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EXTENDED SAFE PRESERVATION PERIOD OF FOODS OF PLANT ORIGIN THROUGH COMBINED TECHNOLOGICAL METHODS

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Abstract

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The sublimation drying of fruits as an innovative technology for preservation their composition and enzyme activity is applied to various fruits: apricots, strawberries, plumbs, peaches and apples. The authors present the main methods of lyophilization as an original biotechnology for cryopreservation of fruits and afterwards are subjected to cold sterilization with 1.5 and 3 kGy doses of gamma irradiation. The combined application of both technologies provides safe and extended preservation of fresh fruits with high content of vitamins, mineral salts, maximum preserved enzyme system, aroma-tasty complex and microbiological purity.

Key words: gamma irradiation, lyophilization, fruits, safety, preservation

Introduction

The contemporary tendencies in the science of nutrition confirm the fact that the human organism should be provided with adequate intake of food substances and energy necessary for normal life functions. Particular attention is focused on various essential nutrition factors that play specific role of in the overall metabolism. Fruits are regarded as important nourishing food especially in the era of industrialization and increased consumption of refined foods with lower content of plant fibres and vitamins (Obretenov, 2002). The reliable fruit preservation requires the application of effective preservation methods that can extend the shelf life along with maintenance of their tasty qualities. Furthermore, the higher requirements of the contemporary consumers for healthy and unmodified food consumption pose a challenge for manufacturers and merchants.

Current theoretical and practical investigations prove that freeze-drying is the best method for qualitative preservation for rapidly spoiled foods, including fruits as well (Nacheva and Georgieva, 2007). The perspective and advantages of this high-technological method for preservation are indisputable, na-mely:

- Raw materials preserve all their properties and qualities;
- Their original structure is preserved at lower weight –easy for transportability;
- Decreased water content up to 2-3 % provides extended shelf life at positive temperatures;
- Rapid rehydration and ready for consumption;

In the course of investigations one of the main criteria for the quality of the lyophilized fruits is their mi-

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crobial purity. Usually, during lyophilization, as a result of the free water reduction, a small number of the vegetative forms of the mesophyllic microorganisms, some yeasts and more rarely- moulds may die. It is possible the spores of bacteria, some microscopic fungi and yeasts with higher resistance to thermic and technological treatment to survive after lyophilization.

Another modern technology for safe food preservation, including fruits and vegetables, is the so-called cold sterilization –food products are exposed to controlled dose of beam energy that eliminates the pathogen microorganisms causing spoiling processes, some parasites similar to pathogens can be inactivated and the shelf life will be extended. (Clarke, 1959; Moy, 1983).

The combination of the above-mentioned both technologies provide not only preservation of food composition but their safety as well through reduction of the microorganisms associated to them. On the basis of this treatment fruits are suitable for direct consumption under extreme conditions and intended for people with weakened immune system.

The main objective of the present study aims at tracing the changes of the qualitative indicators of some kinds of fruits and the microbial insemination with pathogens and potential pathogen microorganisms, yeasts and moulds after lyophilization and treatment with gamma rays.

Materials and Methods

Object of investigations: Fruits of various kinds - apricots, strawberries, plumbs, peaches and apples in native condition after lyophilization and after gamma irradiation;

Technological approaches –freeze-drying (lyophilization) and irradiation with gamma rays.

Methods of analysis – physicochemical –residual moisture content, total proteins and fats, total ash, determined according to standard methods and *microbiological analysis* – the total number of mesophyllic microorganisms in compliance with ISO:4833 in colony-forming units (CFU).

Results and Discussion

During freeze-drying two types of preservation methods are combined: freezing and drying under vacuum at temperatures not above the critical, i.e. such temperatures causing damage of the micro and macrostructure of the product. The parameters for fruit freezing before drying have a significant effect on the quality in a dry state (Tzvetkov et al.,1985). With the help of precise technique we have measured the temperature of the final water freezing temperature (eutectic temperature). During the investigation on fruits the temperature varies from - 32^0 to -42^0C. The freezing has been conducted in cameras with compulsory convection of the air medium at temperature from -32^0C to -38^0C for 13-20 hours. Lyophilization has been carried out in a sublimation installation "Hochvakuum-TG- 16.50" at temperature of the hot plates- -50^0C, total pressure in the sublimator 0.20-0.35 mm/Hg and temperature of fruits drying- +30^0C. The appropriate determination of the temperature regime on drying should guarantee high quality of the final products and good energy efficiency (Gegov, 2003). As a result of the technological investigations in freeze-drying applied to various kinds of fruits, we have defined the following optimal technological parameters of the process which are presented in Table 1.

The irradiation of fruits has been accomplished by gamma- irradiation installation –"Gamma-1300", source of radiation – Cs 137 and dose power- 1.75 Gy/min. Dose power of 1, 5 and 3 kGy have been applied. Unirradiated fruits samples served as control samples.

The freeze-dried fruits have preserved their aroma and tasty qualities with insignificant loss of volatile aroma substances and enzymes.

Due to the physicochemical determination we have

Table 1
Technological parameters for freeze-drying for some kinds of fruits

Parameters	Apri-cot	Straw-berry	Plum	Peach	Apple
Freezing temperature, ^{0}C	-32	-35	-38	-37	-35
Eutectic temperature, ^{0}C	-32	-40	-41	-42	-40
Sublimation temperature, ^{0}C	-30	-38	-40	-41	-38
Total pressure, mm/Hg	0.20	0.25	0.35	0.30	0.30
Terminal temperature, ^{0}C	30	30	30	30	30
Duration of the cycle, h	20	14-14.5	15	14-14.5	16-17
Residual humidity %	2.0-3.0	3.0- 3.5	3.5-4.0	4.0- 4.5	4.0-4.5

detected significant reduction of the moisture content from average 70-90% of the initial products to 2.0 – 4.5 % distributed into the whole volume of the lyophilized fruits (King, 1971). Because of their lyophilic nature, through rehydration lyophilized fruits obtain their initial physical, organoleptic and physiological properties.

The content of proteins in the fruits varies from 1, 59% to 8.26 %, fats – from 0.99 to 3.40, carbohydrates- from 80.0 to 86.20, mineral substances from 2.06 to 4.50.

Mineral salts which are important fruit ingredients have not been seriously transformed during drying process. Freeze –drying does not cause considerable changes in the vitamin content of the food products as it is generally determined by other drying methods. Our investigations have proved insignificant decrease in the quantity of the ascorbic acid – 5-10% and the other water-soluble vitamins:such as nicotine acid-vitamin PP, thiamin –vitamin B_1 and carotenes -8-9%.

Usually during the process freeze-drying, some of the vegetative forms of the mesophyllic microorganisms and yeasts but more rarely moulds may die. While freeze-drying of fruits is applied, these vegetative forms are measured within permitted norms - $<10^2$ CFU/g, the total count of mesophyllic and facultative anaerobic microorganisms $< 10^5$ CFU/g and coli- bacteria have not been detected.

The microbiological analyses carried out show the total count of microorganisms existing in the freeze-dried fruits (unirradiated samples) is approximately 2-3 logarithmic units. Mostly nonpathogenic spore – forming sticky bacteria have been observed. Moulds have been detected in the samples of apricots, apples and strawberries. In the case of apples *Penicillium sp.* has been isolated. The largest number of microorganisms has been detected in the strawberries. The fact is understandable since the strawberries can be easily contaminated by the soil due to their delicate nature and therefore difficult to be washed out.

After irradiation total reduction of the number of microorganisms in all kinds of fruits both at the higher and lower irradiation doses has been observed. The exception has been noticed only in the case of the apples irradiated by 1.5kGy where the total number of microorganisms is 2.6 lg units. In these samples we have found moulds -77% among all the rest microorganisms. The result can be explained with their higher resistance. According to (Frazier, 1988) doses of 1.3 to 11 kGy are necessary for the elimination of moulds. In the course of our investigations complete reduction of the moulds observed in the unirradiated samples of apples, has been detected in the irradiated samples with 3 kGy. This is of particular importance since the natural fruit microflora, f.ex. some types of moulds may produce micotoxins such as aflatoxins and patulin. Investigations by (Afifi et al., 2003) confirm the following fact: when apples are exposed to irradiation

Table 2
Values obtained of the microbiological insemination of the freeze-dried fruits in CFU/g after irradiation

Dose in kGy	PEACH					
	Microbiological population CFU/g					
	Total number of aerobic		Moulds		Yeasts	
Control group	Absolute value	log	Absolute value	log	Absolute value	log
/non irradiated/	$8{,}1.10^{2}$	2.91	1.10^{1}	1	ND	
1.5	ND		ND		ND	
3	ND		ND		ND	
Dose in kGy	**APPLE**					
	Microbiological population CFU/g					
	Total number of aerobic		Moulds		Yeasts	
Control group	Absolute value	log	Absolute value	log	Absolute value	log
/non irradiated/	2.10^{3}	3.3	2.10^{2}	2.3	ND	
1.5	$4{,}2.10^{2}$	2.62	1.10^{2}	2	ND	
3	ND		ND		ND	
Dose in kGy	**BLUE PLUM**					
	Microbiological population CFU/g					
	Total number of aerobic		Moulds		Yeasts	
Control group	Absolute value	log	Absolute value	log	Absolute value	log
/non irradiated/	$3{,}2.10^{1}$	1.5	ND		ND	
1.5	1.10^{1}	1	ND		ND	
3	ND		ND		ND	
Dose in kGy	**STRAWBERRY**					
	Microbiological population CFU/g					
	Total number of aerobic		Moulds		Yeasts	
Control group	Absolute value	log	Absolute value	log	Absolute value	log
/non irradiated/	5.10^{2}	2.7	2.10^{2}	1.3	ND	
1.5	ND		ND		ND	
3	ND		ND		ND	
Dose in kGy	**APRICOT**					
	Microbiological population CFU/g					
	Total number of aerobic		Moulds		Yeasts	
Control group	Absolute value	log	Absolute value	log	Absolute value	log
/non irradiated/	2.10^{2}	2	2.10^{2}	2	ND	
1.5	ND		ND		ND	
3	ND		ND		ND	

ND – Not detected

with gamma rays, the treatment applied has effect on the microflora and produces aflatoxins through inactivation of this kind of microorganisms without causing damage on the fruits.

Pathogen microorganisms in freeze-dried fruits before and after irradiation have not been detected.

The results based on the microbiological investigations of the freeze-dried and irradiated fruits are presented in Table 2.

Conclusions

Freeze-drying (lyophilization) as a contemporary method of fruit preservation can guarantee final products with excellent organoleptic qualities, nutritional and biological value.

Irradiation with gamma-rays (cold sterilization) is a technology that provides safe food preservation through destruction of the existing microorganisms.

Both combined contemporary technologies provide long-term, qualitative and safe preservation of food products.

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