

# Eco-innovative application of phyto-raw materials in the technology of long-term storage of unrefined sunflower oil

Roza Timakova<sup>1,\*</sup>, and Ruslan Iliukhin<sup>2</sup>

<sup>1</sup>USUE, 620144 Yekaterinburg, Russian Federation

<sup>2</sup>Saint- Petersburg state University of telecommunications. M. A. Bonch-Bruevich, 192232 Saint-Petersburg, Russian Federation

**Abstract.** Along with the development of agroecosystems, environmental friendliness of agricultural and industrial technologies for long-term storage of agricultural products is being formed as a result of cognitive technologies development, including innovations in biotechnologies. Achieving the biological safety of bulk unrefined sunflower oil is based on the addition of an unconventional antioxidant phyto-raw material to it - stinging nettle, which slows down oxidative processes. In order to prevent oil contamination, the optimal dose of ionizing radiation for the nettle treatment is established - up to 1.5 kGr, which ensures microbiological safety and antioxidant activity (AOA) at the level of  $0.763 + 0.016$  mMeq, comparable to AOA in the untreated nettle samples after 3 months. After 52 days of storage, the acid number was in the range of 0.99-1.15 mg KOH / g, the peroxide number was 5.09-5.16 mmol active oxygen / kg. Adding 0.5-1.0 wt. % nettle powder to the oil ensures the compliance of organoleptic parameters with the established requirements - transparency, taste and smell. Adding 1.0 wt. % nettle powder to the oil slows down the filtration process of the resulting suspension. The practical relevance of the study is determined by the verification of the research results to prolong the oil shelf life by adding environmentally friendly phyto-raw materials to it.

## 1 Introduction

One of the national goals in accordance with the Strategy for the Development of the Agroindustrial and Fisheries Complexes of the Russian Federation for the period up to 2030 is creating an agroindustrial complex that develops on the basis of modern technologies for the production, processing and storage of agricultural raw materials and food products and determines two vectors of development: on the one hand, agrotechnology itself for the production of raw materials, on the other hand - their complex processing.

For the development of environmentally friendly crop production, the improvement of agroecosystems is of importance: reclamation of soil as an important biological resource [1]

---

\* Corresponding author: [trt64@mail.ru](mailto:trt64@mail.ru)

and ensuring the soil qualitative characteristics, for example, when it is saturated with nitrogen due to changes in the soil biota [2,3]; forming optimal configurations of ridge furrows to improve soil water supply [4] and others. The transformation of agroecosystems based on digital design solutions will help reduce the anthropogenic and technological load on agricultural areas, reduce technological risks and achieve biological safety.

In the medium term, the role of a new technology type - cognitive technologies, determined by the complex of information technologies, biotechnologies and nanotechnologies development [5, 6], is increasing. Digitalization of the agro-industrial sector with the development of the "Mercuriy" ("Mercury") information system, the launch of the StockMeat.com industry program, the introduction of RFID tags for agricultural products, the development of agricultural technology platforms such as "Technology of food and processing industry of the agro-industrial complex - healthy food products" and the "Eurasian agricultural technology platform" and the use of the broadband mobile LPWAN communication to organize large-scale digital agricultural solutions (smart field, smart herd, smart farm, etc.) - increases its investment attractiveness [7, 8].

Within the framework of the strategic direction "Agricultural production" of the "Technology of food and processing industry of the agro-industrial complex - healthy food products" technological platform, one of the promising areas is technologies for long-term storage of agricultural products, including those based on molecular biological methods [9], which can be considered both in terms of physical storage methods that do not affect the chemical composition of the product itself, and in terms of gentle biotechnologies. The choice of innovative technology can be determined by the "circular economy, which, acting as a practical basis for the implementation of a green economy, offers effective business models to ensure more environmentally friendly resource use" [10]. The choice of the processing technology for food raw materials is determined by the goals of processing and the type of food raw materials.

The Russian Federation is the largest exporter of sunflower oil; this predetermines the importance of preserving edible oilseed raw materials. The key preservation factors for vegetable oil during storage are air temperature, darkening of storage areas and lack of oxygen. For the human body, unrefined oils are most useful; yet, the presence of biologically active substances makes unrefined vegetable oils unstable during storage [11]. In the consumer market, a stable niche is occupied by unrefined sunflower oil, which in contrast to refined oil has a shorter shelf life. Unrefined sunflower oil is characterized by a rich taste and smell, it is high in phospholipids, vitamins E, A and K and free fatty acids, which are easily oxidized during storage to hydroperoxides, aldehydes, ketones and alcohols, which reduce the oil nutritional value. In order to provide a prolonged shelf life of the product, biotechnological methods can be applied. The latter are based on the use of phyto-raw materials and serve to slow down oxidative processes due to the content of polyphenols. The use of biotechnological methods can be considered as a promising trend in the greening of technological processes.

According to [12-14], to achieve oxidative stability of vegetable oil and thus, to prolong its shelf life, the most effective way to be used is adding natural antioxidants (AO) to the finished product, such as curcumin for corn oil, green tea extracts for peanut butter, pomegranate peel for coconut oil, sea buckthorn extract, rosemary extracts, meadowsweet, blueberry, capsicum powder, mint and clove for linseed oil, encapsulated extracts of citrus, broccoli and rosemary and olive tree leaves, as well as micellized forms of antioxidants (tocopherin, ascorbic acid) for sunflower oil [15-22].

The research aims to increase the shelf life of bulk unrefined sunflower oil by adding to it the powder of stinging nettle (*Urtica dioica*) of the Rosaceae family.

## 2 Materials and Methods

We took the following raw materials to form the objects of study: bulk unrefined premium sunflower oil and nettle powder of the Nettle genus, the Nettle family, the Rosaceae order. Nettle refers to medicinal and technical raw materials, or phyto-raw materials, with an antioxidant orientation due to the content of flavonoids, essential oils, ascorbic acid (vitamin C) and carotenoids.

6 groups of nettle powder samples were prepared, which, to ensure microbiological purity, were treated with ionizing radiation by a stream of accelerated electrons with doses from 0.5 to 3.0 kGr with a step of 0.5 kGr. The choice of radiation doses is determined by the requirements of GOST 33271-2015 "Dry spices, herbs and vegetable seasonings. Guidance on exposure to pathogens and other microorganisms". According to the requirements of Technical Regulations of the Customs Union 024/2011 "Technical regulations for fat and oil products", microbiological indicators for vegetable oil are not stated.

Antioxidant activity (AOA) in the nettle powder was identified without specifying individual antioxidants by the potentiometric method with the use of an MPA-1 analyzer according to the standard procedure [23].

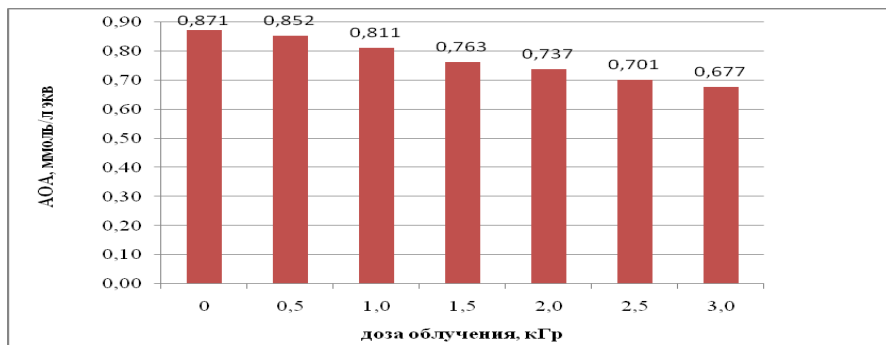
Then 3 groups of samples were formed: 1st control group (samples of bulk unrefined premium sunflower oil), 2nd experimental group (samples of bulk unrefined premium sunflower oil with the added 0.5 wt% nettle powder), 3rd experimental group (samples of bulk unrefined premium sunflower oil with the added 1.0 wt.% nettle powder).

The oxidative damage indicators of the vegetable oil samples, i.e. acid and peroxide numbers were determined by the titrimetric method; microbiological indicators of the nettle powder were determined in accordance with standard analysis methods. The research was conducted in five replicates. The research results were processed by the method of variation statistics.

## 3 Results and Discussion

At the first stage, the nettle powder was explored. We found out that the number of mesophilic aerobic and facultative anaerobic microorganisms (NMAaFAnM) after the nettle powder treatment with doses of 0.5; 1.0; 1.5; 2.0; 2.5 and 3.0 kGr was  $4 \cdot 10^4$ ,  $1 \cdot 10^4$ ,  $7 \cdot 10^3$ ,  $3 \cdot 10^3$ ,  $8 \cdot 10^2$  and  $3 \cdot 10^2$  CFU / g, respectively, which correspond to the requirements of the Technical Regulations of the Customs Union 021/2011 "On food products safety". All the nettle powder samples were free of coliform bacteria, *E. coli* and mold.

Evaluation of antioxidant potential of the nettle powder samples showed that when the radiation dose was increased, AOA decreased with a high coefficient of approximation equal to 0.99. Thus, in the nettle samples treated with a dose of 3 kGr, AOA was  $0.677 \pm 0.022$  mM-eq, which is 22.3% less than in the nettle samples that were not treated with ionizing radiation (Fig. 1).



**Fig. 1.** Changes in antioxidant activity (AOA) in the nettle powder

Where: Доза облучения, кГр - Radiation dose, kGr ; АОА, ммоль/л экв - AOA, mmol / l eq .

The formula for the linear dependence of AOA on the radiation dose is presented as follows:

$$y = - 0.034 x + 0.91 \quad (1)$$

On the basis of the results obtained, the optimal dose of ionizing radiation was established for the use of nettle powder as a phyto-raw material with increased antioxidant activity – up to 1.5 kGr; AOA decreases compared with untreated samples by 12.4% and is 0.763 + 0.016 mM-eq, which is comparable to the decrease in the AOA of untreated samples during storage for up to 3 months.

At the second stage, to obtain a homogeneous suspension, the samples of bulk unrefined sunflower oil were mixed with the nettle powder treated with ionizing radiation of 1.5 kGr in a mixer at a rotation speed of 170-180 rpm and an oil temperature of + 15-18 ° C for 12-15 min. In the experimental samples of the 2nd group, an insignificant suspension of the powder was observed, in the experimental samples of the 3rd group, the suspension was thicker.

After storage of control and experimental samples for 45 days in accordance with the requirements of the regulatory documents and 52 days in accordance with the reserve ratio for non-perishable food products, organoleptic indicators and oxidative damage indicators were analyzed.

As a result of the organoleptic assessment, it was found that the control samples of sunflower oil when stored for up to 45 days met the regulatory requirements, after 52 days of storage, a grid appeared over the sediment and there was a slight smell of oxidation. In the experimental samples of unrefined oil, when stored for up to 45 days and 52 days, the oil was transparent with slight turbidity, the smell and taste were characteristic of unrefined sunflower oil, without any foreign smell or taste.

During storage of the experimental oil samples, suspended particles of nettle powder and phospholipids settle to the bottom, which makes it possible to use such oil after filtration for the production of refined oil. However, in the 3rd experimental group, the filtration process slows down due to a large amount of immiscible residue.

The results obtained for the acid number and peroxide number are presented in Table 1.

**Table 1.** Values of the acid number and peroxide number in the experimental and control samples of bulk unrefined premium sunflower oil during storage

Shelf life, days	Acid number, mg KOH / g			Peroxide number, mmol act. oxygen / kg		
	1 group	2 group	3 group	1 group	2 group	3 group
0	0,54±0,02	0,40±0,02	0,36±0,03	3,22±0,05	2,88±0,03	2,73±0,03
45	1,23±0,08	0,74±0,04	0,68±0,04	5,79±0,11	4,12±0,06	4,01±0,02
52	1,46±0,02	1,15±0,05	0,99±0,04	6,14±0,08	5,16±0,09	5,03±0,05

Thus, as a result of the undertaken experiment we found out that in all samples of vegetable oil, the oxidative damage indicators during storage for up to 45 days and 52 days corresponded to the requirements of the regulatory documents. At the same time, adding 0.5-1.0 wt. % nettle powder in bulk unrefined sunflower oil resulted in lower acid number in the 2nd experimental group – up to 1.15 mg KOH / g and in the 3rd experimental group - up to 0.99 mg KOH / g, which is lower by 21, 2% and 32,2% compared to the indicators of the control oil samples. The corresponding results were obtained for the peroxide number, which is 16.0% and 18.1% lower than the values of the peroxide number in the 2nd and 3rd experimental groups, respectively, which can be explained by the positive effect of phyto-raw materials on the oil oxidative stability.

### 3 Conclusion

On the basis of the results obtained, the following conclusions can be made. Adding nettle powder, treated with a radiation dose of 1.5 kGy, in an amount of 0.5-1.0 wt. % to bulk unrefined sunflower oil leads to a slowdown of oxidative processes in the oil in comparison with the control samples due to antimicrobial properties and high AOA in the nettle powder, equal to  $0.677 \pm 0.022$  mM-eq. Despite the lower quantitative indicators of acid and peroxide numbers when adding 1.0 wt. % nettle powder to the oil, it is advisable to use 0.5 wt. % nettle powder for subsequent high-quality filtration of unrefined oil when processed into refined oil. The practical application of the conducted research is determined by the repeatability of the results obtained.

### References

1. R.L. Soto, M. Martinez-Mena, M.C. Radilla, J. de Vente, *Agr. ecosyst. & environ.*, **306** (2020)
2. Z. Abail, I. K. Whalen, *Pedosph.*, **31(3)**, 405 (2021)
3. D. Vasu, G. Tiwari, S. Sahoo, B. Dach, A. Jangir, R.P. Sharma, R. Naitam, P. Tiwary, K. Karthikeyan, P. Chandran, *Cat.*, **198** (2020)
4. G. Zhang, F. Mo, F. Shah, W. Meng, Y. Liao, J. Han, *Agricul. wat. manag.*, **245** (2020)
5. N.V. Manokhina, *Nov. univer.*, **2(36)**, 52 (2014)
6. Ye.V. Lutsenko, V.N. Laptev, *Politem. set. el. nauchn. zhurn. Kub. gos. ar. un.*, 164, 128 (2020)
7. S. Ognivtsev, *Mezhdun. s.-kh. zhurn.*, **2(368)**, 77 (2019)
8. Ye.N. Trifonova, *Mezhdunar. (och.-zaoch.) nauch.-prakt. konf.*, 243 (2019)
9. Platforma APK, *Strateg. progr.* (2021)
10. N. Batova, P. Sachek, I. Tochitskaya, *BEROC Gr. Ec. Pol. Pap. Ser.*, 1, 14 (2018)
11. R.T. Timakova, YU.V. Il'yukhina, *Tekhn. pishch. i pererab. prom. APK – prod. zdor. pit.*, 3, 45 (2020)
12. E. N. Frankel, *Food Chem.*, **57**, 51 (1996)
13. N. V. Yanishlieva, *Eur.J. Lipid Sci. and Techn.*, **103(11)**, 752 (2001)
14. N.V. Makarova, M.S. Voronina, *Inn. i prod. bezop.*, **3(25)**, 82 (2019)
15. M. Asnaashari, R. Farahmandfar, R. Esmacilzadehkenari, *Int. J. Adv. Sci. Eng. and Technol.*, **5 (3)**, 38 (2017).
16. B. Aydeniz, E. Yilmaz, *Food Technol. Biotechnol.*, **54(1)**, 21 (2016)

17. D. Bopitiya, T. Madhujith, *Trop. Agr. Res.*, **25(3)**, 298 (2014)
18. L.V. Tereshchuk, O.V. Sharmanova, *Mezhdunar. nauch.-prakt. konf.*, 96 (2020)
19. A.V. Bašilov, *Vies. Nac. akad. navuk Bielarusi. Sier. ahrar. navuk.*, **1**, 110 (2009)
20. J.-H. Ahn, Y.-P. Kim, H.-S. Kim, *Food Contr.*, **23**, 528 (2012)
21. P. A. González-Fuentes, M. C. Zuñiga, C. A. Olea-Azar et al., *Cien. Inv. Agr.*, **44(3)**, 262 (2017)
22. A.P. Nechayev, A.V. Samoylov, V.V. Bessonov, Yu.V. Nikolayeva, V.V. Tarasova, O.V. Pilipenko, *Vopr. pit.*, **89(5)**, 101 (2020)
23. Kh.Z. Braynina (RU), A.V. Ivanova (RU), *Pat. № RU 2235998C2, RF* (2004)