GAMMA-ACTIVATION METHOD FOR THE ELEMENT ANALYSIS OF AGRICULTURAL PRODUCTS AFTER VACUUM DRYING

*N.P. Dikiy, V.A. Kutovoy, *S.V. Kutovoy, Yu.V. Lyachko, E.P. Medvedeva, D.V. Medvedev, A.A. Nikolaenko, N.I. Onishchenko, V.L. Uvarov, **I.D. Fedorets, L.D. Grytsan*
*NSC KIPT, Ukraine, *Yuzhnoe SDO, Dnepropetrovsk, Ukraine, **KNU, Ukraine*
E-mail: ndikiy@kipt.kharkov.ua

Development of the combined technologies of drying allows one to speed up the process of moisture moving away from the dried material and to decrease the energy consumption per the production unit. The composition of macro- and microelements before and after drying of the dispersed materials was monitored by the nuclear-physical method. Quantometer method was used for definition of the intensity of oxidative processes at the level of cell membranes. And the method of electron microscopy was used for detection of possible destructive processes in organelles.

PACS: 29.17.+w, 28.41Kw

INTRODUCTION

Economy of power, time and cost expenses during drying of agricultural production with preservation of its quality is of high urgency. For this it is necessary to study the mechanism of moisture recession from the dried products and to develop the drying technology on this basis.

METHODS

Methods of monitoring of water recession from fruits (apples) and vegetables (carrots, beet) were used during this work implementation: gamma-activation analysis for definition of the content of macro- and microelements before and after drying [1], method of chemiluminescence, which allows to explore the intensity of outlet of highly reactionary products through diaphragms of cells and organelles before and after drying [2], and also the method of electron-microscopy for examination of the structure of cell membranes and organelles [3].

γ-activation analysis was conducted at the electron accelerator with E=25 MeV, I=500 μA. The spectrum of γ-radiation was registered by the Ge(Li)-detector with a volume of 50 cm^3 and energy resolution of 2,2 keV on the line of 1333 keV. The isotope relationships of calcium were measured by nuclear reactions $^{48}Ca(\gamma,n)^{47}Ca$, $^{44}Ca(\gamma,p)^{43}K$ [4].

Measuring of intensity of spontaneous (intrinsic) chemiluminescence (CL) and CL induced by hydrogen peroxide solution (for augmentation of intensity of light emission and obtaining of wider information due to presence of several parameters of kinetics) was carried out on quantometer instrument with photomultiplier FEU-140 (the spectral band is 350-750 nanometers) [5]. The object of interest was placed in the box thermoconditioned at 37°C that was situated directly above the FEU photocathode. 10 g-sample of carrot was dried in desiccator and microwave kiln to study the intensity of transport of these high-energy products in the dynamic of drying. Every 15 minutes the probes were taken and weighed. 1 g of the dried product was flooded by 5 ml of distilled water and positioned in the thermostat at the temperature of 37^0C for 30 minutes for incubation. After expiration of this time 2 ml of the obtained extract were taken and placed in thermoconditioned box of the instrument for recording spontaneous and induced CL. Injection of 0.5 ml of 10% hydrogen peroxide initiated the instantaneous flash of light emission (maximal intensity (I_{max}) which for the sample dried in desiccator made $9\cdot 10^3$ impulses per second, and for the sample dried in microwave kiln - $14\cdot 10^3$ impulses per second). Subsequently the light emission gradually dropped and on the 4-th minute of measuring the finite value (I_{final}) was registered at the level of background noise. The integrated light (Σ) was also registered for the whole period of measurements. Decreasing of intensity of light emission during drying, apparently, testifies to the decrease of the transport of highly reactionary products through diaphragms of cells.

The preliminary fixation of the samples for electronic microscopy was performed in solution of glutaroaldehyde within 24 hours with subsequent transmission for additional fixation to the solution of osmium oxide (OsO_4) for 1 hour. The further fixation included dehydration of the samples in spirits with concentration from 50% up to 90%. After that the samples were flooded by epoxy resin for preparation of ultrathin sections with the help of microtome. The obtained sections were colored by 1% solution of dark blue methylene with 1%-solution of borax and positioned on palladium grids for scanning.

RESULTS

Samples of vegetables were cut with dimensions 1.2×10×2.0 mm. At various drying conditions the change of temperature on the cross-section of the dried sample did not exceed 0.4°C. Drying of the samples in the desiccator was performed at the temperature $T=40^0$C. Drying of the samples in the microwave kiln was also performed at the temperature 40^0C, and heat application 0.1 W/g. The drying of the samples at the temperature 40^0C was chosen because at this mode there is no coagulation of albumens and ferments and dissociation of complex bio-molecules is minimized.

During the process of heating in the microwave kiln the power input is proportional to the content of water in the object. The loss of water in vegetables during drying

in the desiccator and the microwave kiln at the temperature 40^0C was registered every 15 minutes.

One can see in Fig.1 that the dependence of the drying rate has complex nature: for microwave drying there is a high rate of water going out that is as high as twice for the drying in the desiccator during first 15 minutes. After 30 minutes one can note the decreasing of water recession rate in both cases, but in the microwave kiln the water recession rate is higher in 7 times. The second peak of water recession appears at 45 minutes, and for microwave drying it is higher in 1.7 times. The third peak of the intensity of water recession for drying in desiccator is monitored during 75 minutes, whereas in the microwave kiln a practically complete water recession is observed.

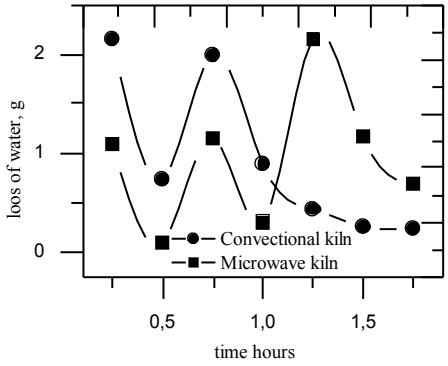

Fig.1. Intensity of water loss by carrot samples during drying in microwave kiln and desiccator at power 0.1 W/g. The weight of the sample is 10 g, T = 40°C, air humidity in room is 55%

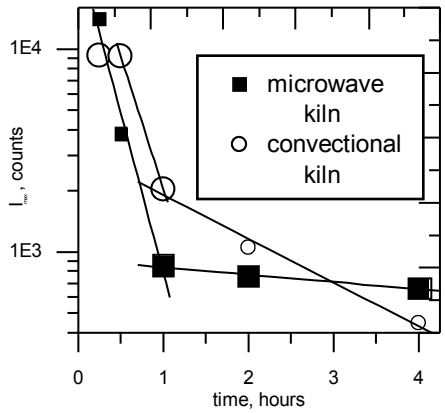

Fig.2. Dependence of logarithm of maximal intensity of flashing of carrot extracts versus the time of drying in the microwave kiln and the desiccator at power 0.1 W/g. The weight of the sample is 10 g, T = 40°C, air humidity in room is 55%

One can see on Fig.2 the dependence of maximum intensity of flashing of carrot extract dried in desiccator and microwave kiln. Different intensity of circulation of high-energetic products through the membrane of cell is noted. The rates of change of intensity of luminescence at the first phase of drying in both cases coincide, that testifies the viability of cell. At further drying process in microwave kiln the intensity of luminescence of carrot extract considerably decreases, which is evidence of the fact that the drying process is completing faster. In this case there is increasing of the rate of water transportation from the cell to the system of capillaries, which results, basically, in the economical (liquid) moisture transfer [6].

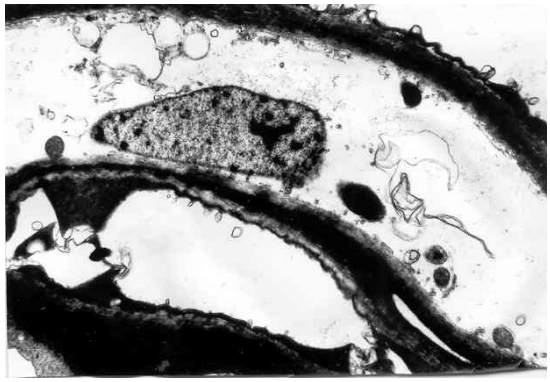

Fig.3a. Ultra thin structure of apples before drying (magnification in 12000 times)

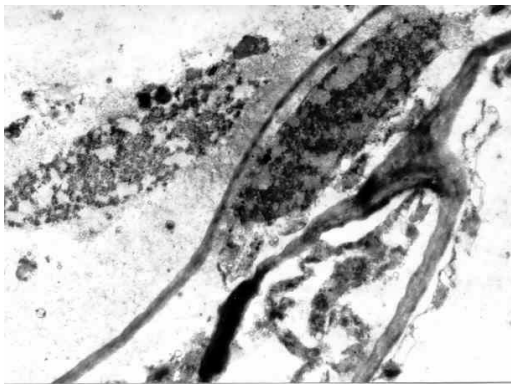

Fig.3b. Ultra thin structure of apples after vacuum drying (magnification in 12000 times)

It is necessary to emphasize, that for the both cases the limiting process of drying of vegetables and fruits is water transfer from the cell to the intercellular system. That is why to maintain a highly economical method of water transportation it is necessary to use optimal rates of moisture evaporation from the surface during the initial phase of drying. Temperature increasing or application of high rates of moisture evaporation during vacuum exhaust could significantly increase power inputs for drying of one unit of product.

The nuclear-physical method was used for research of mechanism of microelement circulation during the drying process. There were used native and dry samples of carrots, beet and apples for analysis of macro- and microelements in agricultural products. The investigated samples did not exceed 1 g of the dry substance.

One can see in Table the results of research on content of elements in the samples of carrot, beet and apples before drying and after vacuum drying using infrared irradiation. Sodium recesses with water from carrot most intensively. It is observed also high degree of

recession of calcium, nickel, barium, manganese, rubidium and zinc from carrot. Calcium, zinc, rubidium recess from beet most intensively. From apples recessed are zinc, barium, rubidium. One could also note an insignificant recession from apples with water of such elements, as calcium, nickel, manganese that is stipulated by the high content of iron. Iron is part of complex compounds with these elements and this hinders their recession from samples.

Content of microelements in carrot, beet and apples before and after vacuum drying (micrograms/gram)

		Carrot			Beet			Apples		
		Before	After	After/ Before	Before	After	After/ Before	Before	After	After/ Before
	^{44}Ca	1601	1777	1.1	3414	4868	1.43	172.5	1436	8.33
Ca	^{48}Ca	512	420	0.82	3340	5316	1.59	157.3	1628	10.4
	^{44}Ca/^{48}Ca	3.13	4.23		1.02	0.92		1.1	0.88	
Zn	^{68}Zn	144.6	313.6	2.17	193	447	2.32	47.3	104	2.2
Na	^{23}Na	1484	152.3	0.1	298.3	1680	5.63	361.9	1237	3.42
Ni	^{58}Ni	1.19	1.27	1.07	0.35	1.6	4.53	0.5	4.22	8.67
Zr	^{90}Zr	0.12	1.2	9.73	1.08	1.6	1.47	0.17	0.99	5.77
Ba	^{136}Ba	2.67	6.2	2.32				5	2.64	0.53
Mn	^{54}Mn	3.98	8.81	2.22	4.01	80.9	20.2	5.4	44.7	8.26
Rb	^{89}Rb	3.86	9.08	2.36	3.74	7.6	2.03	5.66	13.1	2.32

Electronic-microscopic structure of ultra thin sections of apple and beet samples before and after vacuum drying was investigated using the electronic microscope UEM-120 with voltage 75 kV. At optimal mode of drying ($T=40^0C$) the dried samples practically did not differ from native ones, the consistency of membranes and cell organelles remained. Recession of water from the dried samples was characterized by the fact, that cells were flattened per vertical line and stretched per horizontal line.

Thinning of membranes of apple cells was observed at the temperature $T=40^0C$ (see Figure 3a,b).

REFERENCES

1. N.P. Dikiy, V.I. Borovlev, V.D. Zabolotny et al. Nuclear-physical methods analysis of noble metal and rare elements // *PAST. Series: Nuclear Physics Investigations.* 2001, №1, p.81-84.
2. D.A. Janumov, V.A. Veselovskiy, B.N. Tarusov Research of temperature dependence by the methods of spontaneous and photo-induced chemiluminescence // *Physiology of Plants.* 1971, v.18, p.588-593 (in Russian).
3. B Wikly *Electronic Microscopy.* M., 1975, p.389 (in Russian).
4. N.P. Dikiy, A.N. Dovbnya, V.L. Uvarov et al Use of accelerators in geology, medicine, isotopes production and atomic power energetics // *PAST. Series: Nuclear Physics Investigations.* 2001, №1, p.26-35.
5. *Biochemiluminescence.* M.: Nauka, 1983, p.259 (in Russian).
6. A.N. Planovskiy, V.M. Ramm. *Processes and Instruments of Chemical Technology*, M.: GCHI, 1962, p.300 (in Russian).

ГАММА-АКТИВАЦИОННЫЙ МЕТОД ДЛЯ ЭЛЕМЕНТНОГО АНАЛИЗА СЕЛЬХОЗПРОДУКЦИИ ПОСЛЕ ВАКУУМНОЙ СУШКИ

Н.П. Дикий, В.А. Кутовой, С.В. Кутовой, Ю.В. Ляшко, Е.П. Медведева, Д.В. Медведев, А.А. Николаенко, Н.И. Онищенко, В.Л. Уваров, И.Д. Федорец, Л.Д. Грицан

Разработка комбинированных технологий сушки позволяет ускорять процесс ухода влаги из материала и уменьшать затраты энергии на единицу продукции. Состав макро- и микроэлементов до и после сушки материалов был изучен ядерно-физическими методами. Метод регистрации индуцированного излучения использовался для определения интенсивности окислительных процессов на уровне мембран клетки. Метод электронной микроскопии использовался для обнаружения возможных деструктивных процессов в клетке.

ГАММА-АКТИВАЦІЙНИЙ МЕТОД ДЛЯ ЕЛЕМЕНТНОГО АНАЛІЗУ СІЛЬГОСППРОДУКЦІЇ ПІСЛЯ ВАКУУМНОГО СУШІННЯ

М.П. Дикий, В.О. Кутовий, С.В. Кутовий, Ю.В. Ляшко, О.П. Медведєва, Д.В. Медведєв, А.А. Ніколаєнко, М.І. Онищенко, В.Л. Уваров, І.Д. Федорець, Л.Д. Грицан

Розробка комбінованих технологій сушіння дозволяє прискорювати процес відходу вологи з матеріалу і зменшувати витрати енергії на одиницю продукції. Склад макро- і мікроелементів до і після сушіння матеріалів був вивчений ядерно-фізичними методами. Метод реєстрації індукованого випромінювання використовувався для визначення інтенсивності окисних процесів на рівні мембран клітини. Метод електронної мікроскопії використовувався для виявлення можливих деструктивних процесів у клітині.