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STUDY OF THE INFLUENCE OF PLUM DRYING PARAMETERS ON THE CONTENT OF POLYPHENOLIC SUBSTANCES AND ANTIOXIDANT ACTIVITY IN PRUNES

Abstract: *Contemporary prune production is largely driven by industry and market demands. Uniform dimensions and color, balanced taste and attractive flavor are appreciated by consumers. In addition, dried plum is considered a rich source of the essential phytochemicals, mainly polyphenolic compounds. Drying is an effective method of fruit preservation. Drying can maintain the quality of the finished product, but the decisive factor in this process is the method chosen, the equipment and the parameters of the thermal agent. In this work, drying in an infrared cabinet was used as an effective and progressive method that reduces the drying time while preserving the bioactive substances of the initial raw material. To produce a prune authors used the plum species (Prunus domestica L. – domestic plum) of the genus Prunus, the variety «Vengerka domashnya»,*

cultivated in the south of Kazakhstan and as the most suitable variety for obtaining prunes. The results of the study showed that despite the shorter drying time at higher temperature (80°C), drying carried out at 60°C for 10 hours was more effective in terms of polyphenol preservation. Although drying fresh plums causes significant chemical changes, prunes dried in an infrared dryer at temperature 60°C can be considered a functional food due to the high levels of antioxidants: polyphenolic substances in amount 169.51±0.58 *mg GAE/100 g DW and Total Antioxidant Capacity (TAC) in amount* 64.27±0.65 *mg equivalents of α-tocopherol/ g extract.*

Key words: *plum; drying; infrared; temperature; prunes; polyphenolic; antioxidant; activity.*

Introduction

Functional foods or nutraceuticals are excellent tools in the prevention and/or treatment of diseases of various natures. These beneficial effects are due to the constant presence of bioactive components such as carotenoids, phenols, certain vitamins and fibres in the products [1]. Some of the original and important sources of these health benefits are fruits and vegetables, including dried foods. A wide variety of fruits, vegetables, whole grains and other plant foods provide a range of nutrients and various bioactive compounds, including phytochemicals, vitamins, minerals and fibre, which play an important role as antioxidants, phytoestrogens and anti-inflammatory agents, and through various protective mechanisms [2, 3].

Plum fruits and the dried products derived from them in the form of prunes, in this context, can be considered as a rich source of the above-mentioned phytochemicals, mainly polyphenolic compounds. Polyphenolic compounds are considered antioxidant, anticarcinogenic, antimicrobial, anti-allergic, antimutagenic and anti-inflammatory, as well as reducing cardiovascular diseases [4].

According to Bloomberg, many manufacturers are positioning prunes as a sweet, deep-flavoured, pleasantly chewy texture, healthy snack product rich in antioxidants, vitamins, fibre and protein. Most importantly, it is available all year round [5].

American nutritionists have discovered an unexpected property of prunes. In a study published in the Journal of Nutrition Bulletin, they stated that it reduces cravings for sweets. According to experts, people who ate prunes during the study felt less hunger and consumed fewer calories. This product is called by the experts it one of the best for snacking [6].

As already mentioned, the fruit sector faces the challenges of consistent availability of high quality produce all year round, as well as improving and maintaining high nutritional value after harvest and during storage. Although fruits and vegetables are rich in nutraceuticals and bioactive substances, these functional foods have a relatively short shelf life. Methods used to extend their shelf life and availability to consumers includes freezing and dehydration. The dehydration process can be modified to achieve improved nutritional and sensory profiles desired by both producers and consumers [7].

Global dried fruit production has shown a positive trend over the past decade, crossing the 3 million metric tonne threshold over the past six seasons. The total for 2022/23 was just over 3.1 million tonnes. Dried grapes (sultanas, sultanas and currants) were again the leading dried fruit with 1.3 million tonnes (42% of total volume) in 2022/23. With a total volume of almost 1.2 million tonnes, table dates accounted for 37% of total dried fruit production. Table dates were also the fastest growing product over the last ten years, with an average annual growth of 5% between 2013/14 and 2022/23. Sweetened dried cranberries (6%), prunes (6%), apricots (5%) and figs (4%) accounted for the rest of global production (21%). In the 2022/23 season, global prune production amounted to an estimated 171,660 metric tons (Fig.1) [8].

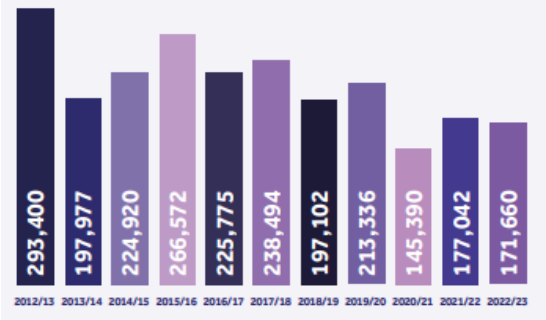

Figure 1 – World production of prunes

Drying is one of the widely used technologies as a method to reduce water content in order to slow down food spoilage by microorganisms [9]. But the high drying temperatures used in convection and other conventional heat treatments can reduce the amount of bioactive compounds including polyphenols [10]. Although [11] showed that although the high processing temperatures used for fruit drying significantly reduced both polyphenol and ascorbic acid content, the antioxidant activity of dried prunes was significantly increased. For this reason the purpose of the work is to determine the influence of different heating temperatures of drying with infrared method on amount of polyphenol substances and antioxidant ability of dried plums.

Objects and methods of research

The experiments were conducted on the plum species (*Prunus domestica L.* - domestic plum) of the genus Prunus, the variety "Vengerka domashnya", cultivated in the south of Kazakhstan and as the most suitable variety for obtaining prunes. The fruits were thoroughly washed, the pits were removed and immediately sent for drying.The drying process was carried out by an infrared drying installation ShS-80 of the Scientific Research Laboratory "Problems of Agro-Industrial Complex and Energy Information Resources" of M. Auezov SKU at different temperature conditions. Qualitative and quantitative analysis of fresh and dried plums was carried out using generally accepted methods in the literature and standards.

Results and discussion

At the first stage, the appearance and biochemical composition of fresh plums were studied: dry matter content, sugar content, titratable acidity. Plums for making prunes must meet certain requirements. Plums of the same size and weight (30-35 g) were selected, skin color - dark blue, with dense intact skin and waxy coating, with a small stone. The results of the analyses are presented in Table 1.

Table 1 – Biochemical composition of fresh plums of «Vengerka domashnya» variety

Type of data	Parameters		
	Dry matter content	Sugar content	Titratable acidity (per malic acid)
Experimental data	18,5%	13,5 %	1,03%
According to requirements	Approximately 20%	To 12%	Approximately 1%

Thus, the plum samples met all the requirements for obtaining high-quality prunes in all respects.

At the next stage, after preliminary preparation of the pitted plum samples, drying was carried out using infrared radiation as promising and cost-effective [12]. Such properties of any object as absorption and emission of radiation in the infrared spectrum give possibility to dry them at moderate temperatures and rapidly. So, selected plum varieties were dried at two different temperatures (60°C and 80°C) and the effect of the drying procedure on total polyphenol content and antioxidant capacity was monitored.

Figure 2 shows the drying curves of plums at different temperatures. Analysing the drying curves of plum samples, it is observed that the drying time decreases with increasing temperature in the infrared cabinet. At 60°C, the drying time is 12 hours, decreasing to 10 hours at 80°C. Thus, increasing the drying temperature from 60 to 80°C reduced the drying time by 1,2 times.

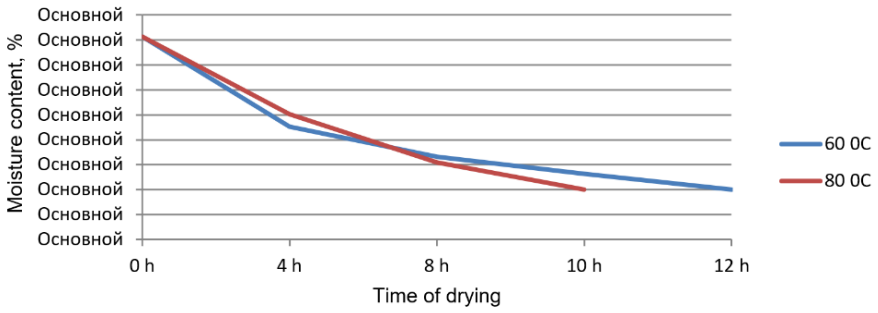

Figure 2 – Influence of the temperature on drying time

At the end of the drying process, the samples were examined for total polyphenolic content using the Folin-Chocalteu method. The content of polyphenols was determined by adding 0,2 ml of the pre-prepared prune extract to a test tube along with 1 ml of Folin-Ciocalteu solution and 3 ml of sodium carbonate solution (20%). The resulting mixture was left to react for one hour in the dark. Absorbance of the mixture was determined on a spectrophotometer at 765 nm. The result was expressed as milligrams of gallic acid equivalents (mg GAE) per 100 mg of starting material (mg GAE/100 g DW). The values for polyphenolic substances (PS) content of the obtained prune samples at different temperatures in the infrared cabinet are shown in Table 2.

It was found that maintaining temperatures of 60°C and 80°C in the infrared cabinet resulted in the following PS values: 169,51±0,58 mg GAE/100 g DW (60°C), and 109,51±0,54 mg GAE/100 g DW (80°C), showing the highest yield of PS content at 60°C. The similar situation resulted in TAC value: 64,27±0,65 mg equivalents of α-tocopherol/ g extract (60°C), and 55,21±0,92 mg equivalents of α-tocopherol/ g extract (80°C), showing the highest yield of TAC value at 60°C.

Table 2 – Biochemical composition of fresh plums of «Vengerka domashnya» variety

Temperature of drying	Parameters	
	Polyphenol substances (PS) mg GAE/100 g DW	Total Antioxidant Capacity (TAC) mg equivalents of α-tocopherol/ g extract
60°C	169,51±0,58	64,27±0,65
80°C	109,51±0,54	55,21±0,92

It is obvious that higher temperatures can increase dissolution and distribution, but high temperatures can also damage the cell wall, causing the release of enzymes such as polyphenol oxidase and peroxidase. Therefore, if the heat treatment temperature is higher, the chemical structure of the heat-sensitive phenolic compounds may undergo permanent modifications. And their content is drastically reduced. In addition, these changes affect the reactivity of aromatic rings interacting with the Folin-Ciocalteu reagent, which explains the lower P retention observed at higher drying temperatures [13-15].

Total Antioxidant Capacity (TAC) Test is a general test of the antioxidant capacity of plant extracts based on the phosphomolybdate method using α-tocopherol as an equivalent standard. The test is performed by mixing the extracts with a special reagent which is a mixture of sulphuric acid, sodium phosphate and ammonium molybdate. The mixture is then incubated at 95 °C for 90 minutes and, after cooling, the absorbance is measured at 695 nm. α-Tocopherol is also tested as a standard using the same procedures. The TAC value can be expressed as mg equivalents of α-tocopherol/ g extract [16].

So the total content of polyphenolic substances in fresh plums according to the number of studies composes from 125.0 to 372.6 mg/100 g expressed as gallic acid equivalents [17,18]. Although drying fresh plums causes significant chemical changes, prunes dried in an infrared dryer at temperature 60°C can be considered a functional food due to the high levels of antioxidants: polyphenolic substances in amount 169.51±0.58 mg GAE/100 g DW and Total Antioxidant Capacity (TAC) in amount 64.27±0.65 mg equivalents of α-tocopherol/ g extract.

Conclusion

Various studies on fruit preservation by drying report high product quality, low microbial contamination, and preservation of functional bioactive substances. Prunes, which are industrially produced by drying fresh plums at 60°C for 10 h, contain higher levels of phenolic compounds than those dried at higher temperatures. Phenolic compounds in prunes have beneficial effects on human health.

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КЕПТІРУ ПАРАМЕТРЛЕРІНІҢ ҚАРА ӨРІКТІҢ ПОЛИФЕНОЛДЫ ЗАТТАРДЫҢ МАЗМҰНЫНА ЖӘНЕ ҚАРА ӨРІКТІҢ АНТИОКСИДАНТТЫҚ БЕЛСЕНДІЛІГІНЕ ӘСЕРІН ЗЕРТТЕУ

Қазіргі заманғы қара өрік өндірісі негізінен өнеркәсіп пен нарық сұранысына байланысты. Біркелкі өлшемдері мен түсі, теңдестірілген дәмі мен тартымды дәмі тұтынушылар тарапынан жоғары бағаланады. Сонымен қатар, кептірілген қара өрік маңызды фитохимиялық заттардың, негізінен полифенолды қосылыстардың бай көзі болып саналады. Кептіру – жемістерді сақтаудың тиімді әдісі. Кептіру дайын өнімнің сапасын сақтай алады, бірақ бұл процесте шешуші фактор

таңдалған әдіс, жабдық және термиялық агенттің параметрлері болып табылады. Бұл жұмыста бастапқы шикізаттың биоактивті заттарын сақтай отырып, кептіру уақытын қысқартатын тиімді және прогрессивті әдіс ретінде инфрақызыл шкафта кептіру қолданылды. Қара өрік алу үшін авторлар қара өрік алу үшін ең қолайлы сорт ретінде Қазақстанның оңтүстігінде өсірілетін Prunus тұқымдасының қара өрік түрін (Prunus domestica L. – отандық қара өрік), «Венгерка домашняя» сортын пайдаланды. Зерттеу нәтижелері жоғары температурада (80°C) қысқа кептіру уақытына қарамастан, 60°C температурада 10 сағат бойы жүргізілген кептіру полифенолды сақтау тұрғысынан тиімдірек екенін көрсетті. Алхорды кептіру айтарлықтай химиялық өзгерістер туғызса да, инфрақызыл кептіргіште 60°C температурада кептірілген қара өрік антиоксиданттардың жоғары деңгейіне байланысты функционалды тағам ретінде қарастырылуы мүмкін: полифенолдық заттар 169,51±0,58 мг GAE/100 г DW және жалпы антиоксиданттық сыйымдылық (TAC) α-токоферол/г сығындысының 64,27±0,65 мг эквивалентінде.

Түйін сөздер: *алхоры; кептіру; инфрақызыл; температура; қара өрік; полифенолды; антиоксидант; белсенділік.*

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ИЗУЧЕНИЕ ВЛИЯНИЯ ПАРАМЕТРОВ СУШКИ СЛИВЫ НА СОДЕРЖАНИЕ ПОЛИФЕНОЛЬНЫХ ВЕЩЕСТВ И АНТИОКСИДАНТНОЙ АКТИВНОСТИ В ЧЕРНОСЛИВЕ

Современное производство чернослива во многом обусловлено требованиями промышленности и рынка. Однородные размеры и цвет, сбалансированный вкус и привлекательный аромат ценятся потребителями. Кроме того, сушеная слива считается богатым источником необходимых фитохимических веществ, в основном полифенольных соединений. Сушка является эффективным методом консервации фруктов. Сушка позволяет сохранить качество готового продукта, но решающим фактором в этом процессе является выбранный метод, оборудование и параметры теплового агента. В данной работе сушка в инфракрасном шкафу использовалась как эффективный и прогрессивный метод, позволяющий сократить время сушки при сохранении биологически активных веществ исходного сырья. Для получения чернослива авторы использовали вид сливы (Prunus domestica L. – слива домашняя) рода Prunus, сорт «Венгерка домашняя», возделываемый на юге Казахстана и как наиболее подходящий сорт для получения чернослива. Результаты исследования показали, что, несмотря на более короткое время сушки при более высокой температуре (80°C), сушка, проведенная при 60°C в течение 10 часов, была более эффективной с точки зрения сохранения полифенолов. Хотя сушка свежих слив вызывает значительные химические изменения, чернослив, высушенный в инфракрасной сушилке при температуре 60°C, можно считать функциональным продуктом питания из-за высокого содержания антиоксидантов: полифенольных веществ в количестве 169,51±0,58 мг GAE/100 г сухой массы и общей антиоксидантной емкости (TAC) в количестве 64,27±0,65 мг эквивалента α-токоферола/г экстракта.

Ключевые слова: *слива; сушка; инфракрасный; температура; чернослив; полифенольный; антиоксидант; активность.*

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СОЗДАНИЕ НОВОГО ВИДА ОБОГАЩЕННОГО МЯГКОГО СЫРА НА ОСНОВЕ РЕЗУЛЬТАТОВ ИССЛЕДОВАНИЯ СЫРОПРИГОДНОСТИ МОЛОКА КОРОВ ПАВЛОДАРСКОГО РЕГИОНА

Аннотация: *В данной статье отражены результаты проведенных исследований сыропригодности молока коров разных пород Павлодарского региона и разработки и усовершенствования технологии производства нового вида обогащенного мягкого сыра функционального назначения.*

На первом этапе НИР был проведен обзор специальной и научно-технической и патентной литературы по вопросам тенденции развития технологии производства натурального сычужного мягкого сыра, с использованием сырья растительного происхождения. Далее в ходе выполнения научно-исследовательской работы были проведены экспериментальные исследования сыропригодности молока 3 пород коров Павлодарского региона «Симментальская», «Красная Степная» и «Казахская белоголовая» к сычужному свертыванию. По результатам проведенных исследований, в качестве основного сырья для производства обогащенного мягкого сыра было отобрано коровье молоко породы «Симментальская.

Затем были составлены несколько вариантов смеси сыропригодного молока коров «Симментальская» и менее сыропригодного молока коров породы «Красная Степная» в различных соотношениях (90/10, 80/20, 70/30, 60/40, 50/50) и соответственно исследован процесс сычужного свертывания отобранных вариантов сыропригодного молока с использованием отобранных заквасок и сычужных ферментов.

По полученным результатам также было установлено, что фермент «Natural Rennet» и закваска «Lactoferm ECO» также обладают очень высокой активностью свертывания различных смесей молока. Динамика изменения титруемой кислотности при свертывании смеси (60/40 и 50/50) сыропригодного молока коров породы «Симментальская» и менее сыропригодного молока коров породы «Красная Степная» достигли максимального показателя по титруемой кислотности

Далее были проведены исследования по подбору и обоснованию добавок растительного происхождения – как функциональных компонентов в рецептуре нового вида обогащенного мягкого сыра для функционального питания. По результатам проведенных исследований в качестве функциональной добавки для получения обогащенного мягкого сыра была разработана молочно-растительная композиция (молочно-белковый сгусток и овощная паста) и определена ее концентрация в компонентном составе обогащеннного мягкого сыра. В результате были отобраны