

## The potato chips and dry mashed as products of potato rational processing

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### Abstract

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**Introduction.** The percentage of potato processing for food products in the former Soviet Union decreased to 1%, at the same time in some countries of Europe and the USA the share of potato processing is 60-80%. Numerous works have shown the economic feasibility of potato processing for food products.

**Materials and methods.** In laboratory and industrial conditions of the open stock company «Mashpishcheprod» (Maryina Gorka, Minsk region, Belarus) researches have been conducted on increase of efficiency of technological processes potato processing. Sampling, preparation and conducting of tests were performed by standard and special methods of analysis.

**Results and discussion.** Potato varieties suitable for the production of dry mashed potatoes and potatocrisps have been determined, acclimatization before processing ensures minimum the content of the reducing sugars, which provide high quality of the finished product. Studies have shown that the process of kneading potato at temperatures close to cooking temperature is optimal, in which the process of destruction cells is hardly taking place. Pneumatic dryers for drying boiled potato provide high product quality due to the low temperature of heating and short contact of a powdered product with a drying agent. However, the contents of damaged cells in the finished product do not exceed 1.3-2.6%. The optimum modes and parameters of potato crisps production have been defined, the processes of cutting, blanching, treatment with salt, drying and roasting have been scientifically grounded, that provide a finished product with fat content not more than 27.7%.

**Conclusion.** Economic expediency of processing the following varieties of potato Desire, Temp, Synthesis for dry mashed potato and potato crisps has been proved. The processes of kneading and drying potato are decisive stages of the processing, because they determine the number of destroyed cells in the finished product. Optimal parameters of production technology of potato crisps have been scientifically grounded.

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## Introduction

Condition of industrial potato processing in Eastern Europe is very deteriorated. Percentage of potato processing decreased to 1%. In Europe and the U.S. part of the potato processing is 60-80%, and the range of potato products increased from 10-15 to 28-30 titles. Common potato products are dried mashed as granules and chips from fresh potatoes. Scientific development of food production of potatoes showed the economic feasibility of potato processing primarily on chips and dried mashed potatoes.

The advantages of potato processing:

- Improving the nutritional value
- Elimination of losses during storage of potatoes
- Reducing containers for storage and transport
- Rational use of waste
- Improvement of working conditions

## Materials and methods

In laboratory and industrial conditions of the open stock company «Mashpishcheprod» (Maryina Gorka, Minsk region, Belarus), where these products are produced, studies have been conducted to refine the scientific and practical fundamentals of technologies of dry mashed potato and potato crisps.

Sampling, preparation and conducting of tests were performed by standard and special organoleptic, physical and chemical and microbiological methods of estimation and the analysis of properties of raw materials and finished products. Starch content has been determined by Evers' method, maintenance of the common and reducing sugar by Bertran's method; fatty acid composition of vegetable oils – by the method of gas chromatography. Mass fraction of fat in potato crisps has been determined by the chromatography method, the contents of protein – Kjeldahl's method.

The obtained results of the research have been described by the arithmetic mean value, which has been determined from the three parallel experiments under 3...5 times repetition of the measurements. The experimental data have been processed by the methods of mathematical statistics using standard computer programs.

## Results and discussion

For the experiments widespread potato varieties of Belarusian and Ukrainian selection with the following physical and chemical parameters of quality [1] have been selected. They are presented in table 1.

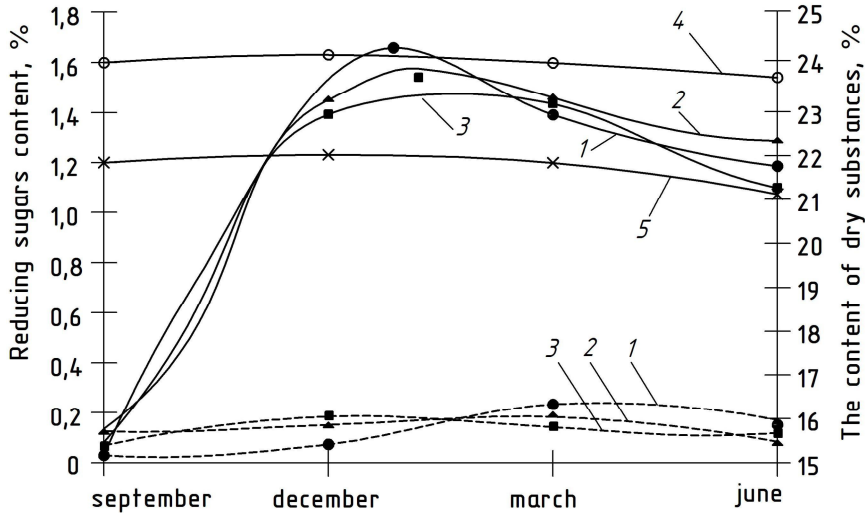
**Table 1**

**Indicators of the quality of potato varieties**

Potato varieties	The content of dry substances, %	Starch content, %	Reducing sugars content, %
Synthesis	23,8±0,1	21,2±0,5	0,10±0,02
Desiree	22,1±1,0	21,0±0,5	0,13±0,03
Temp	21,5±0,1	20,5±0,5	0,12±0,03

These varieties are the most suitable for the production of dry mashed potato and crisps due to their orbicular-oval shape, shallow groundwater buds on the surface of the lower content of reducing sugars and high solids content.

It has been established that intensive assimilation of reducing sugars occurs during the storage, especially at low temperatures and the nature of assimilation of reducing sugars in the tubers at a temperature of 2...4°C has clearly expressed varietal peculiarity [2] (Fig. 1).



**Fig. 1. The character of changes of dry substances and reducing sugars in the tubers during storage:**

**Reducing sugar:**  
 — storage temperature 2...4 °C  
 - - - storage temperature 6... 8 °C  
**Dry substance:**  
 4 - Synthesis; 5 - Temp  
 Varieties: 1 - Synthesis; 2 - Desiree; 3 - Temp

The modification of the contents of reducing sugars in potato after acclimatization for 25 days after its cold storage has been investigated (table 2), while the content of reducing sugars in potato greatly reduces. Therefore acclimatization should be not less than for 20 days at a temperature of 15...20°C, regardless of potato varieties that provides the minimum content of the reducing sugars, the most acceptable for processing. After conducting acclimatization all subjects potato varieties provide good quality products (table 3). The quality of fried products has been determined on a scale.

**Table 2**

**Changes of reducing sugars content in the tubers and the quality of potato crisps during acclimatization**

Variety	Duration of acclimatization, 24 hours									
	0		10		15		20		25	
	%	mark	%	mark	%	mark	%	mark	%	mark
Synthesis	0,54	3,7	0,40	4,0	0,23	4,8	0,12	7,1	0,12	7,1
Temp	0,57	3,5	0,41	3,9	0,24	4,7	0,14	6,9	0,13	6,9
Desiree	0,48	4,0	0,38	4,1	0,21	5,0	0,17	6,5	0,17	6,5

**Table 3**

**Impact of acclimatization on the content of reducing sugars in the tubers and the quality of potato crisps depending on the variety and period of storage**

Variety	September		Storage temperature 2...4° C					
	Reducing sugars content, %	Quality of potato crisps, mark	After acclimatization					
			Reducing sugars content, %			Quality of potato crisps, mark		
			<i>December</i>	<i>March</i>	<i>June</i>	<i>December</i>	<i>March</i>	<i>June</i>
Temp	0,12±0,05	8,0	0,14±0,02	0,14±0,03	0,16±0,02	6,2	7,2	7,2
Desiree	0,13±0,04	7,9	0,17±0,02	0,17±0,01	0,16±0,02	6,0	6,5	8
Synthesis	0,10±0,02	8,7	0,12±0,02	0,14±0,02	0,15±0,01	6,7	7,3	6,7

It is seen from table 3 and figure 1 that the character of change in the tubers of reducing sugars when  $t = 2-4^{\circ}\text{C}$  has varietal characteristics, but the content of dry substance does not depend on the length of storage and depends on the source of their content in the tubers. Increase in the content of dry substances in potato of 1% increases the profitability of processing of 10-20%. In addition, potato should have an insignificant quantity of reducing sugars (not more than 0.25) and a property not to collect them during prolonged storage of tubers. High content of sugars causes a decrease in the quality of the finished product as a result of leaking melanoid reactions between reducing sugars and amino acids. This forms dark-colored substances that cause darkening of the product, deterioration of its taste, being boiled soft, swelling. The researches concerning the determination of the number of destroyed cells potato tubers have been made to clarify the scientific and practical basis for the technology of potato processing into dry mashed potato. Received data are displayed in table 4.

**Table 4**

**Cell destruction of mashed potato during the processing of tubers in different ways**

Stages of the technological process	Number of destroyed cells, %
Blanching	0,1-0,2
Cooking	0,1-0,2
Kneading at different temperatures 80 ° C 40 ° C 20 ° C 10 °	2,1 11,8 32,5 37,8
Drying on contact monorolled dryers	4,5-5,0
Air conditioning of the product with the 2-stage pneumatic dryer	0-0,1

Microscopic examination of tissue boiled potatoes [3] and the data from table 4 have shown that large swelling of corn starch completely filled the cells and all the walls of the cells remained intact (whole) after cooking. Potato research, kneaded at temperatures close

to the temperature of boiling, suggests that the division of cells is easy and damage to cell walls is insignificant. However, with decrease in temperatures during the kneading, the process of cell destruction increases. So, lowering the temperature of kneading with from 80° to 10° C has caused 18 times increase of the percentage of destroyed cells from 2.1 to 37.8.

The most important for obtaining high-quality dry mashed potato plays drying, when it is unacceptable to change the color of the product and its natural organoleptic properties which may occur at the interaction of amino acids and sugars, and a drying agent should have a temperature at which caramelization and destruction of potato cells would not happen. Various methods are used for drying mashed potato, but in recent year two main methods of drying are used: drying on contact monorolled dryers and air conditioning with the pneumatic dryer. A great advantage of using pneumatic dryers is obtaining a high quality product, which is achieved due to the low temperature of product heating and short contact of the powdered product with a drying agent, the possibility to adjust the temperature and the duration of the process. The number of destroyed cells on monorolled dryers is 5.7-7.4 %, and pneumatic is only 0-0.1 %, which affects the quality of the finished product (table 5).

Table 5 shows that the use of pneumatic dryers with soft modes of drying and conducting air conditioning of the product provides the obtaining of a dry mashed potato in the form of granulate, which favourably differs from the flakes on the duration of the recovery, bulk density, the number of destroyed cells that express the stickiness of the product, as well as the amount of liquid that is added for the recovery.

**Table 5**

**Comparative indicators of quality of dried mashed potato**

Name of indicators	Product characteristics	
	Flakes	Granulate
Exterior view	Dry bulk product in the form of plates	Dry bulk powder product
Consistency of reconstituted mashed	Homogeneous characteristic of mashed potatoes, expressed stickiness	Homogeneous characteristic of mashed potato, without the expressed stickiness
Duration of recovery, min	2-3	1-2
Bulk density, g/dm <sup>3</sup>	200-300	700-800
Size of particles, mm	0.8-10,0	Not more than 1.0
The quantity of liquid in one part by weight of dry product, parts by weight	4,0-4,5	5,5-6,0
Number of destroyed cells, %	5,7-7,4	1,3-2,6

While studying the quality of potato crisps, the influence of water temperature that was supplied to the cutting process, has been studied. It has been established that with increase of water temperature the surface petals potato becomes smooth, oil absorbing ability decreases, they evenly absorb oil, and the resulting product has on the whole the surface of the same color and a pleasant taste. Oil absorbing ability decreases as largely retained the integrity of cells unlike petals with a rough surface. The optimum water temperature is 45... 50°C.

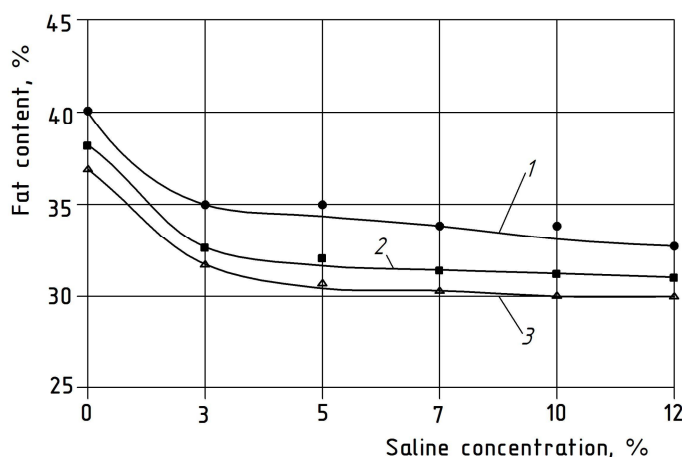
Petals were washed and blanched to improve the quality of finished products. Blanching was a minute processing of petals potato with hot water. It should not give stickiness to the product, and it is necessary to reduce the content of reducing sugars and inactivation of enzymes that contributes to the quality of fried products. In our case a blancher does not perform technological functions as during the production of dry mashed potato, where the blanching process takes place within 10...20 minutes and is required for the hydration of starch grains. [4]

While studying the process of osmotic dehydration it has been shown that with increasing concentration of salt solution there is an increase in the number of dry substances in the wings of a potato and reduction of fat in the potato crisps.

So, during the process of osmotic dehydration of aqueous solutions of salts from 3 to 12% of the amount of dry substances increased from 18.5 to 22.3% (potato variety - Temp, 10.8 cm). The fat content in the final product significantly reduced: from 35.8% to 31.2% (Fig. 2).

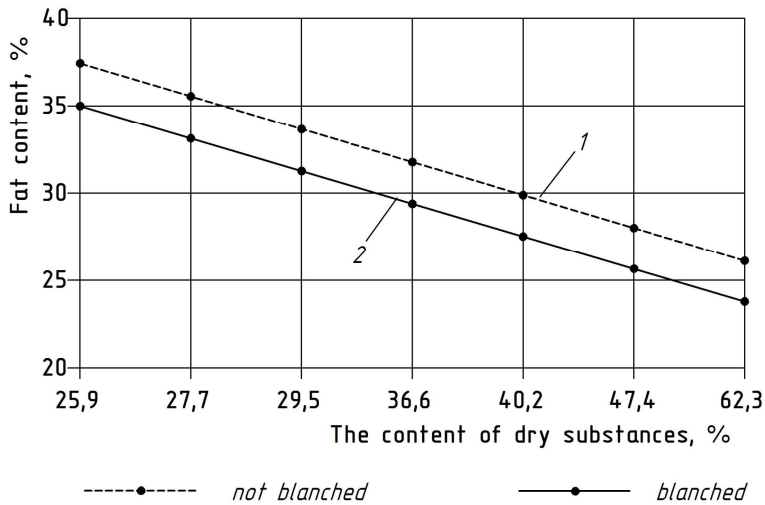
Studies have shown [5] that the salt concentration 3...5% and the content of dry substances in potatoes is not less than 21.5% a finished product had a taste satisfying the degree of salinity. For receiving high-quality potato crisps, it is necessary to apply petals of potatoes by successive processes of blanching at a temperature 78-80°C for 1...2 minutes and osmotic dehydration in the salt solution with the concentration of 5% for 10 minutes.

The influence of dry substances produced by the petals of the potatoes on the quality of potato crisps has been studied. Achieved in the process of drying the increase in the content of dry substances in the petals of potatoes ensures the reduction of fat in potato crisps (Figure 3). For example, the finished product made from potato variety Synthesis, fat content decreased from 35% to 24.2% with increase in the contents of dry substances from 25.9 to 62.3%, respectively.



**Fig. 2. The influence of the process of osmotic dehydration on the fat content in the petals of potato crisps with the specific surface 10.8 cm:**

1 – potato variety - Synthesis; 2 - potato variety - Desire; 3 - potato variety - Temp



**Fig. 3. The influence of the content of dry substances in the petals of potato crisps on the fat content (potato variety - Synthesis, the specific surface 14,1 cm):**  
1 - not blanched; 2 - blanched

The optimum content of dry substances in the petals of potato while drying is from 37 to 40%, which provides high quality of the finished product. At the higher content of dry substances (not more than 40%) potato crisps get tough and burnt edges appear on the surface (Table 6).

**Table 6**  
**The impact of drying process of blanched petals of potato on the indicators of quality of the finished product**

Specific surface area, $cm^{-1}$	Drying time, min	Content of dry substances, %	Quality of potato crisps, mark	
			Desire	Synthesis
14,1	0	22,0±1,4	8,3	8,4
	30	25,7±1,2	8,2	8,4
	60	29,7±1,2	8,2	8,3
	90	36,9±1,4	8,0	8,3
	105	40,2±0,9	8,0	8,3
	120	49,7±1,3	6,9	6,8
	150	62,0±1,3	5,6	5,5
10,8	0	22,2±1,4	8,3	8,2
	30	28,7±1,2	8,2	8,0
	60	32,1±0,8	8,0	8,0
	90	36,8±1,1	8,0	8,0
	120	40,0±1,4	8,0	8,0
	150	44,0±1,4	6,9	6,9
	180	61,0±1,3	5,8	5,7

It should be noted that the optimal content of dry substances during drying the petals of potato is guaranteed if the duration of this process is within 105...120 minutes. For intensification of the process of drying a consistently dryer was used in a vibro-boiling layer and then the belt conveyor dryer was used, reducing the time of drying up to 20..30 minutes.

As a result of mathematical processing of experimental data on the influence of specific surface and oil temperature on the fat content in potato crisps, cooked potato variety Desiree, the following equation has been received:

$$y_2 = -70,29 + 9,12 \cdot X_1 + 0,72 \cdot X_2 - 0,1 \cdot X_1^2 - 0,03 \cdot X_1 \cdot X_2,$$

Dependences for other varieties of potato have been received in the same way.

After organoleptic evaluation of the obtained samples of potato crisps by appearance, colour, smell, texture and taste, it has been established that high product quality is provided at frying pieces of potatoes, the specific surface of which is 10.8. ..14.1 cm. These petals have thickness of 1.5...2.0 mm and the straw has section of 3.0-4.0x4.0 mm. When the thickness of the petals is less than 1.5 mm – excessive accumulation of oil in the product takes place during frying because of the increase of the specific surface of slices of potato, and when the thickness is 2 mm –high quality of the finished product is not ensured (roasted product has burnt edges, soft middle).

A roasting oven was used for frying the product, where thermal oil was used to heat the vegetable oil as the heat carrier agent, which distinguishes it from the roasting oven, where the heat of vegetable oil is made directly with electric heaters.

Optimum temperature for roasting is  $145-150 \pm 1^\circ\text{C}$  for 3-3.5 min.

Unlike traditional technology in the developed technology of production of potato crisps the processes of cutting, blanching, processing with salt, drying and roasting have been scientifically justified, that provided the finished product with high organoleptic and physical and chemical indicators (Table 7). So the colour of the product is evenly golden instead of uneven yellow, and the fat content of the product has decreased from 34.2% to 27.7%.

**Table 7**

**Technological processes of potato crisps production**

Traditional technology	Developed technology
<ul style="list-style-type: none"> <li>• Cutting potatoes on the petalsthickness of 1.5 mm with water supply <math>t=10...20^\circ\text{C}</math></li> <li>• Separation of little things</li> <li>• Rinsing</li> <li>• Air drying</li> <li>• Roasting at <math>t = 140... 170^\circ\text{C}</math> for 4..7 min when vegetable oil is heated by electric heaters</li> </ul>	<ul style="list-style-type: none"> <li>• Cutting potatoes on the petalsthickness of 1.5.. 2 mm with water supply <math>t =45...50^\circ\text{C}</math></li> <li>• Separation of little things</li> <li>• Blanching in water <math>t = 80^\circ\text{C}</math> for 1..2 min</li> <li>• Keeping in 5% salt solution, within 10</li> <li>• Drying with hot air <math>t=80^\circ\text{C}</math></li> <li>• Roasting at <math>t =145..150^\circ\text{C}</math> for 3..3.5 min when thermal oil is used as a heat carrier agent for heating vegetable oil</li> </ul>



## Conclusion

1. Economic expediency of processing the following varieties of potato Desire, Temp, Synthesis for dry mashed potato and potato crisps, which are most suitable according to the content of dry substances (20-24%) and reducing sugars (0.1-0.2%) has been proved. The character of changes in the tubers of reducing sugars when stored at 2-4°C, which has varietal characteristics, but the content of dry substances does not depend on the length of storage and depends on the source of their content in the tubers has been determined. For a high quality product all varieties of potato before processing should be necessary subject to acclimatization within twenty days at a temperature of 15-20°C.
2. It is established that the consistency of dry mashed potato depends on the changes faced the starch of potato in the technological process, and the process of kneading potato - the decisive stage of the processing, because it determines the degree of cell division of boiled potato and the number of destroyed cells. Lowering the temperature of the kneading process increases the destruction of the cells in 18 times that due to the strong stretching of the cell walls of the starch with additional mechanical loads in connection with cooling of the product. Air conditioning with pneumatic drying of mashed potato provides a high quality product by the number of damaged cells, recovery, stickiness, which makes the consistency of the product soft and crumbly.
3. Optimal parameters of production technology of potato crisps have been scientifically grounded. It has been scientifically based that cutting potato on the petals of a specific surface 10.8... 14.1 cm with water supply at a temperature of 45...50°C, processing petals potato before frying, including blanching with water at 80°C for 1-2 minutes, osmotic dehydration in aqueous solution of sodium chloride concentration of 5% for 10 minutes and drying with hot air to the content of dry substances 37...40%, frying oil temperature of 145...150°C duration 3...3.5 minutes, that ensure the high quality of the finished product while reducing the oil content in the product from 34.2% to 27.7%

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