зумовлює тривалість лущення. Вологість зерна перед лущенням має менший вплив. Тривалість відволожування впливає на вихід крупи із зерна спельти найменше, проте її вплив достовірний. Тенденція впливу параметрів оброблення зерна на вихід мучки була подібною до виходу крупи. Оптимальним режимом під час виробництва крупи із спельти слід вважати вологість зерна 15,5–16,0%, тривалість відволожування – 60 хв, тривалість лущення – 140 с. За рекомендованого режиму можна отримати круп'яний продукт із загальною кулінарною оцінкою 8,0–8,5 бали. Вихід крупи за вказаного режиму – 88,6%. Дослідженнями доведено, що процеси поглинання вологи зерном спельти змінюються подібно процесам поглинання традиційних пшениць. Це зумовлює можливість використання стандартного обладнання та технологічних рішень на круп'яних заводах для перероблення очищеного зерна спельти. Найменший вплив тривалості відволожування зумовлює доцільність додаткового дослідження процесів виробництва крупів на заводах різної продуктивності для встановлення економічної доцільності застосування водо теплового оброблення.

Ключові слова: *водо-теплове оброблення, спельта пшениця, лущення, кулінарне оцінювання.*