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INFRARED DRYING IN TECHNOLOGY OF DRIED FRUIT FROM MACROCARPOUS PURPLE CHERRY PLUM

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The application of infrared drying in the technology of production of dried fruit from macrocarpous purple cherry plum has been described in the paper. The employment of large-fruited purple cherry plum as the main raw material of the Turkestan region in the production of dried fruits has been scientifically substantiated. Analyzes of large-fruited purple cherry plum have proved the need of infrared drying for production of dried fruit. The technology of dried fruits from large-fruited red-violet cherry plum has been developed. Infrared drying was carried out in one stage at a temperature of 40-60°C for 5-6 hours when the moisture content of the dried cherry plum reached 15-16%. Samples of a valuable and healthy dried fruit from a large-fruited purple cherry plum with an improved appearance and a high content of useful macro- and microelements have been obtained. The developed technology will expand the assortment of dried fruit.

Key words: infrared drying, cherry plum, chemical composition, technology, dried fruit, fruit, safety.

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АЛШАНЫҢ КЕПТІРІЛГЕН ЖЕМІСТЕРІН АЛУ ТЕХНОЛОГИЯСЫНДАҒЫ ИНФРАҚЫЗЫЛ КЕПТІРУ

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Мақалада ірі жемісті күлгін алшаның кептірілген жемістерін өндіру технологиясында инфрақызыл кептіру әдісін қолдану сипатталған. Түркістан облысының кептірілген жемістер өндірісінде негізгі шикізаты ретінде ірі жемісті күлгін алшаның пайдалануы ғылыми тұрғыдан негізделді. Ірі жемісті күлгін алшаның талдауы инфрақызыл кептіру арқылы кептірілген жемістерді өндіру қажеттілігін негіздейді. Ірі жемісті қызыл-күлгін шие қара өрігінен кептірілген жемістер технологиясы жасалды. Инфрақызыл кептіру бір кезеңде 40-60°С температурада 5-6 сағат бойы кептірілген алшаның ылғалдылығы 15-16% жеткенге дейін жүргізілді. Сыртқы түрі жақсартылған және пайдалы макро- және микроэлементтердің жоғары мөлшері бар ірі жемісті күлгін алшадан

құнды және пайдалы кептірілген жемістердің үлгілері алынды. Жасалған технология кептірілген жемістердің ассортиментін кеңейтеді.

Негізгі сөздер: инфрақызыл кептіру, алша, химиялық құрам, технология, кептірілген жеміс, жемістер, қауіпсіздік.

ҚАРЖЫЛАНДЫРУ ТУРАЛЫ АҚПАРАТ: зерттеулер Қазақстан Республикасы Білім және ғылым министрлігінің AP0885596 (2020-2022) гранттық жобасының шеңберінде жүргізілді.

ИНФРАКРАСНАЯ СУШКА В ТЕХНОЛОГИИ СУХОФРУКТОВ ИЗ АЛЫЧИ КРУПНОПЛОДНОЙ ФИОЛЕТОВОЙ

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В статье описано применение инфракрасной сушки в технологии производства сухофрукта из алычи крупноплодной фиолетовой. Научно обосновано использование алычи крупноплодной красно-фиолетовой как основного сырья Туркестанской области в производстве сухофруктов. Приведенными анализами алычи крупноплодной фиолетовой обоснована необходимость производства сухофрукта методом инфракрасной сушки. Разработана технология сухофруктов из алычи крупноплодной красно-фиолетовой. Инфракрасная сушка была произведена в один этап при температуре 40-60°С 5-6 часов при достижении влажности высушенной алычи 15-16 %. Получены образцы ценного и полезного сухофрукта из алычи крупноплодной фиолетовой с улучшенным внешним видом и высоким содержанием полезных макро и микроэлементов. Разработанная технология позволит расширить ассортимент сухофруктов.

Ключевые слова: инфракрасная сушка, алыча, химический состав, технология, сухофрукт, плоды, безопасность.

ИНФОРМАЦИЯ О ФИНАНСИРОВАНИИ*:* исследования проведены в рамках грантового проекта AP0885596 (2020-2022) Министерства образования и науки Республики Казахстан.

Introduction

One of the main directions in the development of the fruit growing industry is to increase the production of fruits in order to provide the population with high-quality fruit and berry products year-round [1, 2]. In this regard, a large role is given to the storage and processing of fruits [3]. In human nutrition, fruits play an important role and are an essential part of a healthy diet. They regulate biological processes in a body and contribute to its normal functioning. The main nutritional and medicinal value of fruits is in their rich chemical composition.

Infrared drying provides perfect fruit dehydration by means of infrared rays, consumes less amount of energy and preserves the beneficial properties of fresh fruits [1]. Therefore, the task of investigation is to develop a technology for production of dried fruit from macrocarpous purple cherry plum by infrared drying.

Nowadays fruit products must meet high requirements. In food industry it is recommended to apply well-transportable and storable large-size bright colour fruits with pleasure taste and preservation qualities. Chemical composition of fruits determines the suitability of fruits to preservation [1].

Materials and Research Methods

The objects of research are large-fruited purple cherry plum, its dried fruit and technology for obtaining dried fruit.

Experimental studies have been carried out in the research regional laboratory for product testing (Shymkent, Kazakhstan), in the laboratories of the Department of Food Engineering of M. Auezov SKU (Shymkent, Kazakhstan).

Analysis and selection of dried fruit technology was carried out according to scientific and literary sources. The modes of technology for obtaining dried fruit from large-fruited purple cherry plum were worked out on the basis of LLP "InnovTechProduct" (Shymkent, Kazakhstan), in the laboratories of the Department of "Food Engineering" of M. Auezov SKU (Shymkent, Kazakhstan).

Determination of amount of ash residue was carried out according to GOST 26929-94. Determination of content of macro- and microelements was carried out by the method of atomic absorption. The results obtained were processed by generally accepted statistical methods used in the evaluation of laboratory data with determination of Student's and Fisher's criteria [5].

Fat content was determined according to GOST 8756.21-89. The amount of fat was determined by extraction method. The method consists in washing out fats with a solvent. Next, the difference between the masses of a dry flask and a flask after extraction with a fat content was determined [6].

Content of carbohydrates was determined according to GOST 8756.13-87 by polarimetric method based on property of carbohydrates to rotate the plane of polarization of polarized light [7].

Determination of content of dry substances was carried out according to GOST 28561-90 by thermogravimetric method. Dried fruits were crushed in a laboratory mill by passing twice through a grate with a minimum hole diameter so that the particle sizes of the individual components of the product did not exceed 1.5 mm [8].

Main part

Results and their Discussion

Macrocarpous purple cherry plum grows widely in the south part of Kazakhstan. Therefore, it was interesting to determine the chemical composition of cherry plum in order to understand the possibility of using it in the production of dried fruits. The results of experimental studies of chemical composition of large-fruited purple cherry plum are summarized and presented in the table (Table 1).

Table 1 - Chemical composition of macrocarpous purple cherry plum

Content, g	Macrocarpous purple cherry plum
Fats	0,1
Proteins	0,2
Carbohydrates	9,7
Water	89,5
Ash	0,5

From analysis of the table data, we can note the beneficial properties of cherry plum. Obtaining of dried fruit from it will expand the assortment. Therefore, it is necessary to develop a technology for the production of dried fruit from cherry plum. Our choice was infrared drying. Infrared drying is characterized by efficient using of energy costs and preservation of useful properties of the finished product in comparison with convective drying.

Technology for production of dried fruit from macrocarpous purple cherry plum is provided below. Cherry plum, after acceptance procedure, is submitted to intermediate store. Cherry plum through the storage hopper is transported to washing-calibration complex. Cherry plum is washed in a bath. Water in the bath bubbles with compressed air supplied from a blower for most thorough washing of cherry plum. Washed fruits from the washing area are transported by means of an inclined conveyor to next section of the complex, where inspection and sorting are carried out.

Table 2 - Technology for production of dried fruit from macrocarpous purple cherry plum.

Name of technological operation	Equipment	Process parameters
Washing (bubble with compressed air)	Washing bath	No more than 30 minutes
Transportation	Declined conveyor	No more than 30 minutes
Inspection, sorting, size grading	Inspection and calibration complex	Thickness of cherry plum layer is regulated by damper plate
Natural drying of cherry plum	Mesh conveyor	Duration of the process is24 hours Air temperature 25-35 ^{0} C
Infrared drying of cherry plum	Infrared dryer	Duration of the process is 5-6 hours Temperature 40-60^0 C Moisture content of dried cherry plum15-16%
Cooking	Cooking vessel	Duration of cooking is 3 minutes Water temperature 90-95^0 C
Destoning of cherry plum	Pitting machinefor dried fruits	
Dried fruit from cherry plum	Mesh conveyor	Humidity of dried fruit is 18-20 %

Thickness of cherry plum layer is regulated by a damper plate. Sorting and inspection of fruits is conducted simultaneously. Defective copies, outside particles and impurities are removed. Substandard products are selected manually from conveyor belt, dumped into pockets and fallen on the lower branch of the belt, and from there into another container. Sorted cherry plum along the mesh conveyor is sent to infrared drying. Cherry plum is placed in infrared dryer [9, 10]. The penetration depth of infrared rays reaches 6-12mm. A small part of the radiation energy penetrates to this depth, but the temperature of the layer lying at a distance of 6-7 mm from the surface of the material grows much more intensively than when heated by convection. Short-wave infrared rays have a stronger effect on cherry plum, both due to a large penetration depth and a more effective effect on the molecular structure of fruits. Drying is carried out for 5-6 hours under the influence of infrared radiation at a temperature of 40-60 °C to an air-dry state. Infrared drying of cherry plum, as a technological process, is based on the fact that infrared radiation with a certain wavelength is actively absorbed by water contained in the product, but not absorbed by tissue of the dried product (and materials from which the drying equipment is made). Therefore, moisture removal is possible at a low temperature (40-60^{0}C), which promotes almost completely preservation of vitamins, biologically active substances, natural color, taste and aroma of the products exposed to drying. The technology permits to obtain a product that is not critical to storage conditions and is resistant to growth of microflora. As a result, the fruits are dried throughout the entire volume of the fruits. There is not necessity to turn over them. Due to this, the drying process takes place in one stage. The fruits are not over-dried. The pulp is fully preserved. The color of the fruit is preserved. A beautiful appearance of dried fruit is obtained. The taste is as close as possible to the taste of a fresh fruit. The moisture content of the fruit after infrared drying is 15-16%.

Then the semi-finished product is transported on the mesh conveyor to the pitting machine to separate dried fruit from bone. As a result, fruit is freed from bone. Due to the fact that the fruit has passed the drying stage, after removing stone, it does not spoil and does not ferment.

Dried cherry plum is sent to a rotating drum for coating with a liquid preservative potassium sorbate for a few seconds, the temperature of liquid is 90-95^{0}C.

As a result, a dried fruit was obtained from large-fruited purple cherry plum, which is distinguished by an improved appearance.

In order to evaluate the usefulness of dried cherry plum obtained by infrared drying, the analysis of the content of macro- and microelements in the ash residue of dried cherry plum is given (Table 3).

Table 3 – Content of macro- and microelements in ash residue of dried fruit from macrocarpous purple cherry plum.

No	Indicator, measur-ingunit	Actual results (in ash residue)
		Dried fruit from macrocarpous purple cherry plum
1	Ash mass fraction, %	0,6
mg for 100 g of edible part of product		
2	Na, mg/kg	2,1
3	Mg, mg/kg	4,99
4	P, mg/kg	10633,99
5	K, mg/kg	228,90
6	Ca, mg/kg	38,7849
7	Mn, mg/kg	54,33446
8	Fe, мг/кг	0,31
9	Cu, mg/kg	42,99411
10	Zn, mg/kg	0,37
11	Se, mg/kg	1,88

As can be seen from the table, dried fruit from macrocarpous purple cherry plum has a good content of Mg, P, K, Ca, Mn, Fe, Zn, Se. The sodium content in this food group in the study is in good coincidence with the literature data [12]. The range of potassium concentrations in the tables of chemical composition of food products [11] for berries is 161–355 mg/100 g, in the samples presented in the article, 228 mg/100 g, respectively. The iron concentration in the dried fruit was 0.31 mg/100 g. The zinc content was 0.37 mg/100 g.

Conclusions

An analysis of the literature and experimental data on the chemical composition of dried fruit showed the usefulness of macrocarpous purple cherry plum. Therefore, the population of Kazakhstan will have the opportunity to get the necessary macro- and microelements from the dried fruit of the macrocarpous purple cherry plum all year round. To do this, based on the analysis of literature data and the development of modes in industry and laboratory conditions, a technology was developed for obtaining dried fruit from macrocarpous purple cherry plum using infrared drying. Infrared drying is carried out in one stage for 4-6 hours at the temperature 50-60 ^{0}C. As a result, the dried fruit with a moisture content of 16-18% was obtained. The dried fruit has a good content of macro- and microelements. Thus, as confirmed by the results of a scientific study, dried fruits serve as a source of minerals.

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МАТЕМАТИЧЕСКОЕ ОПИСАНИЕ ПРОЦЕССА ОЧИСТКИ ЗЕРНА НА ЭКСПЕРИМЕНТАЛЬНОЙ УСТАНОВКЕ

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Для очистки зерна от легких примесей и пыли используют машины с пневматическими системами. Современные зерноочистительные машины для предварительной очистки от легких примесей и пыли с пневматической системой по своим эксплуатационным качествам не в полной мере отвечают возрастающим требованиям современного сельскохозяйственного производства. В статье представлены принцип работы и математическое описание, которые позволяют определить основные параметры установки. В данной работе был использован аналитический метод исследования на основе анализа дифференциальных уравнений, описывающих процессы очистки зерна от легких примесей и пыли. Для разработки математической модели применен метод построения математических моделей Лагранжа. На основе этой модели была построен ряд уравнений, которые характеризуют: переход потенциальной энергии массы зерна в кинетическую энергию зернового потока; динамическое уравнение равновесного падения зернового потока; объемный расход потока воздуха в межзерновом пространстве, а также уравнение, позволяющее определить потери давления в воздушном потоке, проходящем через жалюзи и среднюю скорость падения зерен. Учитывая выше-названные уравнения, построена математическая модель в виде системы уравнении. Данная матема-тическая модель позволяет определить основные конструктивные параметры новой установки: геометрические размеры рабочей зоны, а также энергетические затраты на процесс очистки зерна. Внедрение разработанной установки в приемных пунктах элеваторов позволяет повысить эффективность очистки зерна от легких примесей и пыли при небольших удельных затратах.

Ключевые слова: очистка, зерно, легкие примеси, математическая модель, пневмосепарирующий канал.

ЭКСПЕРИМЕНТТІК ҚОНДЫРҒЫДА АСТЫҚ ТАЗАЛАУ ПРОЦЕСІНІҢ МАТЕМАТИКАЛЫҚ СИПАТТАМАСЫ

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Пневматикалық жүйесі бар машиналар дәнді жеңіл қоспалардан және шаңнан тазарту үшін қолданылады. Пневматикалық жүйесі бар жеңіл қоспалардан және шаңнан алдын ала тазартуға