

World Oil Seed Congress, Lviv, Ukraine, 2019



**PROCEEDINGS  
BOOK OF ABSTRACTS  
FIRST WORLD OILSEEDS  
CONGRESS**

**NOVEMBER 6-7, 2019**

**LVIV, UKRAINE**

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FIRST WORLD OILSEEDS CONGRESS**

**6-7 NOVEMBER, 2019,  
LVIV, UKRAINE**

**In  
Lviv, Ukraine**

**Organized by  
Trakya University**

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## WELCOME NOTES

We would like to welcome you to the First World Oilseeds Congress (WOS) organized by Trakya University with supports of BYSD, MUMSAD, YABITED, TURKTOB, TSUAB, BISAB and other related associations. This congress is a premier international science, bringing together with producers, trade, industry, technology and business focusing on oilseeds. The program will include a plenary session on oilseed production, markets, economics and the policies and regulations governing oil trade. The technical sessions will highlight invited and volunteer oral presentations on congress topics.

The congress will also give an opportunity to the scientists to present their research results expanding the current knowledge in the field and the industry personnel to introduce new products which may be interest to the global oilseeds and vegetable oil community. The attendees will have ample opportunities for learning, reconnecting, engaging, networking and meeting with producers, academia, industry, marketing and trade with exhibitors. We hope that this congress will facilitate a lively dialog between the scientific community and the industry. The congress will be green congress basis so as much as less papers will be used and with carrying out our environment. Abstract book will be published as electronic book in PDF format that will be distributed during the congress.

In November 2019, it will be held the first edition of the WOS Congress, with ambition of the organizers to make it a periodical event. We are proud to announce that in the WOS 2019 will take part more than 100 scientists and researchers from all over the world. There were submitted 70 scientific papers, of which 50 will be presented as oral talks and 20 as poster presentations. The full author list of all submitted papers comprises 184.

**Congress topics** will cover all oilseeds (sunflower, canola, peanut, flax, sesame, cottonseed, castor, palm, olive and other oilseeds) production, breeding, agronomy, biotechnology, etc. world oilseed and oil trade, oilseed and oil chemistry, oilseed and oil industry and sector, oilseed and oil equipment, nutrition and lipids, processing and industrial applications, food applications and products and methods and standards.

Lviv is a beautiful, lovely and historic city at the eastern edge of Europe. We are thrilled to host you all in Lviv, Ukraine and hope that you will take this opportunity to discover city and around with enjoyable time. We would like to thank you for joining to this congress. We extend our special thanks and gratitude to our sponsors and collaborators for supporting this event.

We wish you a nice stay in Lviv, Ukraine.

Prof Dr Yalcin KAYA

Head of the Organizing Committee

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## COMPARISON OF DIFFERENT FERTILIZATION VARIANTS ON *CAMELINA SATIVA* YIELD, PLANT HEIGHT AND OIL CONTENT

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### ABSTRACT

Oilseed plant *Camelina sativa*, the member of mustard (*Brassicaceae*) family, represents re-emerging low input oilseed energy crop with sustainable agronomic characteristics and environmental attractiveness. *Camelina* is a short-season crop adapted to the cool temperate regions of Europe, Asia, and North America. Although no original Slovak varieties are known to be preserved, *Camelina* recently attracts interest of Slovak agronomists and biofuel producers as it possesses many traits that make it an ideal candidate for the crop rotation schemes even on marginal lands and subsequent utilization for oil production. As a potential feedstock for the production of bio-components to fuels *Camelina* can contribute to achieve the increase of GHG savings. Main focus of this study was aimed to examine the effect of different fertilization conditions on *Camelina sativa* yield, plant height and oil content in Slovak region. Additionally, comparison study of two available varieties Zuzana (Czech variety) and Smilowska (Polish variety) was performed. Field trials evaluating 12 fertilization variants were conducted on spring 2018 and 2019 (as part of a long-term stationary experiment, founded in 1957), at the Research and Breeding Station Vígľaš-Pstruša, Slovakia. Nitrogen doses varied from 0, 40, 80, 120 to 150 kg.ha<sup>-1</sup> and were split into one to four dosages with or without P and K fertilizers. If fertilized with P and K, these were applied once prior to the seeding. The evaluated factors were: (A) – fertilization (12 fertilization variants), (B) – *Camelina* varieties (Zuzana, Smilowska) and (C) – year of study (2018, 2019). The influence of all factors on the yield, the height of plant and the oil content were assessed through multi-factor ANOVA. The study showed that fertilization with nitrogen and phosphorous has positive impact on seed yield, which is in accordance to the literature. Fertilization with nitrogen has positive effect on plant height. The growing conditions of individual year/season have largely influenced the seed yield as well as the height of the plants. It has been observed that oil yield is strongly related to temperature and precipitation conditions in individual year as well as the presence of fertilizers and type of *Camelina* variety.

**Keywords:** *Camelina sativa* (false flax), Fertilization, Seed yield, Oil content

## INTRODUCTION

False flax (*Camelina sativa*) is an annual plant that belongs to the *Brassicaceae* family. It occurs as winter form and also as a spring form. The height of the plants is between 30 - 90 centimetres. Leaves are mostly clenched, 2-8 centimetres long, usually without stems. Flowers are small of pale yellow colour. Seeds are tiny, yellowish - brown, generally 2 till 3 millimetres long. (Putnam et al., 1993, Francis, Warwick, 2009). The oil content of seeds is usually 38 - 43 % and contains 27 - 32 % of proteins (Gugel and Falk, 2006). Published literary sources state that content of oil in false flax seeds could be higher than 42 % with prevalent high content of unsaturated fatty acids. (Zubr, Matthäus, 2002; Abramovič, Abram, 2005; Berti et al., 2011).

False flax is not demanding to location and it is suitable for all production areas. It belongs to the earliest crops with a short vegetation time of about 3.5 months on average. It is possible to cultivate it as an alternative crop. The resistance to diseases and pests is high requiring only simple agro-technology (Stražil, 2008).

The growing of false flax in our territory is mainly intended for use in the non-food industry. False flax oil potential use is for the biofuels production, biofuel additives, for the pet food, aqua feed, animal nutrition markets as well as nutraceutical and personal care markets.

The prerequisites for expanding the false flax in our territory will be effective management of seed production and processing. It is important to develop the right cultivation technology and recommend it for cultivation practice according to Slovak climate conditions.

## MATERIAL AND METHODS

### Material

Two varieties of *Camelina sativa* were used in the experiment, namely Zuzana variety (Czech variety) and Smilowska variety (Polish variety).

Zuzana variety is a spring form of *Camelina sativa*, unpretentious for growing technologies and nutrition. It has been registered in year 2013. It is suitable for cultivation on all types of land except acidic and wet soils. It is characterized by rapid initial development and is therefore suitable competitor to weeds in the early stages. The advantage of this variety is a short growing time with good resistance to diseases and pests. It is moderately resistant to blue mold (*Albugo candida*). The variety is self-pollinating but responds very well to pollination. Oil content reaches 35 – 40 %. Its quality is comparable to linseed oil, but it contains more unconventional fatty acids such as myristic acid.

Smilowska variety is an early spring *Camelina* variety, native to Poland, registered and legally protected since year 2012. It is highly productive oilseed, not demanding on climatic and soil conditions.

### Field trials

*Camelina* spring varieties Zuzana and Smilowska were grown in trial fields at National Agricultural and Food centre, Research and Breeding Station at Víglaš – Pstruša, Slovakia (48°33'20"N 19°17'41"W) as part of a long-term stationary experiment, founded in 1957. The study was conducted for two growing seasons, year 2018 and year 2019, in Slovak cultivation conditions. The plots were 1.25 m wide and 6 m long, the acreage of 7.5 m<sup>2</sup>, with two replicates of each variant, the plot field testing selected fertilizer and a subplot representing its variety. Number of rows per plot were 10, with seeding rate 10 kg.ha<sup>-1</sup>.

Camelina was investigated under 12 different fertilizer inputs variants with respect to its yield performance. The trials evaluating 12 fertilization variants are listed in Table 1. Nitrogen doses varied from 0, 40, 80, 120 to 150 kg. ha<sup>-1</sup> with and without P and K combinations. P and K combinations are applied once in the spring prior to the seeding. N fertilization is divided into basic fertilization, regenerative fertilization, production and quality.

Camelina has been sown in mid-April 2018 and in almost March 2019 with Ojord seedling machine. Camelina seeds were harvested in almost/mid-July by a combine harvester. The moisture content was analysed and recalculated to 15 % humidity. Comparison of an agronomic characteristics and impact of fertilizers on the seed yield (t. ha<sup>-1</sup>), height of plants (cm), oil content (%) has been evaluated.

**Table 1.** Fertilization variants

| Fertilization variants | Doses and form of mineral nutrition (kg.ha <sup>-1</sup> ) |    |    |
|------------------------|--|----|----|
|                        | N  | P  | K  |
| 011*                   | 0  | 0  | 0  |
| 012                    | 0  | 60 | 60 |
| 013                    | 40   | 60 | 60 |
| 014                    | 80   | 60 | 60 |
| 015                    | 120  | 60 | 60 |
| 016                    | 150  | 60 | 60 |
| 021                    | 0  | 0  | 0  |
| 022                    | 120  | 0  | 0  |
| 023                    | 40   | 0  | 0  |
| 024                    | 80   | 0  | 0  |
| 025                    | 80   | 60 | 0  |
| 026                    | 80   | 0  | 60 |

\* Variant 011 tested on field where manure has been applied once per 4 years at dosage 10 t.ha<sup>-1</sup>

### Analysis of oil content

The cold pressing of Camelina seeds for further analyses was performed on Farnet Farmer 10 1FM pressing unit. The oil content was determined on samples of year 2018 and 2019 by extraction method with n-hexane and with gravimetric analysis.

### Calculations and statistical evaluation

The observed parameters of crop, height and oil content were evaluated in two experimental years (2018, 2019) and in two repetitions at 12 levels of mineral nutrition.

The results were evaluated by a multi-factor analysis of variance (ANOVA), where the fertilizer variant, variety and year were considered as sources of variability. Tukey's HSD multiple comparison test at significance level  $\alpha = 0.05$  was used to determine statistically significant differences between groups.

The statistical package STATGRAPHICS plus 5.1 was used for mathematical-statistical data processing using multi-factor analysis ANOVA.

## RESULTS

### Influence of fertilization, *Camelina* variety and year of cultivation on seed yield

Investigated fertilization variants had differed significantly (statistically  $p < 0.01$ ) (Table 2). Statistically, nitrogen fertilization has the most significant effect on the seed yield variability. The NPK (120-0-0), NPK (120-60-60) and NPK (80-0-60) variants proved to be the most optimal fertilization variants. From the results it is clear that P and K fertilizers are effective only in combination with N fertilizers. Already with application of 40 kg of N.ha<sup>-1</sup> (NPK 40-60-60) there was an increase in seed yield in both varieties (Figure 1, Figure 2), which represented an increase in seed yield of 36.2 % compared to the fertilization variant (NPK 0 -60-60).

The varieties of false flax have reacted differently to N fertilization. However, the effect of the variety on the seed yield of both years was not statistically significant. Interesting results were observed in the NPK (120-0-0) fertilized variant compared to the variant with additional phosphorus and potassium NPK (120-60-60). The Zuzana variety reacted very sensitively and the seed yield decreased by 20 % by adding phosphorus and potassium in 2019. In the Smilowska variety we have seen this phenomenon in both years. In 2018, the seed yield was reduced by 16.4 %, but in 2019 only 4 % (Figure 1, Figure 2).

The seed yield has been highly influenced by the year of cultivation (statistically  $p < 0.01$ ). The yield potential of the Czech Zuzana variety was 26 % higher in 2018 compared to 2019. In 2018, the yield potential of the Polish variety Smilowska was up 36 % higher than in 2019 (Figure 1, Figure 2).

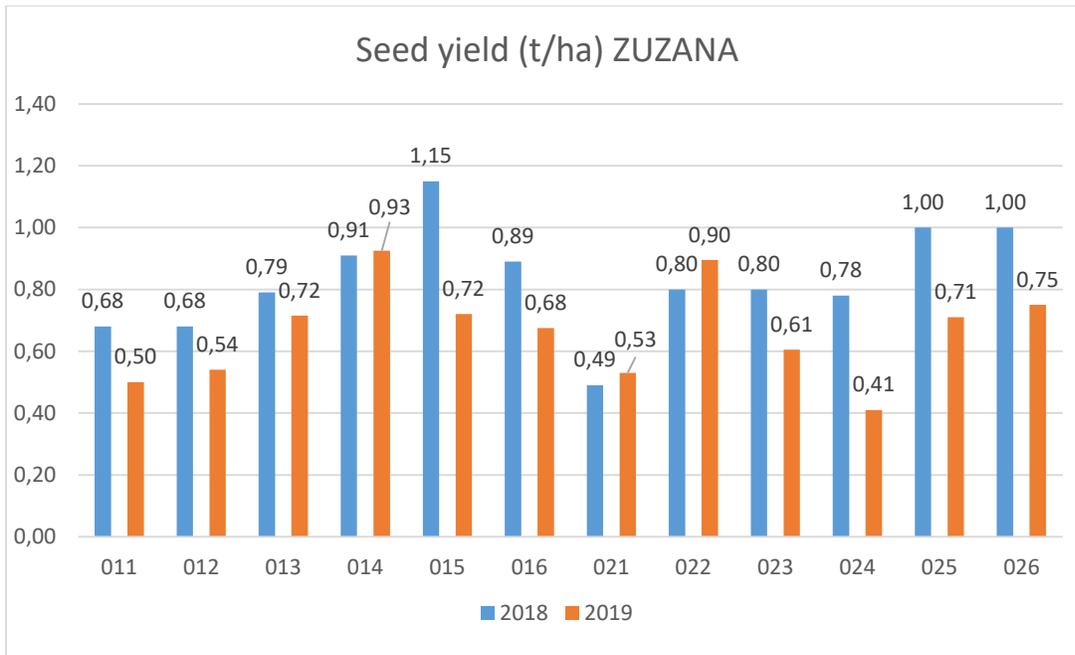
**Table 2.** Average values of seed yield, plant height and oil content in investigated years in individual fertilization variants

| Fertilization variants | Seed yield (t.ha <sup>-1</sup> ) | Height plants (cm)  | Oil content (%)     |
|------------------------|----------------------------------|---------------------|---------------------|
| 011 (NPK 0-0-0)        | 0.54 <sup>ab</sup>               | 72.1 <sup>ab</sup>  | 38.17 <sup>b</sup>  |
| 012 (NPK 0-60-60)      | 0.58 <sup>abc</sup>              | 71.5 <sup>ab</sup>  | 34.82 <sup>ab</sup> |
| 013 (NPK 40-60-60)     | 0.79 <sup>bcd</sup>              | 82.4 <sup>cd</sup>  | 36.46 <sup>ab</sup> |
| 014 (NPK 80-60-60)     | 0.83 <sup>cd</sup>               | 86.2 <sup>cd</sup>  | 33.54 <sup>ab</sup> |
| 015 (NPK 120-60-60)    | 0.88 <sup>d</sup>                | 88.7 <sup>d</sup>   | 33.65 <sup>ab</sup> |
| 016 (NPK 150-60-60)    | 0.76 <sup>bcd</sup>              | 87.9 <sup>d</sup>   | 31.17 <sup>a</sup>  |
| 021 (NPK 0-0-0)        | 0.45 <sup>a</sup>                | 68.8 <sup>a</sup>   | 35.15 <sup>ab</sup> |
| 022 (NPK 120-0-0)      | 0.89 <sup>d</sup>                | 80.1 <sup>bcd</sup> | 33.19 <sup>ab</sup> |
| 023 (NPK 40-0-0)       | 0.72 <sup>abcd</sup>             | 79.7 <sup>bcd</sup> | 34.41 <sup>ab</sup> |
| 024 (NPK 80-0-0)       | 0.69 <sup>abcd</sup>             | 76.2 <sup>abc</sup> | 34.65 <sup>ab</sup> |
| 025 (NPK 80-60-0)      | 0.85 <sup>cd</sup>               | 82.7 <sup>cd</sup>  | 34.48 <sup>ab</sup> |
| 026 (NPK 80-0-60)      | 0.87 <sup>d</sup>                | 82.6 <sup>cd</sup>  | 33.72 <sup>ab</sup> |
| $\bar{x}$              | 0.74                             | 79.9                | 34.45               |

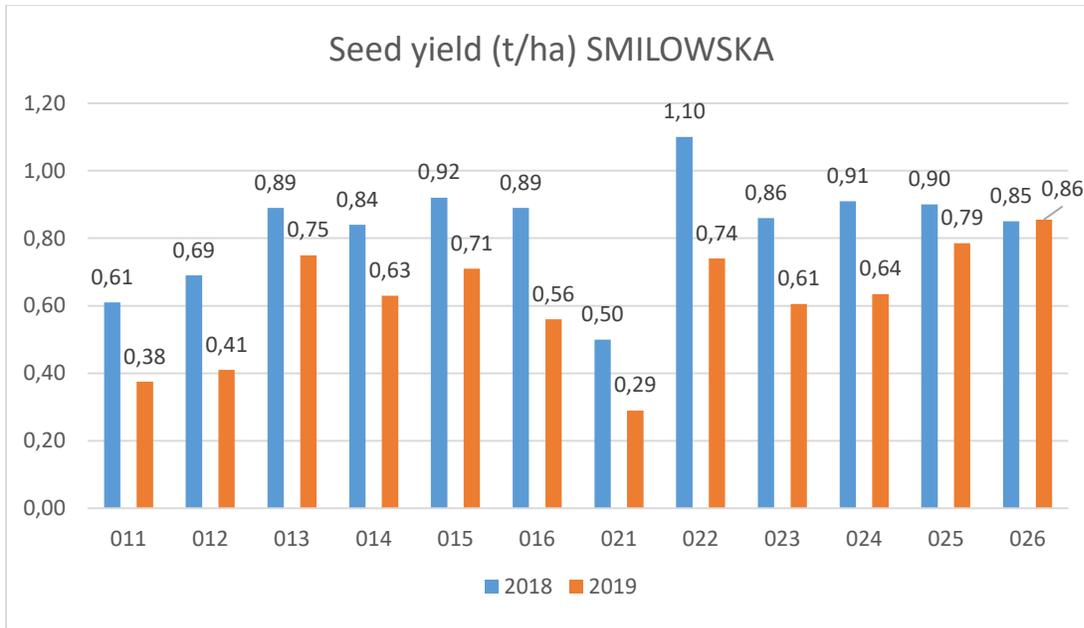
Averages within the column with different coefficients (a, b, c, d) are statistically significantly different at significance level  $\alpha = 0.01$ .

### Effect of fertilization, variety and year on plant height

Fertilization variants in our experiment had a statistically highly significant effect ( $p < 0.01$ ) also on plant height (Table 2). Both varieties in the experiment have grown within two years average with the highest stem obtained when the highest fertilization rates N in combination with P and K (120-60-60; 150-60-60) were applied (Table 2, Figures 3, 4). Naturally, the fertilizer variations with the lowest rates of NPK (0-0-0), NPK (0-60-60) had the lowest impact on the height of the false flax. The effect of variety and year on the plant height was not statistically significant.



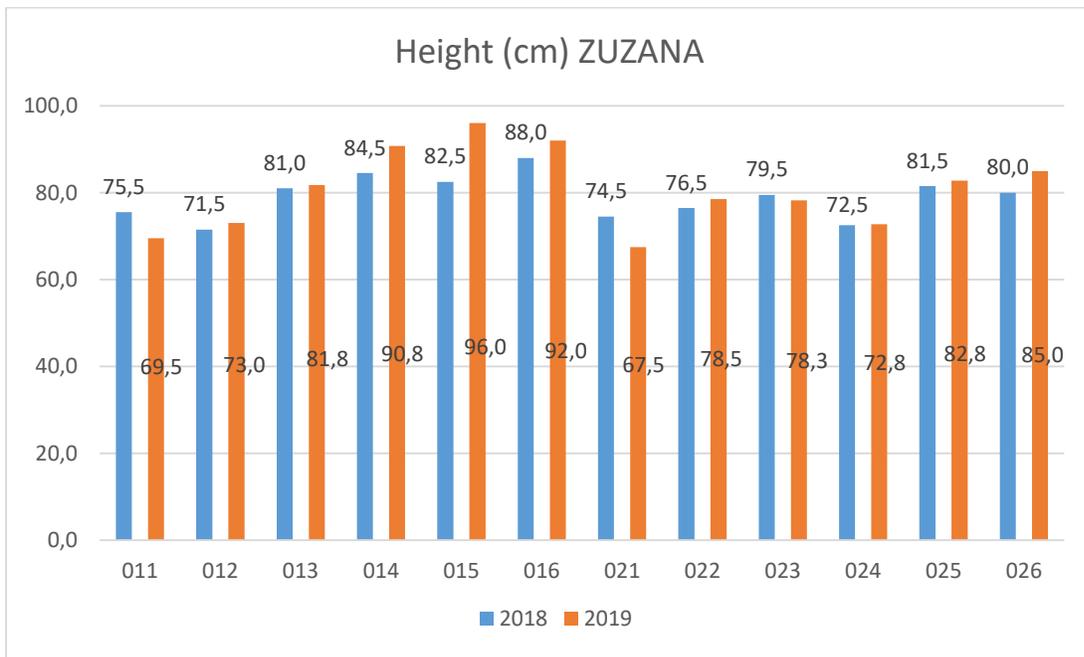
**Figure 1:** Seed yield of the variety Zuzana during the years 2018, 2019



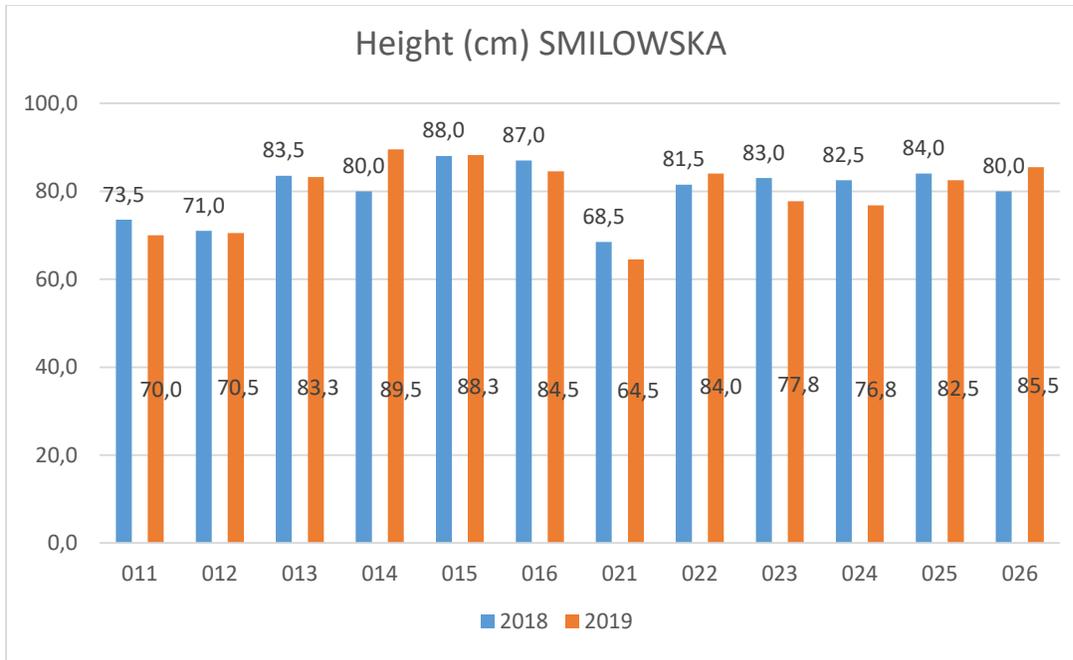
**Figure 2:** Seed yield of the variety Smilowska during the years 2018, 2019

**Influence of fertilization, variety and year on oil content**

Fertilization variants had statistically high significant effect ( $p < 0.01$ ) on the oil content. Nitrogen fertilization as well as phosphorous application reduced the oil content. This negative correlation is known for cereals and *Brassicaceae* family plants such as rapeseed. The application of nitrogen enhances the growth of the stem and increases the protein content in the seed and decreases the oil content in the seed. Phosphorous application causes increased production of phospholipids, that are not extracted into the oil, influencing overall oil yield.



**Figure 3:** The height of plants, variety Zuzana during the years 2018, 2019

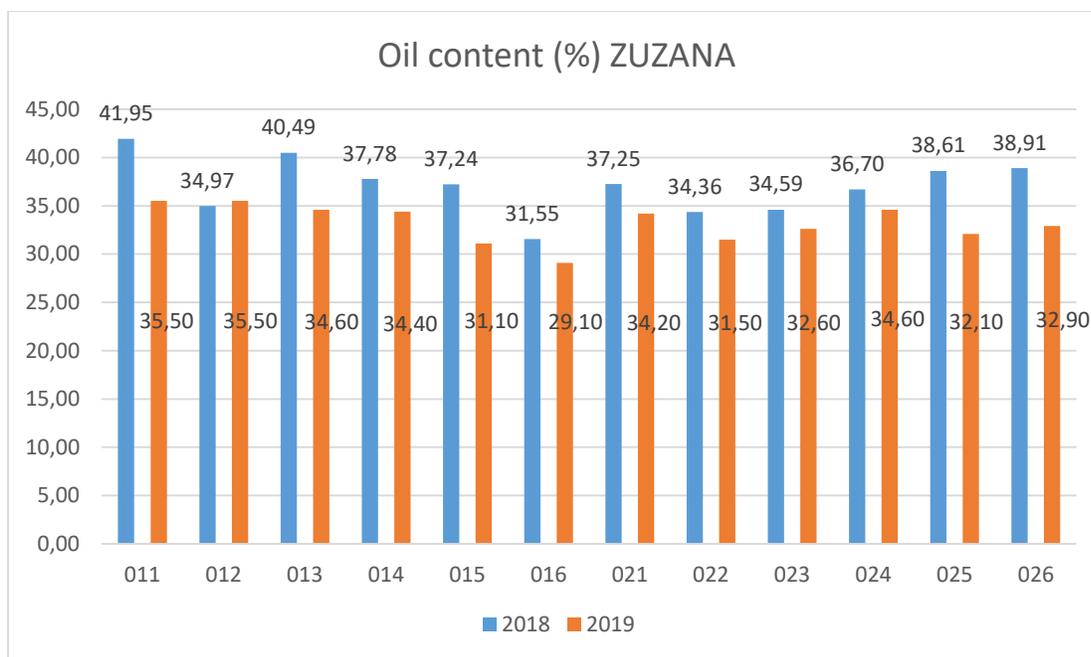


**Figure 4:** The height of plants, variety Smilowska during the years 2018, 2019

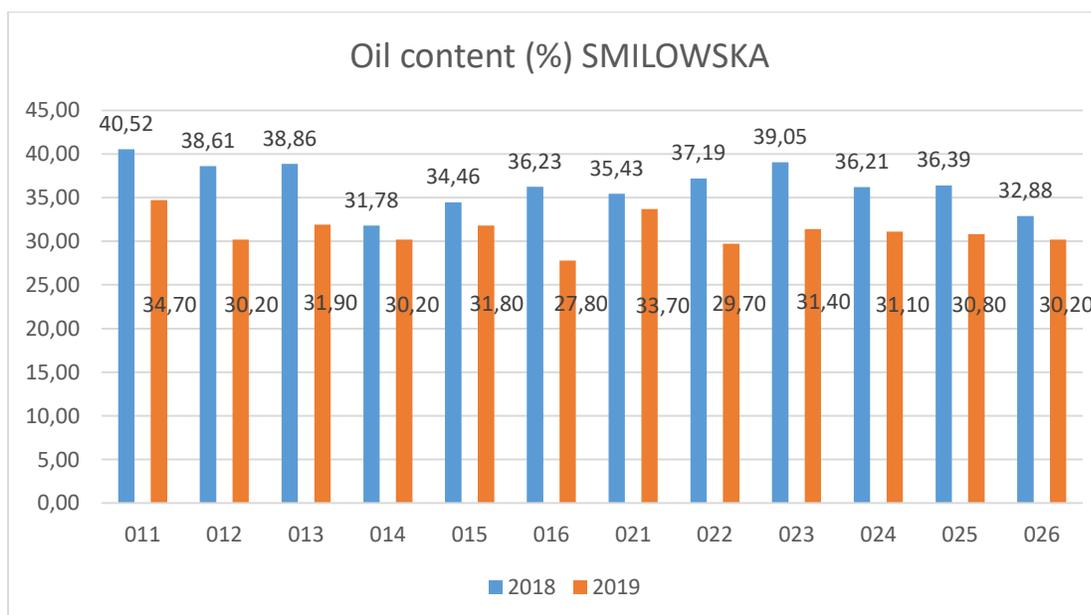
Values of obtained oil yields varied over an average of two years of testing from 38.17 % to 31.17 % (Table 2). The highest oil content in the seeds of the false flax was recorded for the variety Zuzana at the NPK (0-0-0) variant when manure has been applied once per 4 years at dosage 10 t.ha<sup>-1</sup> in 2018. On the other hand, the lowest oil content was detected for the variety Zuzana, but at the NPK (150-60-60) variant (Figure 5, 6).

The oil content of seeds varied depending on the year. In our experiment, the year had a statistically highly significant impact ( $p < 0.01$ ) on the oil content (Figure 5, 6). The lowest percentage of oil in seeds was recorded for both varieties in year 2019, when the weather during the ripening period (June, July) was very warm and dry (+ 3.85 ° C; -37.9 mm from long-term normal). The oil content in this year reached an average 32.15 % for both varieties, which is 4.6 % less than in year 2018.

The variety had a statistically significant effect ( $p < 0.05$ ) on the oil content. Higher oil contents in the seeds of the false flax have been observed for two years in the Czech variety Zuzana (Figure 5, 6).



**Figure 5:** Oil content, variety Zuzana during the years 2018, 2019



**Figure 6:** Oil content, variety Smilowska during the years 2018, 2019

## Discussion

Our experiment suggests that nitrogen is the most important nutrient to increase the yield of the seed of the false flax. Increasing doses of N fertilization had a positive effect on the increase in seed yield. The positive effect of higher doses of nitrogen on the seed yield was also confirmed in studies by other authors (Jiang et al., 2013; Jiang et al., 2014; Sintim et al., 2015). The optimum dose of nitrogen for false flax was determined by Jiang et al. (2013) at 120 to 160 kg.ha<sup>-1</sup>. Research

carried out in Germany confirms that the highest seed yield ( $2.28 \text{ t}\cdot\text{ha}^{-1}$ ) of spring form of false flax has been achieved with a combination of fertilizers with a dose of  $80 \text{ kg}\cdot\text{ha}^{-1}$  at sowing 400 seeds per  $\text{m}^2$  (Agegnehu, Honermeier, 1996). This was also confirmed in our experiment, where we have recorded the highest yields on average of two years and both varieties in NPK (120-0-0), NPK (120-60-60) and NPK (80-0-60) fertilizer variants. Karčauskiene et al., 2014 also confirm the highest seed yield achieved at dose of  $\text{N } 90 \text{ kg}\cdot\text{ha}^{-1}$  in summer form of false flax. Thus, we can conclude that higher doses of nitrogen (over  $120 \text{ kg}\cdot\text{ha}^{-1}$ ) in summer form of false flax have no significance effect for further increase of seed yield. In our experiment with the fertilization variant NPK (150-60-60) no higher seed yield was achieved in any of the studied varieties.

In the experiment, we have also observed a phenomenon where, at the N level of  $120 \text{ kg}\cdot\text{ha}^{-1}$ , the addition of phosphorus and potassium leads to a decrease in the yield. Solisa et al., 2013, also observed in their study the impact of nitrogen with phosphorus (P at 0, 50,  $100 \text{ kg}\cdot\text{ha}^{-1}$ ) on seed yield in various combinations. The maximum seed yield was at  $0 \text{ kg}\cdot\text{ha}^{-1}$  addition of P.

The height of the plants was clearly influenced by the fertilization variant. In both varieties, the average height of the plants was increased by approximately 19 cm due to the effect of mineral nutrition over two years of testing. The results are also confirmed by a team of Urbaniak, 2008, who claim that plant height, seed yield, oil content and protein content are nitrogen-dependent. Even in our experiment, both varieties reached the highest height at the highest fertilization rate in the NPK combination on average for years of testing.

Many authors (Agegnehu, Honermeier, 1996; Malhi et al., 2014) reported that nitrogen fertilization reduced the oil content of the seeds of the false flax. This was confirmed in our experiment. It can be stated that in both varieties, in tested period the higher doses of nitrogen N ( $40\text{-}150 \text{ kg}\cdot\text{ha}^{-1}$ ) reduced the oil content compared to the dose N ( $0 \text{ kg}\cdot\text{ha}^{-1}$ ) by 7 % (Table 2). In publication by Stražil (2008), it is mentioned that the warm and dry weather has negative effect causing the reduction of oil content in seeds of false flax. We can conclude that even in our trial in 2019 such weather had a negative impact on the oil content. Toncea et al. 2013, also stated that the oil content in the seeds of the false flax is strongly dependent on the weather conditions of the year.

## Conclusion

False flax is a suitable crop for growing in our growing conditions at low inputs into the production process. Based on the results of our work, we can recommend a dose of nitrogen fertilization at the level of  $80\text{-}120 \text{ kg}\cdot\text{ha}^{-1}$  for the cultivation of summer form of false flax. At higher doses of N fertilization, the false flax plants have reached the highest growth of the plants, but this led to subsequent lodging of the plants, and seed yield losses. The oil content was influenced mainly by the weather during the year and in part by the variety. By increasing amount of N fertilization the oil content has decreased.

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## ENVIRONMENTAL RESEARCH TO SMALL EMISSION IN THE PEDOSPHERE

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### ABSTRACT

The problem situation is identified and modeled, provides conditions and information for identifying the problem and possibly the problem is clearly formulated. Following is the phase of determining the objectives of the research of the assumed model as a set of systematized ideas and concepts about the mode, elements and parameters of the research. Based on this, they collect the necessary information and define the goals, methods and tools for their realization. Given that research goals can be realized in several ways with appropriate limitations, the third phase of systematic analysis starts with the formation of a criterion model that implements these constraints, and ends with the interpretation of these criteria. After completing the third phase of system analysis, the conditions for forming a system model are achieved. With additional information on the functioning of elements, their interconnections and their connection to the environment, the original model results in a system model. It is necessary to evaluate it on the basis of the criteria for evaluation and information on the parameters of the model parameters. A favorable rating indicates the possibility of applying systematic analysis in the system research process.

This paper will show the significance of environmental research to determine the level of soil contamination by heavy metals and organic pollutants, and the defining of zones with increased probability of occurrence of hazards. Then, the proposed measures will be to prevent and remedy the contaminated area, to prevent the harmful effects of heavy metals and organic pollutants on plants, animals and humans.

**Keywords:** *Environmental research, Analysis, Pedosphere, Pollution, Hazard, Prevention*

### INTRODUCTION

A high standard of living and economic development has been achieved through the construction of industrial plants and technological progress, which has led to disruption of environmental quality parameters. As a result, there is a burden on the sphere of the environment. Environmental protection should not be conditioned by economic and social development, looking through the social aspect, and at the expense of the environment of a healthy life. To manage economic activities in accordance with the environment means to carry out activities with respect to the principles and use of environmental protection criteria. Due to the emissions of various gases and solid particles from industrial plants, it causes pollution of air, water and soil. Soil contamination leads to pollution of drainage and groundwater. The quality of agricultural crops, which are constantly exposed to adverse impacts, and the accumulation of toxicants in plants, is particularly jeopardized. Heavy metals originate from industrial plants as well as organic pollutants. The effects of the load on the pedosphere are negatively affecting the animals of the animals and people who consume agricultural products produced on such land.

By launching a program for monitoring the state of physical and chemical parameters of agricultural land and plants grown on it, it enables observation of unfavorable changes and determining the prevention of degradation and the elaboration of the rehabilitation program or soil remediation.

The research includes: field research, laboratory testing, data processing. For intensive crop production, favorable soil fertility is required. One of the conditions of fertility is the supply of this soil to nutrients, which is learned by examining soil in arable land, in orchards and vegetable plants. Therefore, chemical soil analysis becomes a necessity for modern agriculture. The limit values for heavy metals and organic pollutants are determined according to the legislation, in accordance with the Law on Agricultural Land. The main task of this research is to determine the degree of contamination of agricultural land with heavy metals and organic pollutants, and then assess the possibility of agricultural production in certain areas of the lower Spreča river. Soil protection is based on analysis of the causes of pollution, rehabilitation procedures and reuse.

This paper will show the importance of environmental research on determining the level of soil contamination with heavy metals and organic pollutants and defining the prediction hazard zones.

### **System - Concept and Content**

System (σύστημα σύστημα: an association, a whole of several parts, a composition), a set of elements, real or abstract, presented as whole where all the elements interact with each other or are connected with at least one other element and all have a common goal. Under the system are all processes and phenomena expressed by different means. The system can display, familiarize and explain real objects with the system. There are different system definitions. Russian theorist Sadvovskii has set three different sets of system definitions. It determines the first group as a mathematical abstraction by showing dynamic phenomena.

The other group is defined by different terms such as: element, relationship, relationship, whole.

The third group consists of different concepts: state, input, output, information, management. The system is a set of separated, mutually related elements, which together with their environment make up a whole. Symbolic system is displayed in the form 1:

$$S = \{E, V, F\} \dots\dots\dots (1)$$

where: S - system; E - set of system elements; V - set of links; F - system goal functions.

On the basis of the criteria, the types of systems can be defined: static, dynamic, homeostatic and cybernetic. Systems in our environment are becoming increasingly complex. The complexity of modern systems stems from the existence and interaction of different resources (human, financial, physical, information), as well as from the characteristics of the dynamic and turbulent environment in which they are. Analysis and management of complex systems can not be based on classical engineering methods and methods, without deeper consideration of problems, priorities, interactions, available resources, and in particular without assessing the effects and verification of selected solutions or decisions made. One of the basic problems present in complex systems is the problem of analysis and risk management.

### Phases and Functions of System Analysis

System analysis is carried out through several basic phases and functions. The phases of the systemic analysis are rounded up of purposeful units within the research process. There are 5 basic phases of systemic analysis: formulating research problems, defining objectives, determining constraints and formulating criteria, defining the system, evaluating the functioning of the system. Each phase of the system analysis is carried out in accordance with the advance defined approach (model) on the basis of which the relevant information is collected and concludes within the framework and with the formed model. System analysis functions are interconnected (Table 1). The model of any aspect of system research has meaning through concrete information that is embedded in it and maintains the actual situation.

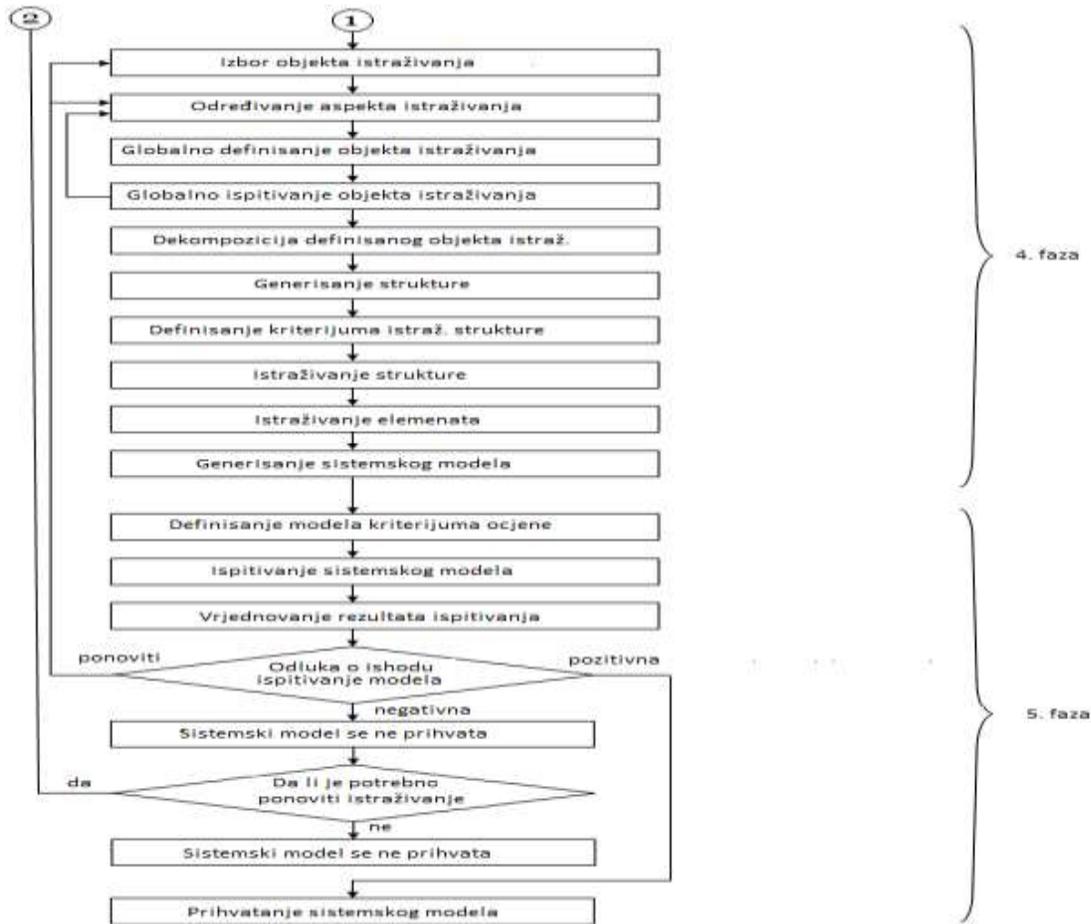
**Table 1.** Interaction of phases and systemic analysis functions

| <b>Funkcije<br/>Faze</b>                            | <b>Formiranje<br/>modela</b> | <b>Prikupljanje<br/>informacija</b>                  | <b>Sinteza</b>                |
|---|------------------------------|--|-------------------------------|
| Formulating research problems                       | Problem situation model      | Information for identifying and formulating problems | Interpreting the problem      |
| Determination of research objectives                | Research model               | Information for modeling the model                   | Interpretation of objectives  |
| Determination of Limits and Formulation of Criteria | Criterion Model              | Information on Interpretations                       | Criteria Interpretation       |
| System definition                                   | System model                 | Information for model detailing                      | Synthesis of the system model |
| Assessment of System Functionality                  | Model Criteria Assessment    | Information for Assessment of Functioning            | System Rating                 |

System research begins with a problem-solving phase in which it is recognized and modeled by a problem situation, providing conditions and information for identifying problems and, if possible, formulating the problem.

The research phase is followed. In that sense, it is necessary to have some research model as a set of systematized ideas and concepts about the mode, elements and parameters of the research. On this basis, the necessary information is collected and goals are defined, as are the methods and tools for their realization. The third phase of systemic analysis begins with the formation of a

model of criteria that implement these constraints and ends with the interpretation of these criteria. After the third phase of the system analysis has been completed, the conditions for forming the system model are met. With additional information in the functioning of the elements, their interconnections and relationships with the environment, the original model results in a system model. A favorable evaluation shows the possibility of applying a system model in the process of system research (Figure 2).



**Figure 2.** System algorithm for system analysis

### Formulating research problems

The task of the research can be clearly formulated if the conditions and method of application of the investigated system (structure, environment, behavior) are known and the goal to be achieved. The symbolic task of the research can be written in the form: (U; N; C)

where they are:

U - system application conditions

N - the method of applying the system

C - the goal of the system

If only the conditions and method of applying the system are known, without a clearly defined goal, we are talking about the situation. It is symbolically written: (U; N; -)

An investigational problem in the record: (-; -; C) occurs when the target system is known, while the conditions and method of application are not given.

When, instead of formulated conditions, we figure out indefinite sets of factors, and instead of a clearly defined goal - unspecified assumptions and requirements, we are talking about a problematic situation that is symbolically written (-; -; -)

Recognizing the problem situation is the basis of the preliminary research in which the information needed to formulate the research problem arises. If, on the basis of the information collected, the problem is clearly formulated, we are talking about a structured problem. The unspecified formulation of the objectives of the system points to an unstructured problem, or to the formulation of a problem situation.

### **Defining research objectives**

The goal of system research is to solve the problem. Structured problems involve clearly defining research objectives, while unstructured problems condition the uncertainty of research objectives.

The objectives of the research should be:

- adequately formulated (clear to all research participants);
- measurable (quantitative or qualitatively investigated);
- achievable (only achievable goals make sense);
- time limited (achievable in a predefined time period).

Regardless of the type of problem, the research should formulate the conditions and methods of applying the systems that achieve the goals of functioning. Therefore, the research objectives are closely related to the objectives of the research system. The goals of the system can be: existential, developmental, service.

The main goal of each system is survival, ie the preservation of existence. This goal is achieved by the basic function of the system. The assumption of long-term survival is development - the goal that is achieved by the development function of the system. The system is a product that needs to satisfy the needs of the user, individual or society. Complex systems have complex goals that can be achieved through the realization of certain sub-goals.

### **Formulation of research criteria**

The limitations of research objectives are the consequence of resource constraints (material, economic, energy, information, and time) and most often show a set of inequalities.

The aims of the research themselves are presented using the criteria. By their nature, the criteria can be qualitative and quantitative. Quantitative criteria are supported by criteria functions or quantitative values, and qualitative criteria - qualitative grades.

The choice of criteria and the determination of their value depends on the purpose of the research and the limitations. Criteria allow you to compare alternatives for achieving research goals and selecting the best function or a set of optimal alternatives.

### **Aspects of systemic analysis**

The definition of a research system begins with the determination of a set of possible aspects of observation. In researching and solving complex system problems, six basic aspects of observation are used: philosophical - systemic, cognitive - methodological, natural - scientific, technical - technological, economic - financial.

The relevance of individual aspects depends on: the aim of research, knowledge and intuition of researchers, techniques and tools of research, the complexity of research facilities, available resources, research time, etc. Since the systemic approach implies only the essential aspects of the existence, function, development, behavior and management of the system, it is therefore necessary to form a set of criteria for the evaluation and ranking of certain aspects. In this way it is possible to define a set of aspects of system observation, and whose elements are important aspects of observation  $\alpha_i$  ( $i = 1, \dots, n, m$ , which shows the equation 2).

$$\alpha = (\alpha_1, \alpha_2, \dots, \alpha_i, \dots, \alpha_n) \dots\dots\dots (2)$$

### **Report by the Federal Institute for Agropedology on the monitoring of the river, as a basis for systematic environmental research**

The Federal Institute for Agropedology has presented the results of the analysis of the soil and plant material sample in this area as part of the project "Monitoring of the Lower Spraeck River Basin", where the concentrations of heavy metals exceeding the limit values have been determined. For example, in the 2015 report the live content (Hg) is above the permitted limit value and is 1,314 [mg / kg]. In the valid legislation in the FBiH, the limit for the content of the total live form in the soil is 0.5 [mg / kg] for sandy soils. The Preliminary Risk Zone for the cultivation of agricultural crops in the total area of 351 [ha] was defined, (Figure 3). It has been stated that a rehabilitation program for this area needs to be developed, preventive measures and long-term soil protection measures have to be developed.



**Figure 3.** Sprečansko polje na području općina Lukavac i Gračanica

In the report of the Federal Institute for Agropedology on the monitoring of the lower flow of the Spreča River for 2016, the rest stated that at 24 microlocation the contents were living in the soil, above the allowed limit value. The increased values of this, according to the health of people, of very dangerous heavy metals, range from (0.922 - 3.653) [mg / kg] per sample. The results of live content in the country in 2016 are higher than in 2014 and 2015. In most samples, the increased content of the total forms of heavy metals in the soil was detected, nickel, whose values ranged from (67.37-1136.80) [mg/kg], and chromium from (39.60-329.70) [mg/kg]. In 2016, the value of cadmium increased only at one location, which was not the case in the 2014 and 2015 surveys.

These results prove that heavy metals and Polycyclic Aromatic Hydrocarbons (PAHs) in the soil are applied to the flowing waves of the Sprecha River. When it comes to nickel and chromium, it was concluded that their presence in the watercourse from the crust of decomposition of the geological substrate in the upper course of the Spreče River, while other heavy metals and Polycyclic Aromatic Hydrocarbons can be linked to the industry in the Tuzla basin.

## CONCLUSION

The maintenance of pedohigienism, that is soil and soil hygiene, is an imperative in the cultivation of health-healthy food with adequate preservation of the natural environment. Since these two conditions are inseparable (healthy nutrition and environmental protection), they should be considered as one whole and thus related to them. The "load" of soil is primarily concerned with mechanization, mineral fertilizers, contamination of soil with heavy metals, pesticides and aerosols.

In order to give a complex system an adequate method, it is necessary to use a certain methodology. System analysis represents a general methodology of system research aimed at defining the problems in the system and determining the ways and ways of their solution. System analysis is carried out through five basic phases: formulation of research problems, determination of research

objectives, determination of limitations and formulation of criteria, definition of both system and method of functioning of the system, as well as through three functions: model formation, information collection and synthesis of information using the model. Each phase of the system analysis is carried out in accordance with a predefined approach on the basis of which the information is collected and concludes through the synthesis of the collected information, within and through the formed model.

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## PHYSICOCHEMICAL CHARACTERISTICS OF ALGERIAN AND TURKISH *PINUS HALEPENSIS* SEED OILS EXTRACTED BY DIFFERENT METHODS

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### ABSTRACT

*Pinus halepensis* (Aleppo pine) is an endemic species grown in the Mediterranean countries. The present study aims to investigate the differences of physicochemical composition of *Pinus halepensis* seed oils obtained from Algerian and Turkish varieties by solvent maceration (hexane) and cold pressing techniques. Refractive indices of the oils ranged from 1.4491 to 1.4584. The acid values of the oils were found between 0.07–0.22% oleic acid and significantly ( $p < 0.05$ ) affected by origin of the seeds. Iodine and peroxide values ranged between 105.85–124.52 g/100g and 0.99–6.85 meq O<sub>2</sub>/kg, respectively. Interaction between origin and oil extraction method significantly ( $p < 0.05$ ) affected these two values. On the other side, only oil extraction method had a statistically significant ( $p < 0.05$ ) effect on K<sub>232</sub> values. In general, solvent-extracted seed oils had higher K<sub>232</sub> values than cold-pressed ones in this study. Total carotenoids, total chlorophylls contents and total antioxidant activities ranged between 0.81–1.36 mg lutein/kg, 2.35–3.43 mg pheophytine a/kg, and 17.25–26.94 mM Trolox equivalent/kg, respectively. All these parameters were significantly ( $p < 0.05$ ) affected by origin × oil extraction method interaction. Cold-pressed *Pinus halepensis* seed oils had significantly ( $p < 0.05$ ) higher total phenolic contents than solvent-extracted oils. *Pinus halepensis* seed oils were majorly consisted of linoleic, and oleic acids. The highest contents of linoleic acid were found in cold pressed oils (58.41–57.87%), while the lowest contents were found in hexane-extracted oils (56.64–56.81%) of Algerian and Turkish seed varieties, respectively. The results of this study suggest that *Pinus halepensis* seeds can be considered as a good source of high-quality oil. It could be economically used as valuable natural products for industrial, cosmetic and phytotherapy uses.

**Keywords :** *Chemical characteristics, Cold pressing, pinus halepensis, Solvent maceration*

### Abbreviations :

C.PH.A : Algerian *Pinus halepensis* seed oils obtained by cold pressing technique

C.PH.T : Turkish *Pinus halepensis* seed oils obtained by cold pressing technique

S.PH.A : Algerian *Pinus halepensis* seed oils obtained by solvent maceration technique

S.PH.T : Turkish *Pinus halepensis* seed oils obtained by solvent maceration technique

## INTRODUCTION

*Pinus halepensis* is an endemic species which is extensively cultivated in the Mediterranean basin. It can diversely be used in traditional food preparations (Kadri et al., 2013). It has been shown that *Pinus halepensis* seeds are rich in lipids and fatty acids (Cheikh-Rouhou et al 2006 and 2007; Kadri et al., 2013). They are used as natural remedy for several diseases (Watanabe et al., 1995). The aim of this study was therefore to examine physicochemical characteristics and antioxidant activities of Algerian and Turkish *pinus halepensis* seed oils extracted by different methods. The seed oils have a potential applications in cosmetic, food and medicine.

## MATERIAL AND METHODS

### Experimental Design

*Pinus halepensis* seed oils from Algerian and Turkish varieties obtained by using two methods such as cold pressing (Toper Machine, Turkey) and solvent maceration techniques. Peroxide value, free fatty acid, conjugated dienes, iodine and p-anisidine values of oils were determined by using standard methods (TS,2015a; TS,2015b; AOCS, 1997). Total carotenoids and total chlorophyll contents were measured by UV-Spectrophotometer according to the Minguez-Mosquera et al. (1991). Total phenolic content was estimated by Folin-Ciocalteu assay (Hrncirik and Fritsche, 2004). To evaluate the antioxidant activity of oils, DPPH – radical scavenging test was used (Rotondi et al., 2004). Fatty acid composition was determined as fatty acid methyl esters using a Gas Chromatography (Agilent 6890 series) as described by AOCS (2009).

### Statistical analysis

Results of descriptive analyses are expressed as mean and standard deviation (SD). The obtained results were performed in three replicates and were analyzed using a 2-factorial design by using SAS Statistical Analysis Programme (SAS, 2001).

### Results

Color and refractive index values of Algerian and Turkish *pinus halepensis* seed oils are given in Table 1. The lightness values of the oils were found near to hundred. While (-) a value signifie greens, (+) b value signifie yellowness. As for statistical analysis result, the interaction of treatment and origin affected the a values of oils ( $p < 0.05$ ). In case of importance of interactions, we didn't analyse treatment and origin separately. Treatment and origin did not affect refractive index values and lightness, statistically ( $p > 0.05$ ). Only the effect of origin was found statistically important on b values ( $p < 0.0001$ ).

In respect of chemical properties, CPHA possess the lowest peroxide value (PV) as 0.99 meq  $O_2$ /kg oil (Table 2). The PV of other oils were found higher than CPHA but nevertheless, they are below the limit of 15 meq  $O_2$ /kg of oil according to the Turkish Codex on Vegetable Oils. Only the effect of origin was found significantly important on free fatty acid composition of oils ( $p < 0.05$ ). Conjugated diene values were affected from treatment and iodine values were affected from interaction of treatment and origin ( $p < 0.05$ ). Iodine values of cold pressed oils are higher than solvent extracted oils and ranged between 120.37- 124.52 g/100 g.

Figure 1 shows the changes of total carotenoid and chlorophyll contents of oils. Almost all values are similar and were determined between 2.35-3.42 mg/kg and 0.81-1.34 mg/kg, respectively. For all of the oils tested in this study, the total polyphenol contents ranged from

246.29 to 329.94 mg GAE/ kg of oil. Particularly, the oils obtained by cold pressing method contained great amounts of total polyphenols as 326.94 mg GAE/ kg for turkish variety and 301.3 mg GAE/ kg of oil for Algerian variety followed by solvent extracted oils (Figure 2). While treatment affected significantly total phenolic contents of oils ( $p < 0.05$ ), no statistically importance of origin was observed ( $p > 0.05$ ).

To compare the antioxidant activity of *pinus halepensis* seed oils, DPPH scavenging activity was tested. The results revealed that DPPH ranged from 17.25 to 26.94 mM TE / kg of oils (Figure 3). According to the obtained values, cold pressed oils are more stable than solvent extracted oils. The highest antioxidant activity was observed for the oils in which total phenolic contents were also higher. There are no more studies on antioxidant activity of *pinus halepensis* seed oils so, it's thought that our results will shed light on future studies.

Regarding to the fatty acid composition, linoleic acid is the major fatty acid for *pinus halepensis* seed oils followed by oleic acid, palmitic acid, linolenic acid and stearic acid, respectively (Table 3). When compared our fatty acid composition results with the results of other researchers, it can be seen that there are in good accordance (Cheikh-Rouhou et al 2006 and 2007; Kadri et al., 2015).

## DISCUSSION

In this study, antioxidant activity and physicochemical properties as well as carotenoid, total chlorophylls, carotenoid and phenolic contents, fatty acid compositions of *pinus halepensis* seed oils extracted using different methods has been examined. The results revealed that seed oils extracted from Algerian and Turkish *Pinus halepensis* seeds (C.PH.A and C.PH.T) contained many bioactive compounds and pigments such as phenolic, carotenoids and chlorophylls. The amounts of minor compounds such as phenols (301.3 - 329.94 mg/kg oils), chlorophylls (3.19 - 3.42 mg/kg oils) and carotenoids (1.34 - 1.36 mg/kg oils) were found higher in cold pressed oils than solvent extracted oils. At the same time, cold pressed seed oils possess higher antioxidant activity and phenolic content than the solvent extracted oils. They are also rich in oleic acid which prevents human of heart diseases and in linoleic acid which has a beneficial effects on atherosclerosis and inflammatory diseases and is indispensable for the healthy growth of human skin (Connor, 2000; Bruckert, 2001; Nergiz and Donmez, 2004).

## CONCLUSION

Cold pressing is one of the safe technique of the green chemistry methods that it ensures extraction and conservation of bioactive compounds in oils at less time and does not require refining process. Results of physicochemical parameters reveal that *Pinus* seeds are a good source of quality oil. The high content of fatty acids and minor biactive compounds found in cold pressed seed oils obtained from Algerian and Turkish *Pinus halepensis* seeds suggest that it could be nutritionally considered as a natural supply for pharmaceutical industries, edible purposes and provide health benefits to the consumers.

**Acknowledgements:** This work was done as part of doctoral thesis (2018) of PhD student Sihem AIT ATMANE. We appreciate to the Turkish and Algerian laboratories collaboration.

**Table 1:** Colour and refractive index values of *Pinus halepensis* seed oils

| Samples            | L     | a      | b       | Refractive Index (n D20C°) |
|--------------------|-------|--------|---------|----------------------------|
| C.PH.A             | 86.04 | -5.41  | 30.33   | 14.585                     |
| C.PH.T             | 92.24 | -5.65  | 23.47   | 14.491                     |
| S.PH.A             | 86.74 | -6.90  | 30.97   | 1.4549                     |
| S.PH.T             | 80.82 | -4.20  | 23.50   | 1.4545                     |
| Treatment          | ns*   | -      | ns      | ns                         |
| Origin             | ns    | -      | p<.0001 | ns                         |
| Treatment × Origin | ns    | p<0.05 | ns      | ns                         |

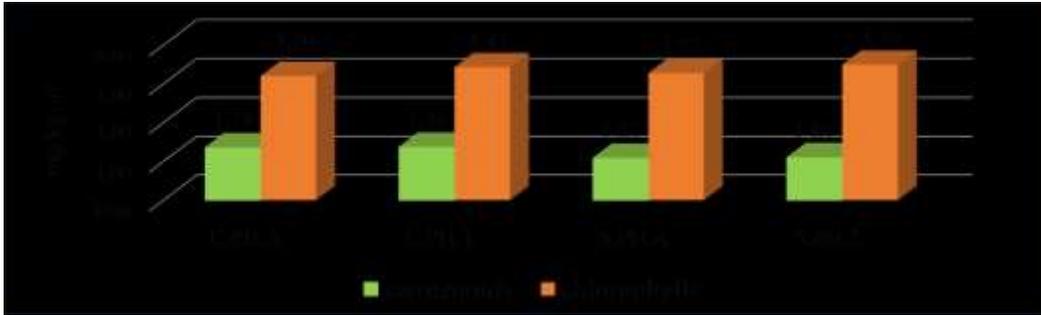
\*not significant

**Table 2:** Chemical properties of *Pinus halepensis* seed oils

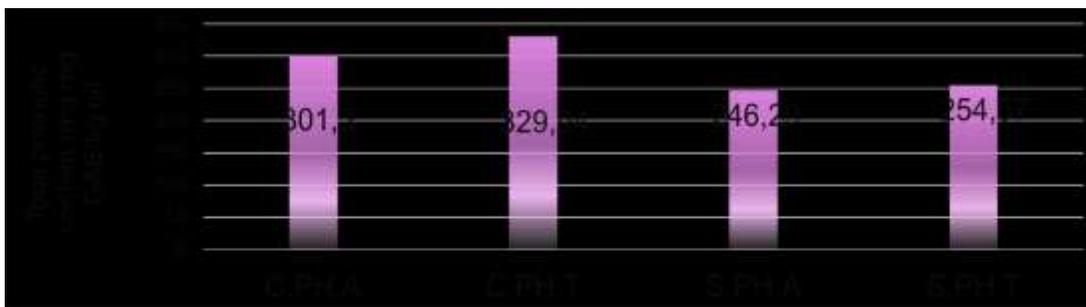
| Samples            | Peroxide value<br>(meq O <sub>2</sub> /kg oil) | Free fatty acid<br>(oleic acid, %) | Conjugated dienes<br>(%) | Iodine value<br>(g/100 g) | P-anisidine value |
|--------------------|--|------------------------------------|--------------------------|---------------------------|-------------------|
| C.PH.A             | 0.99   | 0.22                               | 0.016                    | 120.37                    | 0.352             |
| C.PH.T             | 5.90   | 0.10                               | 0.016                    | 124.52                    | 0.727             |
| S.PH.A             | 6.58   | 0.20                               | 0.020                    | 113.65                    | 0.351             |
| S.PH.T             | 3.62   | 0.07                               | 0.018                    | 105.85                    | 0.487             |
| Treatment          | -  | ns                                 | P<0.05                   | -                         | ns                |
| Origin             | -  | P<.0001                            | ns                       | -                         | ns                |
| Treatment × Origin | P<0.05   | ns                                 | ns                       | P<0.05                    | ns                |

**Table 3 :** Fatty acid compositions of *Pinus halepensis* seed oils (%)

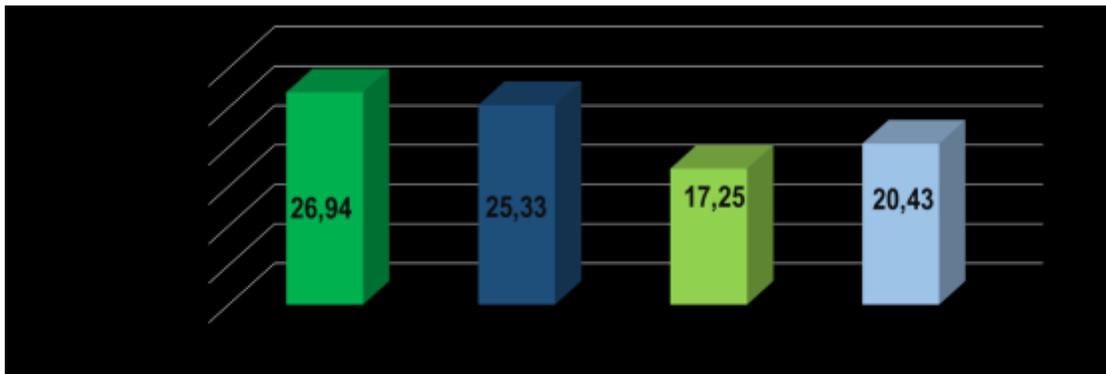
|                            | C.PH.A | C.PH.T | S.PH.A | S.PH.T | Treatment (T) | Origin (O) | T × O  |
|----------------------------|--------|--------|--------|--------|---------------|------------|--------|
| Palmitic acid (C16:0)      | 4.83   | 4.74   | 4.85   | 4.72   | ns            | ns         | ns     |
| stearic acid (C18:0)       | 3.25   | 3.22   | 3.40   | 3.10   | -             | -          | P<0.05 |
| Arachidic acid (C20:0)     | 0.49   | 0.55   | 0.51   | 0.54   | -             | -          | P<0.05 |
| Heneicosanoic acid (C21:0) | 0.44   | 0.55   | 0.47   | 0.54   | -             | -          | P<0.05 |
| Behenic acid (C22:0)       | 3.50   | 3.68   | 3.58   | 3.61   | ns            | P<0.05     | ns     |
| ∑SFA (%)                   | 12.50  | 12.73  | 12.80  | 12.51  | -             | -          | P<0.05 |
| Oleic acid (C18:1)         | 23.18  | 23.94  | 24.71  | 25.31  | P<0.05        | ns         | ns     |
| Eicosenoic acid (C20:1)    | 0.80   | 0.76   | 0.81   | 0.78   | ns            | ns         | ns     |
| ∑MUFA (%)                  | 23.98  | 24.70  | 25.52  | 26.09  | P<0.05        | ns         | ns     |
| Linoleic acid(C18:2)       | 58.41  | 57.87  | 56.64  | 56.82  | P<0.05        | ns         | ns     |
| Linolenic acid(C18:3)      | 4.34   | 3.99   | 4.28   | 3.89   | ns            | P<0.05     | ns     |
| Eicosadienoic acid(C20:2)  | 0.55   | 0.49   | 0.52   | 0.48   | ns            | P<0.05     | na     |
| Arachidonic acid(C20:4)    | 0.22   | 0.22   | 0.24   | 0.22   | ns            | ns         | ns     |
| ∑PUFA (%)                  | 63.52  | 62.57  | 61.68  | 61.40  | P<0.05        | ns         | ns     |



**Figure 1 :** Changes in total carotenoids and chlorophyll contents of *Pinus halepensis* seed oils according to the extraction method and origin



**Figure 2 :** Changes in total phenolic contents of *Pinus halepensis* seed oils according to the extraction method and origin



**Figure 3 :** Changes in total antioxidant activity of *Pinus halepensis* seed oils according to the extraction method and origin

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## CONDITION AND PROSPECTS OF OILSEED PRODUCTION IN UKRAINE IN THE CONTEXT OF THE GLOBALIZATION

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### ABSTRACT

The study was carried out to describe the main trends in the world oilseeds market. It is revealed that the market of oilseeds is characterized by high dynamics of development. The structure of oilseeds cultivation by their species in the world is investigated. A significant share in the Ukraine's oilseeds structure of sunflower, rapeseed, and soybeans is revealed. The world demand and supply for sunflower seeds is outlined. The analysis of importing and exporting countries of oilseeds in the world is made. The importance of the influence of the Polish oilseed production market on the development of the Ukrainian oilseed market is substantiated. The dynamics of world oilseeds production and the share of Ukraine and Poland are analyzed. The state and prospects of oilseed production both in Ukraine and Poland are investigated. It is revealed that in Poland the main oilseed plant is rapeseed, and in Ukraine sunflower is predominant. We saw an increase in oilseed production both in Poland and Ukraine. The structure of demand for oilseeds has been investigated. It is justified that the growing demand for oilseeds in Poland is related to the development of biofuel production, while in Ukraine it is due to the growing demand on the world oilseeds markets and oilseeds in general.

**Keywords:** *Oilseeds, Production, Consumption, Global market, International trade*

### INTRODUCTION

In the last decade, Ukraine has become an integral part of the global market for oilseeds and their products, which is deeply integrated into the global structure of labor distribution. Our country is a powerful supplier and holds the first place in the world market of sunflower oil, rapeseed and soybeans. But Ukraine has not yet exhausted its potential to further develop and increase the production and export of oilseeds and their products, expanding its presence in traditional markets and opening new markets.

The world market for oilseeds has always been and remains one of the most promising and stable in its development among the main agro-food markets. In recent years, this has been facilitated, above all, by the development of the biofuel industry with increased demand for all types of oilseeds. Increased consumption of biofuels leads to higher prices for oil products. Therefore, the study of trends in the world market for oilseeds is extremely important now.

The production of oilseeds for agricultural enterprises is one of the main sources of profitability, which allows to ensure their effective activity. Oilseed production plays an important role in providing the population with valuable food, the livestock industry as a feedstuff, and the processing industry as raw materials. In a market economy, oilseeds are a reliable source of

monetary income for their economic operators. Their seeds and processing products are competitive and in demand both domestically and globally. In the last decade, Ukraine has become an integral part of the global market for oilseeds and their products, which is deeply integrated into the global structure of labor distribution.

## MATERIAL AND METHODS

The purpose of the article is to present the state and perspectives of oilseed production in Ukraine and Poland, including measures for further effective and competitive development in the long term on the basis of studying the indicators characterizing the current state of the domestic oil and fat products market, comparing the situation and existing experience of functioning of enterprises.

The study was based on a review of the literature on the subject and supplemented with empirical illustrations using public statistics data. Statistical materials were used: the State Statistics Service of Ukraine (UKRSTAT), Ukrainian Grain Association, the Central Statistical Office (GUS), market analyzes of the Institute of Agricultural and Food Economics, USDA.

## RESULTS

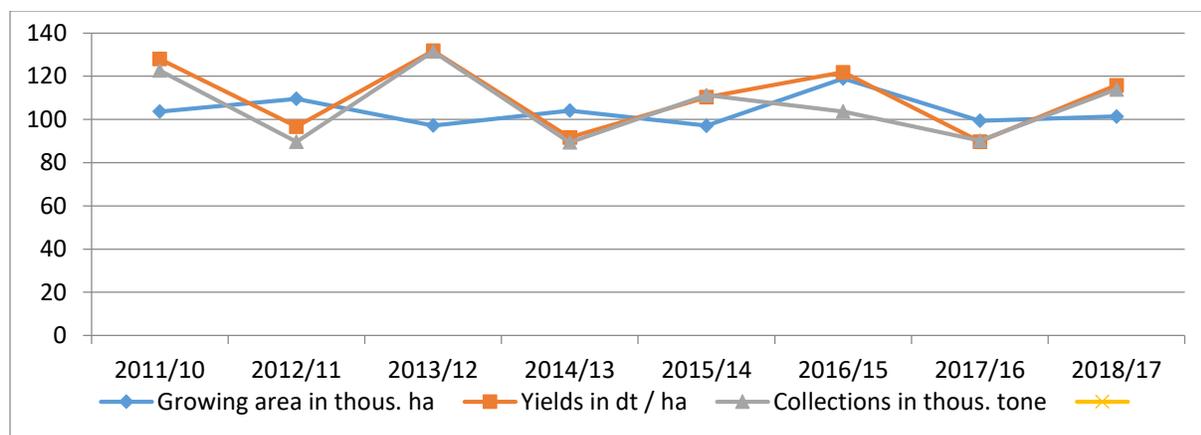
Ukraine is one of the world leaders in the production and export of oil products. Domestic oil companies produce delicious and fragrant oil, mainly from sunflower seeds, soybeans and rapeseed. Due to the climatic conditions, these cultures are traditional for our region. Among the oilseeds, the largest acreage is set aside for sunflower.

**Table 1.** Area, crops, crops and sunflower harvest in Ukraine

| Year | Growing area in thous. ha | Yields in dt / ha | Collections in thous. tone |
|------|---------------------------|-------------------|----------------------------|
| 2010 | 4572                      | 15,0              | 6772                       |
| 2011 | 4739                      | 18,4              | 8671                       |
| 2012 | 5194                      | 16,5              | 8387                       |
| 2013 | 5051                      | 21,7              | 11051                      |
| 2014 | 5257                      | 19,4              | 10134                      |
| 2015 | 5105                      | 21,6              | 11181                      |
| 2016 | 6073                      | 22,4              | 13627                      |
| 2017 | 6034                      | 20,2              | 12236                      |
| 2018 | 6117                      | 23,0              | 14165                      |

In 2018, the acreage of this crop amounted to 6.117 million hectares, but in 2019 the size of the acreage decreased by 5.3%. As of May 2019, only 2.2 million hectares were sown, of the declared 5.809 million hectares, 38%. In contrast, soybean and winter rape acreage showed an increase (6.2% and 33%, respectively). As of May, 177,000 hectares were sown with soybeans and 1.3 million hectares with winter rape.

The dynamics of the main indicators of sunflower growing in Ukraine for 2010-2018 are shown in the figure 1.



**Figure 1.** Dynamics of the main indicators of sunflower growing in Ukraine for 2010-2018

The production of other oilseeds in Ukraine is less significant. For example, rapeseed in Ukraine is a relatively new and still much undervalued oilseed crop. Currently, it does not yet have a significant impact on the oil and fat industry's resource potential. Rape is the second oilseed crop in Ukraine in terms of crop area and gross production unlike in Poland. Another situation with rapeseed is in Poland.

In Poland, the most important in the production of vegetable fats is rapeseed. It is the most important oil-protein plant in this country. Rapeseed plays a very important role in domestic agriculture, food economy and processing industry. It is the basic raw material for the production of consumer and technical fats and is a source of feed protein.

Poland's accession to the European Union and the Union's policy on biofuels and renewable energy has accelerated the development of rapeseed production in Poland. With the long-term stabilization of demand for rapeseed (rapeseed oil) from the food sector at the level of approx. 1 million tons, a rapidly growing demand for this raw material used in the production of biocomponents was created.

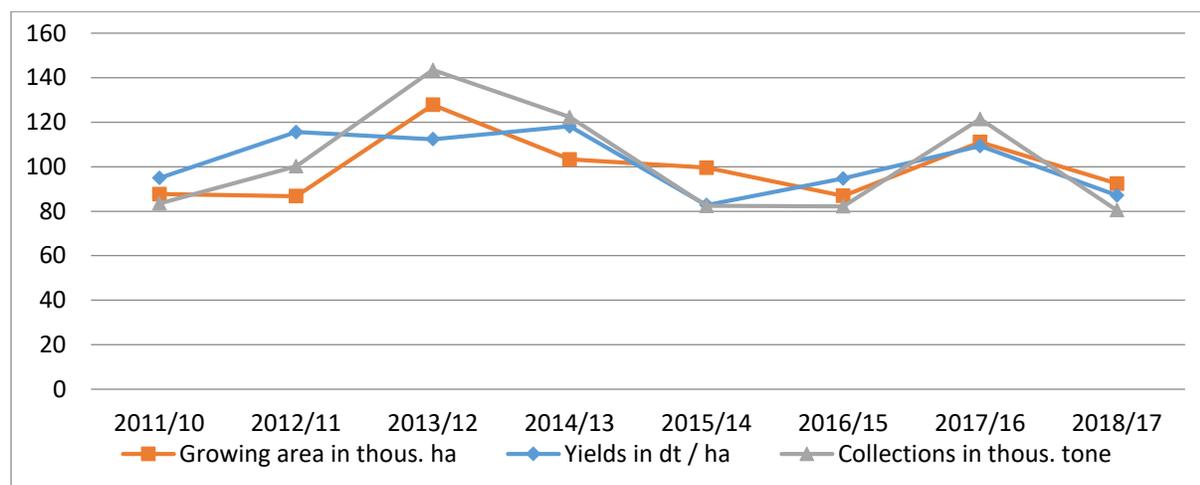
**Table 1.** Area, crops, crops and rapeseed harvest in Poland

| Year | Growing area in thous. ha | Yields in dt / ha | Collections in thous. tone |
|------|---------------------------|-------------------|----------------------------|
| 2010 | 946,1                     | 23,6              | 2228,7                     |
| 2011 | 830,1                     | 22,4              | 1861,8                     |
| 2012 | 720,3                     | 25,9              | 1865,6                     |
| 2013 | 920,7                     | 29,1              | 2677,7                     |
| 2014 | 951,1                     | 34,4              | 3275,8                     |
| 2015 | 947,1                     | 28,5              | 2700,8                     |
| 2016 | 822,6                     | 27                | 2219,3                     |
| 2017 | 914,3                     | 29,5              | 2697,3                     |
| 2018 | 845                       | 25,7              | 2171,7                     |

Rapeseed harvest increased from 0.9 million tonnes on average in the last three years (before accession (2001-2003) to 2.5 million tonnes in 2015-2017, as a result of more than a twofold increase in acreage (from 0.4 to 0, 9 million ha), but also over 30% increase in yield (from 2.1 to

2.8 t / ha). The share of rapeseed in the national sown area has more than doubled (from 3.9% on average in the last years before accession to 4 % in 2015-2017). The number of rapeseed farms has more than doubled (from 43,000 in 2002 to 90,000 in 2018), while the total number of farms decreased.

The dynamics in the main indicators of rapeseed growing in Poland for 2010-2019 are shown in the figure 2.



**Figure 2.** Dynamics of the main indicators of rapeseed growing in Poland for 2010-2018

Due to the constant demand of the fuel industry for biodiesel, the demand for rapeseed does not decrease. Rapeseed cultivates around 90,000 farms in Poland, producing a total of 2.2 to 2.5 million tons of grain. Fuel companies in the EU are required to produce biodiesel. In Poland, 90% of it is produced from rapeseed. According to Statistics Poland data, more than half of rapeseed yields are found thanks to the demand generated by the fuel industry. According to Statistics Poland in 2018 rapeseed harvests in Poland decreased by 19.5% - to the level of 2,171.7 thousand tone. Lower other crops were also noted by three other major producers in Europe: France, Great Britain and Germany.

According to Statistics Poland data, rapeseed was sown on an area of approx. 740 thousand ha for the harvest this year, i.e. by around 5% less than in the previous year. It is estimated that the total area of rapeseed (winter and spring) cultivation in 2019 is a total of 800 - 820 thousand. ha and is smaller than in 2018.

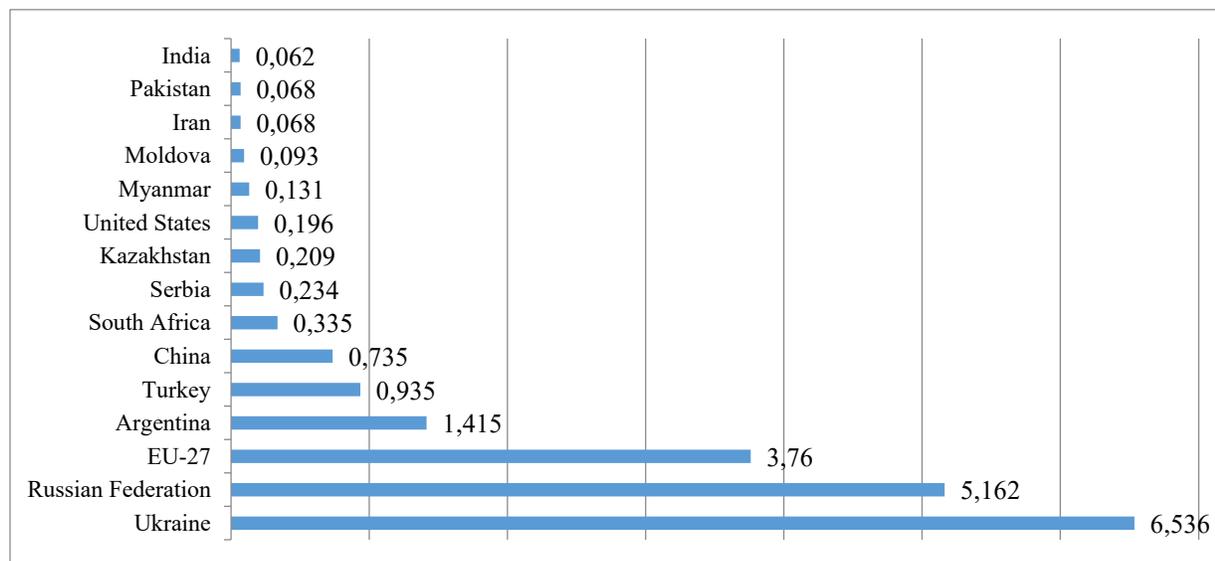
Rapeseed harvest in the current year amount to 2.2 - 2.4 million tons, by 3 - 9% higher compared to last year. Winter rapeseed for harvest in 2018 was sown on an area of 800 - 850 thousand ha, i.e. by 2 - 8% smaller compared to its cultivated area last year.

After Poland's accession to the European Union, foreign trade turnover in oilseeds increased. Poland regained the position of a large exporter of rape, lost in the nineties, maintained the position of a large exporter of rapeseed meal and developed the export of rapeseed oil. Despite the dynamic development of exports, Poland, like the entire EU, remains a permanent net importer of total oil products, and the negative trade balance is deepening. This is due to the limited possibilities of developing oilseed production and the growing demand for vegetable oils (in connection with the development of biofuels) and oil meal.

The main oilseeds grown in the world, depending on geographical and climatic features, are soybean, rapeseed, cotton, sunflower, peanut, copra and oil palm.

The overall volume of world trade in vegetable oils is characterized by an upward trend. Increasing demand for sunflower oil from foreign consumers is a major impetus in the market, which causes an increase in raw material production every year.

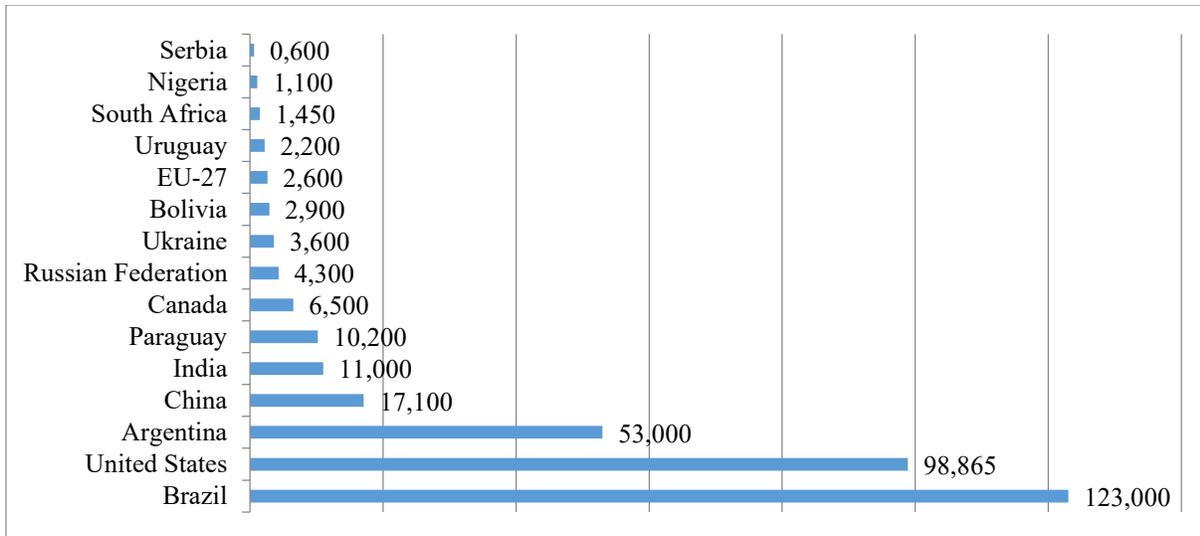
The major producers of sunflower, soybean and rapeseed oil in 2019 are showed on the figures 3, 4, 5.



**Figure 3.** Sunflowerseed Oil Production by Country in 1000 MT, 2019

Ukraine has a leading position in the production of sunflower oil (6,536 MT). The TOP-5 countries also include Russia (5,162 MT), European Union countries (3.76 MT), Argentina (1,415 MT) and Turkey (0.935 MT) (figure 3).

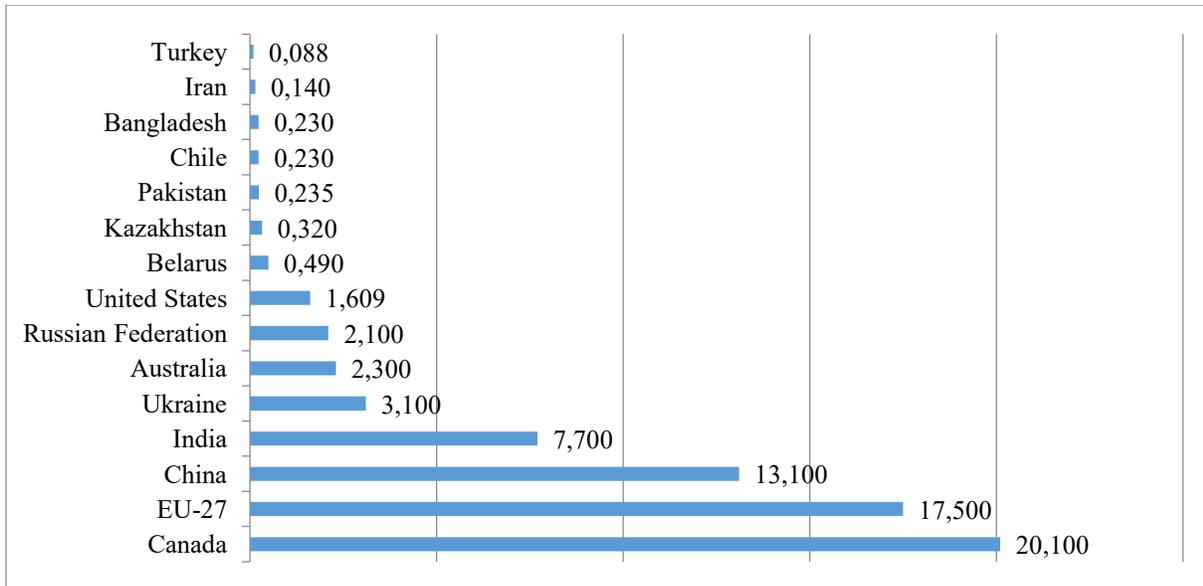
The production of sunflower oil in Ukraine from the beginning of the 2018-2019 increased by 10%, compared to the same period last year and amounted to more than 1.9 million tons.



**Figure 4.** Soybean Oilseed Production by Country in 1000 MT, 2019

Ukraine increased food exports to \$ 10.4 billion. In the first four months of the current season, the production of sunflower oil was 1.99 million tons, compared to 1.81 million tons a year earlier. It is also reported that in December 2018 large and medium-sized enterprises of Ukraine produced 525.3 thousand tons of sunflower oil, which is 1.5% more compared to November 2018 and 10.2% compared to December 2017. Sunflower oil production decreased in Ukraine by 7.7% to 4.8 million tons in 2018. In the 2017-2018, Ukraine reduced its production of sunflower oil by 13.6% to 4.6 million tons. In 2016-2017, Ukraine increased its production of sunflower oil to a record 5.3 million tons.

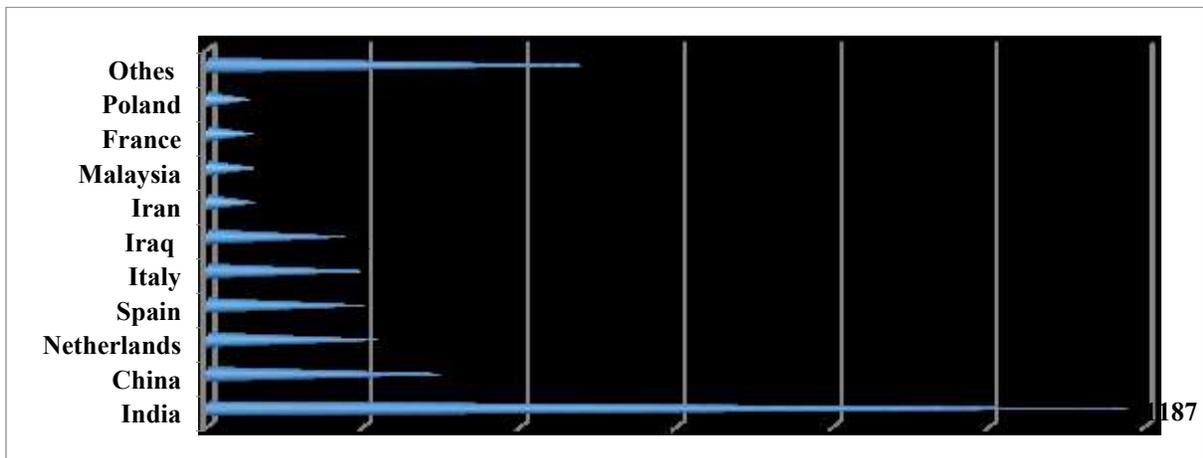
Soybean production in Brazil has already overtaken the US level due to increased acreage and yield. Today, Brazil's soybean acreage is slightly larger than the US crop. In both countries, this figure is over 35 million hectares. Brazil's leadership in soybean production is due to several factors: favorable climatic conditions: it is possible to harvest two crops a year, and for some crops, up to three; water conditions: the amount of water in most parts of the country is very high; professionalism: producers have achieved high levels of technology, which, for example, has allowed them to overtake the US in soybean production, and it is expected that the same will happen with corn; a profitable place to export: Brazil has several exits to international distribution channels, allowing it to easily enter the external consumer market, so today its products reach 224 countries; a large area of cultivation: about 70 million hectares of arable land is currently used, but another 40 million hectares can be used without harming nature.



**Figure 5.** Rapeseed Oilseed Production by Country in 1000 MT, 2019

Rape is one of the world's leading oilseeds. In terms of world production only soybeans are inferior. Canada is the largest producer of rapeseed. The current season they produced 20.1 MT, which is almost 30% of the world crop. Leading rapeseed producers also include European Union countries with production volumes of 17.5 MT, China (13.1 MT) and India (7.7 MT), which are also the largest consumers of this seed. By volume of oilseed production rape has second position only after sunflower in Ukraine. For production of rapeseed Ukraine is among 5 leaders with the number 3.1 MT.

A good prospect for oilseed producers in Ukraine is the European Union's significant dependence on imports of oilseeds and their processing products (oils and middlings), which are used for consumption, feed and industrial needs.



**Figure 6.** Top-10 countries of Ukrainian sunflower oil importers in 2018-2019 MY, '000 tones

The main buyer of Ukrainian sunflower oil is traditionally India. In January-June 2019, its share in the structure of Ukrainian exports of this type of products was 32.1%. The rest of the major importing countries of Ukrainian fats and oils are significantly inferior to India in terms of value of purchases: China accounts for 301 MT, the Netherlands - 219 MT, Spain - 200 MT, Italy - 197 MT, and Iraq - 174 MT (figure 6).

## CONCLUSIONS

In order to ensure sustainable future development of the market of oil and fat products in Ukraine and Poland, it is necessary to: restructure the raw materials and technical base of the industry; revive the production of traditional domestic oilseeds and introduce new, high-tech crop rotations; to use innovative technologies; introduce state regulation of the market for oil and fat products; to intensify work to strengthen and expand position of Ukraine and Poland in world markets.

In order to stay in the market in the conditions of competition, oil and fat companies should form their structure in the form of vertically-integrative formations, which in addition to processing factories include agro-industrial organizations, logistics units - transport, elevators, trading houses. All businesses should be typically multi-disciplinary. Partially the activities are diversified to produce mayonnaise, ketchup, mustard, soap, animal feed and various additives. Companies are constantly improving their range of products.

In our opinion, the main guideline of the economic strategy of enterprises is to improve the quality and safety of products. The complex of the above measures - modern production methods, logistics development, scientific research, constant expansion of the range, certification of goods according to international standards will keep Ukrainian producers in the leaders of the market of oil and fat products for many years and create additional development opportunities for Polish producers.

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## VARIABILITY OF QUANTITATIVE PROPERTIES IN OILSEED RAPE - *BRASSICA NAPUS* L., AND EFFICIENCY FROM APPLICATION OF CERTAIN MACRO AND MICROELEMENTS

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### ABSTRACT

Determination of quantitative characteristics by using macro and microelements that have great importance on the development of oilseed rape - *Brassica napus* L. started by setting the experiment (2014), and applying Mg and Mn as elements corresponding for the purpose. The trials were set in order to see the impact of magnesium and manganese on the quantitative properties of winter oilseed rape genotypes - *Brassica napus* L.. For this purpose, certain concentrations of magnesium sulphate and manganese chelate by foliar fertilizer application was applied on 3 genotype winter oilseed rape (Hybrirock, Petrol and Speed) in 5 variants, as follows: Variant 1 Control Ø NPK, Variant 2 NPK+MgSO<sub>4</sub> 25%, Variant 3 NPK+MgSO<sub>4</sub> 35%, Variant 4 NPK+Mn chelate 20%, and Variant 5 NPK+Mn chelate 30%. By specifying the appropriate fertilizers with Mg and Mn (their concentrations), except for quantitative properties, the adaptability of the tested genotypes of specific agro-climatic and soil conditions was observed and the following parameters were monitored: plant height (cm), the number of branches/plant, number of pods/plant, pod length (cm), the number of seeds in the pod and seed yield (t/ha). According to the results of the preliminary experiment can be concluded that higher concentrations of magnesium sulphate (35%) and manganese chelate (30%) leads to increased the components of yield and seed in tested genotypes. Efficiency of variants, generated by certain concentrations of fertilizers has also confirmed impact of higher concentrations; in terms of dosages and prices of yields (NPK+Mn chelate 30% and NPK+Mg SO<sub>4</sub> 35%).

**Keywords:** *Oilseed rape, Magnesium, Manganese, Yield, Efficiency, DEA*

### INTRODUCTION

In terms of the annual oilseed crops, oilseed rape is the second source of edible oil in the world with oil content in the seed between 40-45% (Sovero, 1993). Regarding the needs of mineral elements in order to increase the yield of seed, it is a crop with high nutritional needs receives mainly from soil, but foliar fertilization can be also used. These applications do not only apply nitrogen, potassium and magnesium, but also other mineral nutrients (Kwiatkowski, 2012).

The plant has great needs for nutrients during intense growth of aboveground biomass, and that 3 to 4 weeks before the flowering stage, and during the formation of the pods and seed (Czuba et al., 1995). Application of different concentrations of foliar fertilizers have different impact on seed yield. According to Kwiatkowski (2012), application of foliar fertilizers have a positive effect on the productivity of winter oilseed rape genotypes, improving qualitative features of culture, even if the doses of soil applications of mineral NPK fertilizers are reduced by 1/4. Foliar fertilization with  $MgSO_4$  in similar surveys in Germany, showed an increase in the yield to 1,40 t/ha, depending on soil conditions, ie deficit of sulfur (Orlovius., 2003). Proper fertilization affects the quality of the yield and helps to strengthen the plant, especially the provision and supply of magnesium (Czuba et al., 1995). The role of secondary macro element magnesium (Mg) in the physiological development of plants is important because it is present in the central atom in the molecule of chlorophyll and is essential for the absorption of light energy. Magnesium deficiency first appears on lower leaves, which turn yellow and turn white, while the stem remains dark green. Manganese as trace elements, affect plant enzymes in order to reduce nitrates before the creation of protein. The deficit of manganese usually appears at the top of the sheet in the form of necrotic and yellow spots (Omid, 2011), and in cases where oilseed rape is grown in many limestone and sandy soils (Orlovius., 2003). Using of the respective framework data analysis (DEA - Data envelopment analysis), as a technique to measure the effectiveness of the given doses with relatively homogeneous set, of which compares values from multiple inputs and outputs. The measurements of performance where there are multiple inputs and outputs focus on creating efficient hypothetical number as a certain average of effective units, to allow comparison of inefficient units (Farrell and Fieldhouse., 1962). In survey of DEA applications with methodological use of DEA for analyze results, in 20 years of development, five industries dominated in the use: banking, health, agriculture, transport and education (Liu J.S. et al., 2012).

## MATERIAL AND METHODS

For accurate determination of the effect of foliar application of Mg and Mn, in 2014 field experiment was set in the surroundings of Skopje (the village Stajkovci - 42 7 ° 02'08 "N; 21 ° 30'42 0" E), on 3 genotypes of winter oilseed rape - Hybrirock, Petrol и Speed. Total area was 600 m<sup>2</sup>, separated in 45 plots set up in four randomized blocks. The plots measuring 10 m<sup>2</sup> (5m x 2m) each, with 5 rows and 40 cm between. Sowing was performed on 10th September with sowing rate of 0.005 t/ha (5 g per plot = 1g in row). From total amount of mineral fertilizer - NPK (8:16:24) only 2/3 were used by the autumn before sowing, and 1/3 used at spring. Different concentrations of foliar fertilizers made the following variants:

|  |             |
|--|-------------|
| Variante 1 Control Ø, NPK              | (0,42 t/ha) |
| Variante 2 NPK+MgSO <sub>4</sub> - 25% | (5,6 l/ha)  |
| Variante 3 NPK+MgSO <sub>4</sub> - 35% | (7,8 l/ha)  |
| Variante 4 NPK+Mn chelate - 20%        | (4,4 l/ha)  |
| Variante 5 NPK+Mn chelate - 30%        | (6,6 l/ha)  |

Foliar applications were carried out on two occasions, over a period of 15 days (according to BBCH \*) as follows:

- I. phase of formation of flower bud (when individual buds are formed, but still closed) and
- II. phase of full bloom, or when 50% of the buds are open and the old flowers have fallen (Weber and Bleiholder, 1990; Lancashire et al., 1991).

Ten randomly selected plants per variant were taken to separate biometric measurements such as: plant height (cm), number of branches/plant, number of pods/plant, length of the pod (cm), and number of seeds in the pod. Collecting the seed in the stage of technical maturity, was done by hand, in the period from June 27 to July 10, by collecting medium 3 rows (eliminating the first and last row of variants).

### Calculations and statistical evaluation

The yield was recorded, calculated and represented in t/ha for each of the variants. The results were statistically processed using analysis of variance and LSD test through SPSS program (PSAW 18). The calculations for determining the efficiency are set as a relation among the variants (of predetermined concentrations of fertilizers) presented as inputs, as the contributions received and the prices thereof. Results for reviewing efficiency are processed through the Framework Data Analysis (DEA), using the platform framework for data analysis DEAFrontierFree (DEAFrontierFree\_SolverPlatform, DEAFrontierFree OpenSolver).

### RESULTS AND DISCUSSION

The differences among genotypes basically due to the genetic potential as of the effect of the external environment. El-Nakhlawy and Bakhawain (2009), concluded that oil seed rape varieties differ significantly in terms of the height of the plants. Certain varieties can be sensitive to environmental factors, while others may be tolerant (Sana et al., 2003). Through the analysis of the variants, analyzed morphological characteristics and yield are identified, while significant differences were determined by LSD test. The average values of morphological characteristics and yield of oilseed rape seeds, tested in four variants compared with the Control  $\emptyset$  - NPK, are presented in Table 1.

**Table 1.** Differences in morphological characteristics and yield

| Variant                       | Height of plant (cm) | Number of branches / plant | Length of pod (cm) | Number of pods / plant | Number of seed / pod | Yield t/ha |
|-------------------------------|----------------------|----------------------------|--------------------|------------------------|----------------------|------------|
| V1 Control $\emptyset$ (NPK)  | 160,44               | 4,42                       | 7,10               | 121,64                 | 34,36                | 3,31       |
| V2 NPK+Mg SO <sub>4</sub> 25% | 163,11               | 4,18                       | 7,04               | 94,24                  | 32,53                | 3,84*      |
| V3 NPK+Mg SO <sub>4</sub>     | 160,67               | 4,62                       | 6,96               | 101,96                 | 32,18                | 4,04**     |
| V4 NPK+Mn chelate             | 168,56*              | 3,98                       | 6,68               | 89,44                  | 31,60                | 3,80*      |
| V5 NPK+Mn chelate             | 172,78**             | 4,89*                      | 6,86               | 113,20                 | 34,04                | 4,20**     |
| LSD <sub>0,05</sub>           | 0,06                 | 0,41                       | 0,64               | 33,93                  | 5,34                 | 0,37       |
| LSD <sub>0,01</sub>           | 0,09                 | 0,58                       | 0,92               | 48,05                  | 7,60                 | 0,53       |

The results of the plant height confirm highly significant difference by applying the manganese chelate on level 0.05 of statistical significance (for Variant 4) and level 0.01 (for Variant 5). Differences in plant height compared to the controls was 8.11 cm Variant 4 (NPK + Mn chelate 20%) and 12.33 cm Variant 5 (NPK + Mn chelate 30%). According number of branches / plant there is a reasonable statistical difference at the level of 0.05% in the Variant 5 (NPK + Mn chelate 30%) compared to the control. In other morphological characteristics - length of pod and number of pods/plant, a statistical significance was not recorded.

Analyzing the yield of seed, all variants had higher yield in comparison with the control (3,31 t/ha) at both levels of significance (0.05 and 0.01). The highest yield was obtained in the Variant 5 (Mn chelate - 30%) - 4,20 t/ha, the second highest yield in Variant 3 (Mn chelate - 20%) - 4,04 t/ha, followed by Variant 2 (MgSO<sub>4</sub> - 35 %) - 3,84 t/ha, and the lowest yield was obtained in the Variant 4 (MgSO<sub>4</sub> 25%) with 3,80 t/ha. The variants with a lower concentration of fertilizer (Variant 2 and Variant 4) had statistically significant differences at the level of 0.05 compared to control, while Variant 3 and Variant 5 had increased yield of 0.72 and 0,89 t/ha compared to control or statistical justification of 0.01%.

Comparing the values of the higher and lower concentrations of MgSO<sub>4</sub> and Mn chelate, statistical justification is not recorded. Generally, higher yields are achieved with the use of higher concentrations of applied fertilizers (MgSO<sub>4</sub> - 35% Mn chelate - 30%).

From the ascertained efficiency of the quantities of specified concentrations of foliar fertilizer applied and achieved yields shown in Table 2, it can be noted that the variant 5 (NPK+Mn chelate 30%), provides the highest efficiency in comparison to all other variants.

**Table 2.** Determination of efficiency between the quantity of doses and yields

| Inputs | Outputs | Variant                        | Efficiency (%) | Sum of Lambdas ( $\lambda$ ) | RTS        | Compared to achieved efficiency |
|--------|---------|--------------------------------|----------------|------------------------------|------------|---------------------------------|
| Doses  | Yield   | V1 -control (NPK)              | 80             | 0,79                         | Increasing | V5 -NPK +Mn chelate 30%         |
|        |         | V2 -NPK+Mg SO <sub>4</sub> 25% | 92             | 0,91                         | Increasing | V5 -NPK +Mn chelate 30%         |
|        |         | V3 -NPK+Mg SO <sub>4</sub> 35% | 95             | 0,96                         | Increasing | V5 -NPK +Mn chelate 30%         |
|        |         | V4 -NPK+Mn chelate 20%         | 91             | 0,90                         | Increasing | V5 -NPK +Mn chelate 30%         |
|        |         | V5 -NPK+Mn chelate 30%         | 100            | 1,00                         | Constant   | V5 -NPK +Mn chelate 30%         |

Effectiveness of the relevant doses corresponds to previous statistical analysis of the obtained the highest yield (Table 1). Remarkably high efficiency is obtained in version 3, when applying concentrations of NPK + MgSO<sub>4</sub> - 35%, while the lowest efficiency is obtained in the Variant 1 (NPK). Efficiency of applied doses (kg ha<sup>-1</sup>) as input, in relation with realized yield as output, it is efficient in V5, while the yields of V1(3,31 t ha<sup>-1</sup>), V2 (3,84 t ha<sup>-1</sup>), V3 (4,04 t ha<sup>-1</sup>) and V4 (3,80 t ha<sup>-1</sup>) can be achieved with a smaller dose (V1, 83,5 kg, V2 35,4 kg, V3 17,8 kg, V4 38,7 kg). In Table 3, the performance between the cost (price) for the purchase of fertilizers that are applied in five variants and yields has been determined, according to the price of the market in Republic of Macedonia, in the year of research.

**Table 3.** Determination of efficiency between the prices of applied doses and prices by obtained yields

| Inputs     | Outputs      | Variant                         | Efficiency (%) | Sum of Lambdas ( $\lambda$ ) | RTS        | Compared to achieved efficiency |
|------------|--------------|---------------------------------|----------------|------------------------------|------------|---------------------------------|
| Dose price | Yields price | V1 -control (NPK)               | 87             | 0,82                         | Increasing | V3 -NPK +Mg SO <sub>4</sub> 35% |
|            |              | V2 -NPK +Mg SO <sub>4</sub> 25% | 96             | 0,95                         | Increasing | V3 -NPK +Mg SO <sub>4</sub> 35% |
|            |              | V3 -NPK +Mg SO <sub>4</sub> 35% | 100            | 1,00                         | Constant   | V3 -NPK +Mg SO <sub>4</sub> 35% |
|            |              | V4 -NPK +Mn chelate 20%         | 86             | 0,94                         | Increasing | V3 -NPK +Mg SO <sub>4</sub> 35% |
|            |              | V5 -NPK +Mn chelate 30%         | 89             | 1,04                         | Decreasing | V3 -NPK +Mg SO <sub>4</sub> 35% |

The costs made for the purchase of quantities of fertilizer and yield (expressed in MKD), showed the best efficiency in variant 3, where NPK fertilizer (0.42 t) and Mg SO<sub>4</sub> (7,8 l/ha) were used. In variant 5 (Table 3), have been made excessive costs fertilizer applied to the given dose compared to the yield obtained, thus reducing efficiency (4%). Although variant 1 control (NPK) apply only basic fertilizer thus costs are lower, however efficiency is lowest compared to the yield obtained in all variants.

### Conclusion

The research with respect to the applied foliar fertilizer with magnesium and manganese have shown that there is a statistical significance for two of four concentration used MgSO<sub>4</sub> 35% and Mn helat 30% (variant 3 and variant 5). Efficiency of variants, generated by certain concentrations of fertilizers confirmed impact of higher concentrations; in terms of dosages and prices of yields (NPK+Mn chelate 30% and NPK+Mg SO<sub>4</sub> 35%).

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## ENCAPSULATION METHODS AND MATERIALS FOR BLACK CUMIN SEED OIL

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### ABSTRACT

Some seed oils such as Black Cumin seed (*Nigella sativa*) oils are functional oils that have biologically active omega-6 fatty acid. Cumin seed contains saturated/unsaturated fatty acids and essential oils, carbohydrates, proteins, amino acids, alkaloids, tannins, saponins, fiber, minerals, vitamins. Unsaturated fatty acids (% 80- 85) of cumin seed are linoleic, oleic, arachidonic, palmitoleic, eicosadienoic and saturated fatty (%15-20) acids are palmitic, stearic and myristic fatty acids. Thymoquinone is obtained from the essential oil of the cumin seed which is the phenolic compound responsible for the antioxidant activity. During storage of the oil, lipid oxidation occurs and this causes chemical changes, the deterioration of lipids, and the development of rancid taste off-flavor. Also, lipid oxidation lowers the nutritional value of the edible oils. Microencapsulation is a method of preserving sensitive compounds like oils from external conditions such as light, oxygen, moisture, etc. In the food industry common method for encapsulation is spray drying but also different technics used for the encapsulation of sensitive materials. The aim of this research is to review the techniques and materials used in black seed oil microencapsulation and the encapsulation of oils.

**Keywords:** *Edible oil, Encapsulation, Cumin seed oil*

### INTRODUCTION

The seeds have long been used to treat diseases for centuries in Southeast Asia and the Middle East. Traditional uses of these plant materials attracted the attention of researchers and lots of studies conducted to determine the chemical compositions of plants and bioactive properties of compounds (Ramadan, 2007).

Black cumin seed, seed oil or essential oil has many nutritional and pharmaceutical uses. The seed can be added to different types of foods. Also, the seed oil has been used to treat skin disorders and for beauty. Black cumin seeds are extensively used as a natural remedy and the seeds are extensively used as spice, carminative, condiment and (Ramadan, 2007).

The oxidative degradation of oils deteriorates the quality of the products and forms unpleasant tastes, generates free radicals. The shelf life, sensorial properties, and acceptability of the product negatively affected by these changes (Velasco, Dobarganes, & Marquez-Ruiz, 2003).

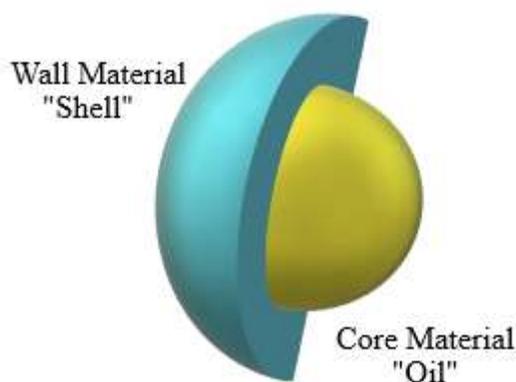
In addition, most people seeking the benefits of black cumin take the oil in capsule form. Encapsulation of oils from different sources (marine, vegetable, and essential oils) protects the oil from some chemical and physical reactions. This technique protects the oil from environmental conditions and saves the biological and functional characteristics (Bakry et al., 2016).

## Profile of Black Cumin Seed and Oil

Black cumin seed oil contains volatile and fixed oils at a ratio of 0.5-1.6 % and 35.6-41.6 % respectively and an important amount of proteins (22.7), amino acids are (e.g. lysine, leucine, isoleucine, valine, glycine, alanine, phenylalanine, cysteine, glutamic acid, aspartic acid, proline, serine, threonine, tryptophan, and tyrosine). Reducing sugars, mucilage, alkaloids, organic acids, tannins, resins, toxic glucoside, metarbin, bitter principles, glycosidal saponins, melanthin resembling helleborin, melanthigenin, ash, moisture and arabic acid found in the seeds (Al-Gaby, 1988). The crude oil expressed from the seeds of *Nigella sativa* is considered among the functional oils due to its rich content of omega-6 and omega-9 fatty acids including linoleic (54.0–70.0%) and oleic (15.0–24.0%), respectively (Tulukcu, 2011). Black cumin seed fatty acids are palmitic acid, oleic acid and linoleic acid, terpenoids, aliphatic alcohols, and unsaturated hydroxy ketones. Moreover, free sterols, steryl esters, steryl glucosides and acylated steryl glucosides were isolated from the seed oil (Ramadan & Moersel, 2003). A novel alkaloid (nigellicine), an isoquinoline alkaloid (nigellimine) and an indazole alkaloid (nigellidine) were isolated from the black cumin seeds (Atta-ur-Rahman et al., 1995) The active constituents of the seeds include the volatile oil consisting of carvone, an unsaturated ketone, terpene or d-limonene also called carvene, a-pinene, and p-cymene. The crystalline active principle, nigellone, is the only constituent of the carbonyl fraction of the oil. Pharmacologically, active constituents of the olatile oil are thymoquinone, dithymoquinone, thymohydroquinone and thymol (Ghosheh et al., 1999).

## Encapsulation of Black Cumin Seed Oil

Bakry et al. (2016) defined the microencapsulation process as building a functional barrier between the core and shell material to protect from chemical and physical reactions and maintain the biological, functional and physicochemical properties of the encapsulated material.



**Figure 1.** Encapsulated Oil “Simple Structure”

## **Wall Materials**

Wall materials used commonly for the microencapsulation of oils include synthetic polymers and natural biomaterials (usually carbohydrates and proteins). (Bakry et al., 2016)

Wall material can be changed due to the encapsulation technique. Gouin (2004) concluded that according to the final product, characteristics of the core material affect the selection of wall materials. Wall materials can be selected from natural sources such as starches, celluloses or synthetic sources such as polyethylene, polyester, etc. In spray drying processes, wall material must be water-soluble because of the aqueous feed solution needed for the process.

Wall material selection for the spray drying process is carried out by trial and error method. After encapsulation of core material, analysis (encapsulation efficiency, particle size determination, stability tests for the core materials under different environmental conditions) are made for the evaluation of capsules (Perez-Alonso, Baez-Gonzalez, Beristain, Vernon-Carter, & Vizcarra-Mendoza, 2003).

Physicochemical properties such as solubility, molecular weight, glass/melting transition, crystallinity, diffusibility, and film forming and emulsifying properties effective parameters for the selection of the wall materials (Gharsallaoui, Roudaut, Chambin, Voilley, & Saurel, 2007).

## **Encapsulation Techniques**

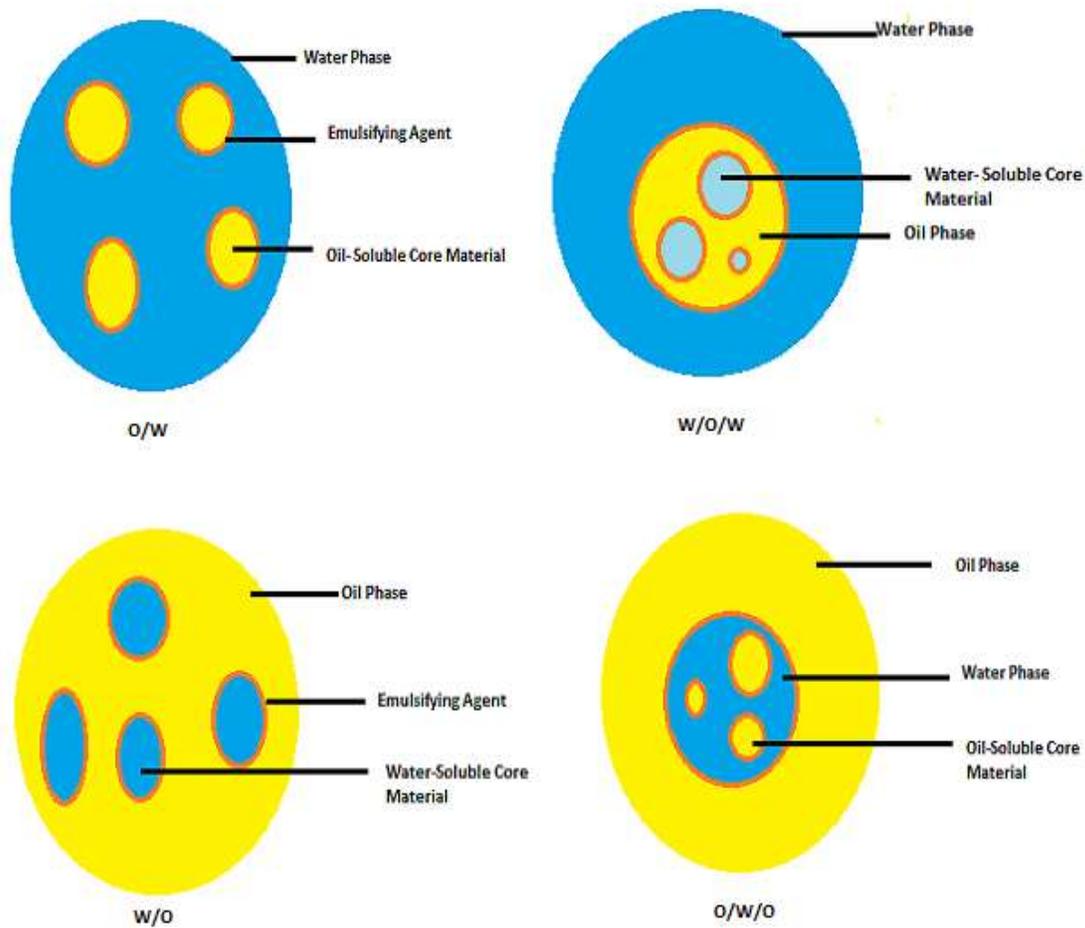
Commonly used microencapsulation techniques are emulsification, spray-drying, coaxial electrospray system, freeze-drying, coacervation, in situ polymerization, extrusion, fluidized-bed-coating, and supercritical fluid technology (Bakry et al., 2016).

## **Emulsification**

Emulsification is an important step in the encapsulation of oils. Prepared emulsions can be encapsulated by nanoemulsions or with different methods such as spray drying, freeze-drying, extrusion, coacervation (Bakry et al., 2016).

## **Nanoemulsions**

The emulsion contains at least two immiscible liquids. When oil droplets dispersed in aqueous phase called oil-in-water (O/W) emulsion whereas water droplets dispersed in oil called water-in-oil (W/O) emulsions. Multiple emulsions can be formed such as oil-in-water-in-oil (O/W/O) and water-in-oil-in-water (W/O/W). Emulsifiers are commonly added because of the immiscible characteristics of oil and water (Figure 2) (Bakry et al., 2016).



**Figure 2.** Emulsion types (Adapted from Bakry et al., 2016)

In nanoemulsions, droplets show distribution in the size of 20-200 nm. High-pressure homogenization, microfluidization, ultrasonic emulsification, membrane emulsification, phase inversion temperature method, lipophilic solvent method, amphiphilic solvent method, hydrophilic solvent method are the methods used to obtain nanoemulsions. (İlyasoğlu & El, 2010).

Jufri and Natalia (2014) prepared a nanoemulsion contains black cumin seed oil with different ratios. According to physical stability test results, nanoemulsion gel found stable at room and low temperatures for 8 weeks. But at higher temperatures (40 °C) gels found unstable.

### **Spray Drying**

Spray drying is the most used technique in commercial products. The cost of the process is 30-50 times cheaper than the freeze-drying.

Spray drying method has some advantages in encapsulation technology.

- A simple method for producing microcapsules,
- Continuous operating, production,
- Inexpensive
- Rapid and reproducible,

- Allowing easy scale-up when compared with other methods (Schafroth, Arpagaus, Jadhav, Makne, & Douroumis, 2012).

High temperatures are used for the evaporation of water in the drying chamber of the spray dryer from the atomized emulsions. So very fast evaporation and entrapment of oils are done instantaneously (Tonon, Grosso, & Hubinger, 2011).

The microencapsulation by spray-drying involves 4 stages;

- (i) Dispersion
- (ii) Homogenization (Emulsification)
- (iii) Atomization
- (iv) Dehydration (Bakry et al., 2016)

Oleoresin of *Nigella sativa* encapsulated with gum Arabic/maltodextrin (1:1 w/w) aqueous solution mixture by spray drying method (Edris et al., 2016). The results showed that spray-dried oleoresin contains higher amounts of carvacrol and thymoquinone when compared to unencapsulated oleoresins. Major volatile compound  $\alpha$ -thujene in the oleoresin before encapsulation but almost lost from the powder after drying. According to researchers, this volatile fraction of the oleoresin is relatively retained and concentrated in the powder. These compounds are well-known antioxidants and antimicrobial constituents of the oil. Authors concluded that this encapsulated functional oleoresin can be used in different foods, dairy products or nutraceutical applications.

Nithin and Priya (2016) showed the storage stability of encapsulated black cumin seed oil using gum Arabic and maltodextrin with different ratios by spray drying in their research. They found that the moisture content, water activity, peroxide value was slightly increased during storage while there was insignificant degradation found in the antioxidant activity and color of the powder.

Mohammed et al. (2018) encapsulated the black cumin seed oil by the spray-drying method. Before spray-drying black cumin seed oil was homogenized with maltodextrin (DE 10) and sodium caseinate (1:3 core/wall ratio) to obtain 40% solid content and emulsified with soy lecithin. They showed that the oxidative stability of the microencapsulated oil was due to the encapsulation process. Because unencapsulated oil was oxidized easily when compared with encapsulated oil.

### **Freeze-drying**

Encapsulation with freeze-drying or lyophilization method is suitable for the heat-sensitive core materials and aromas like oils. Before freeze-drying of the oil dispersion must be prepared and froze (between  $-90^{\circ}\text{C}$  /  $-40^{\circ}\text{C}$ ) (Heinzelmann, Franke, Jensen, & Haahr, 2000) and then the pressure is reduced and heat is added to sublimation of frozen water. Encapsulation of volatile compounds with freeze-drying has maximum retention time when compared to spray-dried samples (Krokida & Philippopoulos, 2006).

### **Coacervation**

Another oldest and most widely used encapsulation techniques is coacervation. Coacervates formation occurs by electrostatic attraction between two biopolymers of opposing charges over a narrow pH range (Leimann, Goncalves, Machado, & Bolzan, 2009).

Abdel-Razek et al. (2018) coacervates the black cumin seed oil then spray dried the micro and nanocapsules by a spray dryer. They used maltodextrin, gum Arabic and whey protein concentrate as wall materials for micro and nanocapsules and they also used ultrasonication for producing nanocapsules. They found that

the peroxide and thiobarbituric values of oil droplets were shown fewer changes. Aflatoxin reducing effect of nanoemulsions was found higher than the crude oil.

## CONCLUSION

The health benefits of black cumin seed oil have been determined by various studies. Encapsulation techniques can be used to protect the bioactive properties of black cumin seed oil. Microencapsulation is an effective method to ensure the chemical, oxidative and thermal stability. Although bioactivity, functionality, quality, and release of the active components can be enhanced. Spray-drying and emulsification are the most used method for the encapsulation of black cumin seed oil. The application area of the encapsulated materials can be enhanced. Encapsulated oils have been used in different food preparations, pharmaceuticals, textile or pesticide products.

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## ROSEMARY ESSENTIAL OIL AND MICROENCAPSULATION

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### ABSTRACT

Rosemary (*Rosmarinus officinalis L.*) is a valuable plant species that always remains green, a needle-like, thin-leaved plant of the family Lamiaceae. Rosemary extract has contain carnosol and rosmanol. The main components of rosemary essential oil are 1,8-cineole,  $\alpha$ -pinene, camphor, camphene. Rosemary essential oil is sensitive to light and oxygen. The shelf life of this valuable oil can be increased by using the microencapsulation technique. Microencapsulation is a technology used to obtain a microcapsule by wrapping the surrounding of an active substance with one or more coating materials. It is important to delay the volatility of the essential oils by coating them with a layer and thus to protect the components contained therein. This is due to the fact that the micro-capsule form essential oils exhibit less interaction with other components in the food, show stability for a longer period of time and also increase the effectiveness of antioxidant essential oils by converting them into microcapsule form. In our study, coating materials and techniques that can be used in microencapsulation of rosemary essential oil were investigated.

**Keywords:** *Microencapsulation, Rosemary Essential Oil, Spray drying, Gum arabic*

### INTRODUCTION

Medicinal and aromatic plants are used for the treatment of diseases from ancient times to the present day (Bayram et al., 2010). Rosemary (*Rosmarinus officinalis L.*) from the family *Laminaceae (Labiatae)* is an important medicinal and aromatic plant species (Malayoğlu, 2010). Among the medicinal and aromatic plants, rosemary is one of the most produced and used. Fresh and dried rosemary leaves are often used in traditional Mediterranean cuisine (Jiang et al., 2010).

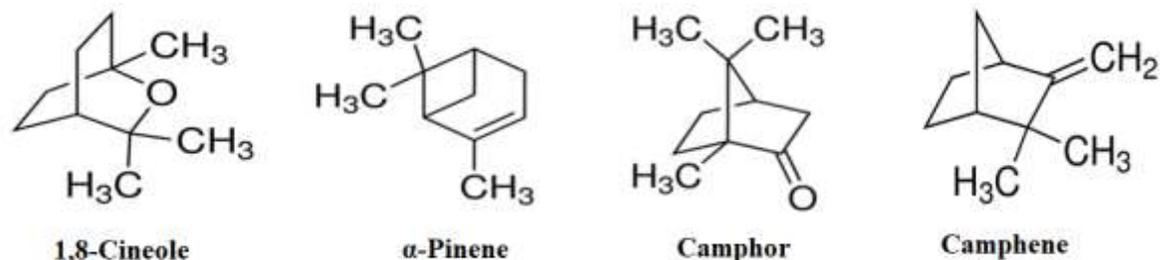
Essential oils are volatile and aromatic compounds derived from plants and phytochemicals known as monoterpenes, sesquiterpenes and their oxygen derivatives (Souza et al., 2005). Essential oils and various plant extracts have aroused interest as natural product sources. There are potential uses as an alternative solution for the treatment of many diseases (Agunu et al., 2005). However, essential oils are sensitive to environmental factors such as heat and light. The shelf life of essential oils is therefore short. Different techniques are used to increase the shelf life of essential oils. One of these techniques is microencapsulation (Başyigit et al., 2017).

Microencapsulation is a technology that allows the surrounding of an active substance to be encapsulated with one or more coating agents. Encapsulation technology is currently being used in many different sectors. The microencapsulation technique is generally used in the food industry

to improve the functional properties of the products and increase their shelf life by coating materials (Koç et al., 2010).

### Rosemary Essential Oil

The main components of rosemary essential oil were 1,8-Cineole 26.54%,  $\alpha$ -Pinene 20.14%, Camphor 12.88% and Camphene 11.38% (Jiang et al., 2010). Figure 1 shows the chemical structures of these major components.



**Figure 1.** Chemical structure of the major components of rosemary essential oil

Also, rosemary contains antioxidative compounds such as carnosol and rosmanol (Yanishlieva et al., 2010). Although rosemary oil has antioxidant content, it is sensitive to light and oxygen. When the protective effect of antioxidants is over, deterioration reactions begin. Microencapsulation techniques are applied to arrest oxidative reactions and rise shelf life.

### Microencapsulation

The stability of essential oils can be improved using microencapsulation. The microencapsulation process generally occurs of the formation of a multi-component structure in the form of microparticles consisting of core material and encapsulation. The various properties of the active materials can be altered by encapsulation and processing and flow properties can be developed by transforming a liquid into a pulverized encapsulated form (Fernandes et al., 2013). Although the most commonly used technique for microencapsulation is spray drying, it can be performed using many different techniques such as liposome conjugation, coacervation, lyophilization, spray-cooling, and fluidized bed coating (Desai and Park, 2005).

In the microencapsulation process, carbohydrates such as starch, maltodextrin, pullulan, sucrose, and maltose; proteins such as gelatin, whey proteins, casein, caseinates; and gums such as gum arabic are preferred as coating materials (Koç et al., 2010). In microencapsulation of oils and aroma substances, gum arabic is the most used prominent among coating materials. It has been found that gum arabic gives more effective results especially in the case of volatile aroma substances. Another important feature of gum arabic is its high emulsifying capacity for apolar compounds in the water phase. However, since maltodextrin has high concentrations, low viscosity, low price, good solubility, natural flavor and low emulsion capacity, it is used in combination with other coating materials (Başyigit et al., 2017).

## CONCLUSIONS

Turkey in the field of medicinal and aromatic plants has a significant potential. The tendency towards medicinal and aromatic plants is increasing day by day for both health and food needs. It is important that medicinal aromatic plants such as rosemary are processed and converted into high value-added products. Rosemary essential oil production in Turkey is made widely available. Since rosemary essential oil is sensitive to ambient temperature, oxygen and light, microencapsulation with substances such as gum arabic will increase shelf life. Spray drying is the most widely used microencapsulation techniques because of its cheapness and ease of use. Products obtained as a result of microencapsulation of rosemary essential oils can be used in food enrichment.

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## FATTY ACID COMPOSITION OF BLUE, WHITE, AND YELLOW POPPY SEEDS AND THEIR COMPARISON WITH SOME OTHER SEEDS

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### ABSTRACT

Poppy (*Papaver somniferum*) is one of the oldest earliest plants known. Poppy seed is characterized by 45 to 55 percent fat and 30 percent protein content. Turkey's Aegean and Central Anatolian region, most particularly Afyonkarahisar, including Denizli, Konya, Istanbul and Burdur is grown in the provinces. In Turkey, the most widely produced yellow, white, and blue seed poppy varieties. We think that poppy oil can be an alternative consumption against other oils. Therefore we investigated the chemical composition of yellow, white and blue seed poppy oil and its comparison with some other oil seeds. The seeds were also compared for antioxidant content.

**Keywords:** *Fatty acid, Poppy oil, Antioxidant capacity*

### INTRODUCTION

The homeland and cultural root of Hashaş plant is Anatolian, so poppy has a strong importance in our country. As stated in many sources, the cultivation of poppy plant in Anatolia has been continuing for 3000 years (Özcan and Atalay 2006). Research on poppy mostly focuses on medicinal value and botanical properties. *P. somniferum* contains more than 30 separate alkaloids. *P. somniferum* is a fine-known source of isoquinoline derivatives and is a fine-known source of major morphine opium alkaloids, such as morphine, codeine, thebaine, papaverine and narcotin, and has a broad pharmacological activity (Singh et al., 2000).

Poppy also has antioxidant capacity. Antioxidants are successful in eliminating free radicals that are formed continuously as a result of biochemical reactions in the body. Free radicals can cause a wide variety of diseases, including atherosclerosis, heart disease, cancer and diabetes (Kasnak and Palamutoglu, 2015).

Poppy paste is a traditional product obtained by crushing poppy seeds. Poppy seed, which has a large amount of oil content besides vitamin and mineral matter content, is an important source in human nutrition because it is rich in omega fatty acids. Poppy oil contains useful phytosterols. It also offers a rich content of unsaturated fatty acids. In particular, the production and consumption of seed oils are widespread in Turkey. Poppy oil can be an alternative to existing seed oils due to its taste, aroma, antioxidant and phenolic content and its health.

## Fatty Acid Composition of the Poppy Oil

Poppy oil is a good source of polyunsaturated fatty acids. Table 1 shows the comparison of the fatty acid composition of poppy oil with some other oils.

**Table 1.** The fatty acids compositions of some oils (Prescha et al., 2014)

| Oil type         | C14:0     | C16:0      | C18:0      | C18:1n-9   | C18:2n-6    | C18:3n-3   | C20       | C20:1n-9  |
|------------------|-----------|------------|------------|------------|-------------|------------|-----------|-----------|
| Macadamia oil    | 0.8 ± 0.1 | 8.2 ± 0.6  | 3.3 ± 0.3  | 58.9 ± 2.0 | 3.5 ± 0.9   | 0.5 ± 0.5  | 2.7 ± 0.1 | 2.4 ± 0.1 |
| Avocado oil      | 0.1 ± 0.1 | 17.5 ± 1.0 | 0.7 ± 0.2  | 61.0 ± 1.5 | 10.5 ± 0.7  | 0.8 ± 0.2  | 0.1 ± 0.1 | 0.3 ± 0.1 |
| Sesame oil       | 0.1 ± 0.0 | 10.4 ± 1.3 | 5.3 ± 0.8  | 39.5 ± 0.9 | 42.9 ± 1.8  | 0.5 ± 0.2  | 0.5 ± 0.1 | 0.2 ± 0.0 |
| Safflower oil    | 0.1 ± 0.0 | 6.2 ± 0.4  | 2.88 ± 0.5 | 20.6 ± 4.8 | 67.3 ± 3.0  | 0.6 ± 0.2  | 0.8 ± 0.3 | 0.3 ± 0.0 |
| Pumpkin oil      | 0.2 ± 0.0 | 12.3 ± 0.9 | 6.1 ± 0.4  | 32.3 ± 6.2 | 47.2 ± 5.5  | 0.4 ± 0.1  | 0.4 ± 0.0 | 0.1 ± 0.0 |
| Rose hip oil     | 0.1 ± 0.0 | 3.8 ± 0.4  | 1.8 ± 0.1  | 14.6 ± 0.2 | 44.1 ± 0.3  | 34.0 ± 0.4 | 0.6 ± 0.3 | 0.3 ± 0.2 |
| Linola oil       | 0.1 ± 0.0 | 5.6 ± 0.6  | 3.9 ± 0.1  | 16.6 ± 0.7 | 71.05 ± 0.4 | 2.0 ± 0.2  | 0.1 ± 0.0 | 0.1 ± 0.0 |
| Flaxseed oil     | 0.1 ± 0.0 | 5.2 ± 0.2  | 4.2 ± 0.5  | 19.3 ± 3.0 | 14.0 ± 1.4  | 51.2 ± 3.7 | 0.2 ± 0.0 | 0.1 ± 0.1 |
| Walnut oil       | < 0.05%   | 7.1 ± 0.3  | 2.6 ± 0.1  | 18.4 ± 1.2 | 59.7 ± 1.9  | 11.2 ± 0.7 | 0.1 ± 0.0 | 0.5 ± 0.3 |
| Hempseed oil     | 0.1 ± 0.0 | 6.1 ± 0.2  | 2.6 ± 0.3  | 12.5 ± 4.2 | 55.2 ± 1.5  | 18.9 ± 2.6 | 0.7 ± 0.2 | 0.4 ± 0.1 |
| Poppy oil        | 0.1 ± 0.0 | 9.6 ± 0.5  | 2.3 ± 0.1  | 15.2 ± 0.4 | 71.00 ± 0.6 | 0.8 ± 0.2  | 0.1 ± 0.0 | 0.6 ± 0.3 |
| Milk thistle oil | 0.2 ± 0.1 | 8.2 ± 0.4  | 4.8 ± 0.4  | 22.8 ± 0.8 | 55.8 ± 1.6  | 0.3 ± 0.0  | 2.9 ± 0.2 | 0.9 ± 0.1 |

The main fatty acids of poppy seed oil are linoleic, oleic and palmitic acid. Since poppy oil has a high content of unsaturated fatty acids, it contains a balanced distribution of fatty acids and is rich in polyunsaturated and essential fatty acids, indicating good quality for human nutrition (Abudak, 2014). Poppy oil is one of the oils with the highest linoleic acid content. Omega-6 oils, which we obtain mainly from vegetable oils, are also useful. It lowers harmful LDL cholesterol and increases protective HDL. They help to keep blood sugar under control by increasing the body's sensitivity to insulin (Anonymous, 2019). However, increasing consumption of omega-6 fatty acids in the western diet causes the conversion of linoleic acid to another fatty acid called Arachidonic acid in the body. Arachidonic acid is a building block for molecules that can increase inflammation in the body, blood clotting and narrowing of the vessels (Simopoulos, 2008). For this reason, a low ratio of omega-6 / omega-3 fatty acids such as 4: 1 in the diet is to reduce the risk of high prevalence chronic diseases (Simopoulos, 2002). Table 2 shows the fatty acid composition of three different poppy cultivars.

**Table 2.** Fatty acid composition of the poppy seed oil (Emir et al., 2015)

| Fatty Acid (%)                     | Ofis 3 (blue) | Ofis 4 (yellow) | Ofis 8 (white) |
|------------------------------------|---------------|-----------------|----------------|
| Palmitic acid (C16:0)              | 9.51 ± 0.08   | 8.70 ± 0.09     | 8.90 ± 0.13    |
| Stearic acid (C18:0)               | 2.30 ± 0.03   | 2.50 ± 0.03     | 2.30 ± 0.08    |
| Oleic acid (C18:1) (n-9)           | 13.60 ± 0.01  | 14.30 ± 0.05    | 13.60 ± 0.43   |
| Linoleic acid (C18:2) (n-6)        | 74.20 ± 0.10  | 73.90 ± 0.17    | 74.50 ± 0.70   |
| Gamma-linolenic acid (C18:3) (n-3) | 0.50 ± 0.01   | 0.50 ± 0.01     | 0.60 ± 0.00    |

As shown in Table 2, the highest oleic acid and the lowest linoleic acid content are observed in Office 4 variety which is consumed a lot in Afyonkarahisar city. Poppy oil is poor in omega 3 fatty acid and there is no significant difference in quantities in cultivars.

### Phytochemical Capacity of the Poppy Oil

Poppy is not only an important oil plant, but also has a high antioxidant content (Aklale ve Güneşer, 2019). Antioxidants have a positive effect on health by resisting oxidative reactions. Table 3 shows the antioxidant capacity of some coldpressed oils containing poppy in hydrophilic, lipophilic and oil.

**Table 3** The results of antiradical scavenging activity of oils–DPPH assay (mM TAEC/kg) (Prescha et al., 2014)

| Oil type         | Mean $\pm$ SD <sup>a</sup>  |                             |                             |                              |
|------------------|-----------------------------|-----------------------------|-----------------------------|------------------------------|
|                  | Oil                         | LF                          | HF                          | LF/HF                        |
| Macadamia oil    | 0.17 $\pm$ 0.03 (0.14–0.20) | 0.12 $\pm$ 0.06 (0.05–0.16) | 0.09 $\pm$ 0.07 (0.04–0.16) | 1.31 $\pm$ 0.02 (0.81–4.05)  |
| Avocado oil      | 0.58 $\pm$ 0.08 (0.52–0.66) | 0.51 $\pm$ 0.11 (0.40–0.64) | 0.09 $\pm$ 0.03 (0.07–0.12) | 5.74 $\pm$ 0.30 (4.95–7.26)  |
| Sesame oil       | 1.38 $\pm$ 0.47 (0.96–1.94) | 1.15 $\pm$ 0.34 (0.80–1.58) | 0.50 $\pm$ 0.34 (0.26–1.05) | 2.33 $\pm$ 0.47 (1.08–9.36)  |
| Safflower oil    | 1.77 $\pm$ 0.05 (1.74–1.83) | 1.57 $\pm$ 0.04 (1.54–1.63) | 0.21 $\pm$ 0.03 (0.18–0.25) | 7.60 $\pm$ 0.97 (6.17–9.04)  |
| Pumpkin oil      | 1.44 $\pm$ 0.33 (1.11–1.77) | 1.35 $\pm$ 0.19 (1.17–1.54) | 0.41 $\pm$ 0.22 (0.23–0.65) | 3.30 $\pm$ 0.66 (2.38–3.38)  |
| Rose hip oil     | 2.32 $\pm$ 0.04 (2.28–2.37) | 2.14 $\pm$ 0.13 (2.05–2.30) | 0.39 $\pm$ 0.03 (0.36–0.42) | 5.49 $\pm$ 1.24 (4.97–6.30)  |
| Linola oil       | 1.68 $\pm$ 0.21 (1.52–1.92) | 1.52 $\pm$ 0.24 (1.33–1.80) | 0.21 $\pm$ 0.03 (0.18–0.23) | 7.37 $\pm$ 0.93 (6.14–10.00) |
| Flaxseed oil     | 1.58 $\pm$ 0.17 (1.30–1.72) | 1.35 $\pm$ 0.21 (1.07–1.66) | 0.19 $\pm$ 0.03 (0.14–0.23) | 7.06 $\pm$ 0.82 (5.66–10.04) |
| Walnut oil       | 1.28 $\pm$ 0.12 (1.15–1.37) | 1.08 $\pm$ 0.09 (1.02–1.18) | 0.37 $\pm$ 0.29 (0.14–0.69) | 2.93 $\pm$ 0.50 (1.70–7.34)  |
| Hempseed oil     | 1.74 $\pm$ 0.26 (1.47–2.00) | 1.51 $\pm$ 0.23 (1.25–1.66) | 0.35 $\pm$ 0.06 (0.29–0.42) | 4.27 $\pm$ 0.82 (3.85–4.75)  |
| Poppy oil        | 0.72 $\pm$ 0.08 (0.67–0.81) | 0.67 $\pm$ 0.13 (0.55–0.81) | 0.22 $\pm$ 0.17 (0.12–0.41) | 3.03 $\pm$ 0.32 (1.53–6.37)  |
| Milk thistle oil | 1.70 $\pm$ 0.23 (1.56–1.97) | 1.28 $\pm$ 0.16 (1.12–1.44) | 0.28 $\pm$ 0.06 (0.24–0.35) | 4.57 $\pm$ 0.71 (4.17–4.98)  |

As shown in Table 3, the antioxidant capacity of poppy oil is moderate compared to other oils. The antioxidant capacity of lipophilic extraction of poppy oil is three times higher than that of hydrophilic extraction. Phenolic acids and their derivatives and flavonoids are predominant phenolic compounds in seed-rich oils (Bozan and Temelli, 2008). Phenolic compounds are effective in preventing the oxidation of oils in seeds (Shahidi 2000). Table 4 shows the total phenolic content and percentage of antioxidants of some poppy varieties.

**Table 4.** Phytochemical Capacity of the poppy seed oil (Abudak, 2014)

| Phytochemical Capacity             | Ofis 95          | Ofis 96          | Ofis 3           | Ofis 8           | TMO-T            | TMO-1            |
|------------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Total Phenolic Content (mg GAE/mL) | 2.66 $\pm$ 0.23  | 2.92 $\pm$ 0.26  | 2.66 $\pm$ 0.02  | 2.79 $\pm$ 0.08  | 2.62 $\pm$ 0.05  | 2.70 $\pm$ 0.30  |
| Antioxidant Capacity (%)           | 72.23 $\pm$ 1.77 | 87.30 $\pm$ 2.26 | 68.98 $\pm$ 8.21 | 74.58 $\pm$ 2.69 | 72.08 $\pm$ 1.45 | 56.50 $\pm$ 5.74 |

As seen in Table 4, office 98 variety has the highest phenolic content and antioxidant capacity. TMO-T variety has the lowest phenolic content and TMO-1 variety has the lowest antioxidant capacity. The phenolic content of poppy seed in Eskişehir and Konya regions in free and esterified form was examined and it was found that the phenolic content was 229 mg / 100g seed and 701mg / 100g seed respectively (Bozan and Temelli, 2008).

## CONCLUSIONS

There are four dominant fatty acids in poppy oil. These are palmitic acid (C16:0), stearic acid (C18:0), oleic acid (C18:1) and linoleic acid (C18:2). Poppy has a high rate of polyunsaturated fatty acids. Since the omega 6 / omega 3 ratio is very high, continuous consumption of poppy oil can pose a cardiovascular risk. In order to prevent this, instead of not consuming poppy oil, we should increase omega 3 consumption. Because poppy oil is rich in essential fatty acids, phenolic compounds and tocopherols. Also it has high antioxidant capacity. The rich nutrient content of poppy oil makes it an alternative to other oils.

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## PROXIMATE AND MINERAL COMPOSITION OF SELECTED SOYBEAN GENOTYPES IN NIGERIA

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### ABSTRACT

An experiment was conducted at the Central Services Laboratory of the National Cereals Research Institute, Badeggi, Nigeria to evaluate proximate and mineral composition of eight soybean accessions (NG/MR/11/11/060, NG/SA/07/100, NG/SA/JAN/09/48, NGB00111, NGB00113, NGB00116, NGB01318) conserved in the National Genebank at National Centre for Genetic Resources and Biotechnology (NACGRAB), Ibadan, Nigeria and twelve varieties (TGX1019-2EB, TGX1019-2EN, TGX1440-1E, TGX1448-2E, TGX1485-1D, TGX1835-10E, TGX1904-6F, TGX1951-3F, TGX1987-62F, TGX1989-19F, TGX923-2E, TGX1987-10F) developed at National Cereals Research (NCRI) in collaboration with International Institute for Tropical Agriculture (IITA) and The result showed wide significant variations in the proximate and mineral contents. TGX1987-62F recorded the highest dry matter content of 98.34% while TGX 923-2E gave the highest moisture content (6.12%). Highest values for Crude ash (5.02%) and crude fibre (6.12%) were recorded for TGX1951-3F. NGB00116 had the significantly highest protein content of 41.92% and an appreciable oil content of 27.65%. Protein content was also high for TGX1987-10F (41.33%) and NG/MR/11/11/060 (41.31%). TGX1989-19F had the highest oil content of with 30.45% and energy value (496.37Kcal/g). NGB00113 had the highest carbohydrate content of 52.74%. K, Na, Ca, Mg and P were highest in NG/SA/JAN/09/48 (1.99%), NGB00116(0.57%), TGX1485-1D (1.60%) TGX1951-3F (0.84%) and NGB00113 (0.85%) respectively. The study provides valuable information on soybean genotypes with very high protein and oil content for recommendation to farmers and other end users and for breeders to select and utilize in soybean quality improvement programmes.

**Keywords:** *Accessions, Protein content, Oil content, Soybean*

## INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is a member of Papilionaceae family, believed to have originated in Northeastern China and distributed in Asia, USA, Brazil, Argentina and other parts of the world. This crop is aptly called as “Miracle crop” of the 20th century as it is aptly called due to its multiple uses. Soybean with an average protein content of 40% and oil content of 20% has the highest protein of all food crops for food and feed (Sharma *et al.*, 2013; Hossain and Komatsu, 2014), including those of cowpea and common bean (Nwadike *et al.*, 2018), and second only to groundnut in terms of oil content among food legumes. Compared to other protein rich foods such as meat, fish, and eggs, it is by far the cheapest. Soybean seeds have been described as “protein hope” of the future (Satheet *et al.*, 2009) and meat that grows on plant (Henkel, 2000) owing to its high nutritive value. Soybean seeds besides being rich in in proteins, contain unsaturated, cholesterol free fatty acids, minerals and vitamins A, B, C and D which meet the nutritional needs of humans and other animals (Maleket *et al.*, 2014; Ghosh *et al.*, 2014), and contains numerous antioxidants beneficial to human health, as they significantly reduce the risk of many diseases (Kumar *et al.*, 2014).

Nigeria is the largest producer in Africa. Though, soybean is grown in many states of Nigeria, the Northern and Southern guinea savanna regions record the highest soybean production. Production mainly in the southern guinea savanna zones comprising Benue, Kaduna, Oyo, Ondo, Adamawa, Taraba and Plateau with Benue as the highest (Smith *et al.*, 1995). According to Odeleye *et al.*, (2007) there is a wide margin between what is needed and what is currently produced. Due to its great potentials in Nigeria for oil production and relatively cheap protein source for the vast resource poor populace, evaluation of collected released varieties and accessions is necessary to identify their individual nutritional composition.

Information of the protein content of soybean varieties released over the years in Nigeria is non-existent at worst and at best rare to come by in literature. This may be due to the general assumption that soybean is rich in protein and oil. Thus most of the varieties released in Nigeria are based on seed yield, early maturity, low shattering and resistance to disease especially rust. Similarly, accessions held in the National Genebank have not been previously evaluated for nutritional content. Therefore, this pioneer attempt to unravel the proximate and mineral compositions of selection released varieties as well as accessions will give a depth knowledge to the wealth of nutrient in each genotype studied. This will also provide very useful information for breeders seeking to improve the nutritional quality of this crop while equipping farmers and the populace on the specific varieties to plant and consume for specific nutritional needs.

## MATERIALS AND METHODS

### Genotypes Used and Parameters Evaluated

Twenty (20) soybean genotypes (Table 1) comprising 11 varieties released in Nigeria and 9 accessions collected from different parts of Nigeria and held in trust of the National Genebank at National Centre for Genetic Resources and Biotechnology (NACRAB), Ibadan, Nigeria were evaluated for proximate and macro mineral nutrient contents. Percentage compositions in dry matter, moisture, ash, crude fat/oil, crude protein, crude fibre, carbohydrate and energy value

(Kcal/g) were evaluated. Potassium (K), Sodium (Na), calcium (Ca), Magnesium (Mg) and Phosphorus (P) contents of these genotypes were also evaluated. The experiment was conducted at the General Laboratory of National Cereals Research Institute, Badeggi, Nigeria.

**Table 1:** List and sources of plant materials used in the experiment.

| S/N | Accessions       | Source          | Status                                      |
|-----|------------------|-----------------|---|
| 1   | NG/AA/SEP/09/166 | NACGRAB, Ibadan | Farmer's cultivar conserved in the genebank |
| 2   | NG/MR/11/11/060  | “               | “   |
| 3   | NG/SA/07/100     | “               | “   |
| 4   | NG/SA/JAN/09/48  | “               | “   |
| 5   | NGB 00111        | “               | “   |
| 6   | NGB 00113        | “               | “   |
| 7   | NGB 00116        | “               | “   |
| 8   | NGB 01318        | “               | “   |
| 9   | TGX 1019-2EB     | IITA, Ibadan    | Improved registered variety                 |
| 10  | TGX 1019-2EN     | “               | “   |
| 11  | TGX 1440-1E      | “               | “   |
| 12  | TGX 1448-2E      | “               | “   |
| 13  | TGX 1485-1D      | “               | “   |
| 14  | TGX 1835-10E     | “               | “   |
| 15  | TGX 1904-6F      | “               | “   |
| 16  | TGX 1951-3F      | “               | “   |
| 17  | TGX 1987-62F     | “               | “   |
| 18  | TGX 1989-19F     | “               | “   |
| 19  | TGX 923-2E       | “               | “   |
| 20  | TGX1987-10F      | “               | “   |

### Proximate Composition

Seed bean Nitrogen (N) was determined by the thermal conductivity procedure that included the combustion of the sample to 10 40°C (Sadzawka *et al.*, 2007). The N content of the seed was multiplied by 6.25 to obtain the protein content (Guzmán-Maldonado *et al.*, 2000).

Moisture content was determination using the air oven method. Crucibles were washed and dried in an oven. They were allowed to cool in the desiccator and weight was noted. A known weight of samples were then transferred into the crucibles and dried at a temperature between 103-105°C. The dry samples were cooled in a desiccator and the weight noted. They were later returned to the oven and the process continued until constant weights were obtained. Moisture content was calculated using the formula

$$\% \text{ moisture content} = \frac{\text{weight loss} \times 100}{\text{weight of smaple}}$$

Ash content was determined by weighing of finely ground sample into clean, dried previously weighed crucible with lid (W1). The sample was ignited over a low flame to char the organic matter with lid removed. The crucible was then placed in muffle furnace at 600°C for 6h until it

ashed completely. It was then transferred directly to desiccators, cooled and weighed immediately (W2).

$$\% \text{ Ash content} = \frac{\text{weight loss} \times 100}{\text{weight of sample}}$$

Crude fat was determined using Soxhlet apparatus. A known weight of sample was weighed into a weighed filter paper and folded neatly. This was put inside preweighed thimble (W1). The thimble with the sample (W2) was inserted into the Soxhlet apparatus and extraction under reflux was carried out with petroleum ether (40°C – 60°C boiling range) for 6h. At the end of extraction, the thimble was dried in the oven for about 30 minutes at 100°C to evaporate off the solvent and thimble was cooled in a desiccator and later weighed (W3). The fat extracted from a given quantity of sample was then calculated:

$$\% \text{ Fat} = \frac{\text{loss in weight of sample} \times 100}{\text{original weight of sample}}$$

Crude fibre was determined by taking the fat free extract obtained after determining Ether Extract and weight part of it. This is then serially heated with dilute acid and dilute alkali to hydrolyse away the digestible portion. The residue is dried and weighed. This weight, less the weight of ash is the fibre content. The percentage carbohydrate content of seeds was determined by summing up the percentages of moisture, ash, crude protein, fat (ether extract) and subtracting from 100% CHO = 100 - (Sum of the percentages of moisture, ash, fat, protein and crude fibre). The difference in value was taken as the percentage total carbohydrate content of seed (A.O.A.C., 2006; Ameh, 2007).

### **Mineral Composition Analysis**

Twenty (20) accessions of soybean genotypes were analysed for Ca, Fe, B, Zn, K, Mg, Mn and P by flame atomic absorption spectrometry (Perkin-Elmer spectrophotometer, model 1100B, Phoenix, Arizona, USA), (Sadzawka *et al.*, 2007). Bean seed samples were ground to a fine powder to ensure homogeneity before analysis of macro and micronutrients. The samples were concentrated by evaporating 100ml of sample to about 20ml. They were thereafter aspirated through the nebulizer into the air-acetylene flame where atomization took place. Using a source lamp for each element, the amount of energy absorbed in the flame is proportional to the concentration of the element in the sample over a limited concentration range.

### **Statistical Analysis**

All data were subjected to an ANOVA. The least significant difference (LSD) was used to compare the means of the genotypes using the STAR (2014) statistical software. Significantly different means were separated using SNK at  $P \leq 0.05$  probability level.

## **RESULTS AND DISCUSSIONS**

### **Results**

Results of the proximate and mineral compositions of twenty soybean genotypes (Table 2) showed significant differences for all the parameters evaluated. Total dry matter (%) value of 98.34% recorded for TGX1987-62F was significantly highest, followed by 97.27% for TGX1019-2EN. TGX923-2E had the least dry matter content of 93.48%. Moisture content varied significantly

among the genotypes with TGX923-2E (6.12%) and TGX1989-19F (5.12%) having the highest moisture contents while, least moisture content of 1.88% was observed for TGX1987-62F. NGB00116 recorded the highest ash content of 5.36% while BG/SA/JAN/09/48 had the lowest (3.34%).

Crude fat/oil content varied significantly with the highest value of 30.45% recorded for TGX1989-19F, followed by 28.44%.and 28.11% recorded in NG/MR/11/11/060 and TGX1904-3F respectively. The least value of 21.12% recorded for NG/SA/JAN/09/48. Protein content was significantly highest at 41.92% for NG00116 followed by 41.33%, 41.31% and 40.32% in TGX1987-10F, NG/AA/SEP/09/166 and TGX1835-10E respectively. NG00113 (12.96%) had the lowest recorded crude protein. Crude fibre (%) was observed to be highest in TGX1951-3F recording 6.12% followed by TGX1440-1E (6.09%), but the least value for this parameter observed in TGX923-2E was 3.75%.

NGB00113 (52.74%) recorded significantly highest carbohydrate value followed by TGX1019-2EN (46.64%). The least value for carbohydrate (15.83%) was recorded for NGB00116. Energy value (Kcal/g) was significantly highest for TGX1989-19F at 496.37Kcal/g. The genotype with significantly lowest energy value of 459.97Kcal/g was TGX1440-1E.

Mineral composition results (Table 3) showed that NG/SA/JAN/09/48 (1.99%) and TGX923-2E (1.09%) had the significantly highest and lowest Potassium (K%) content respectively among the genotypes used in this study. Sodium (Na%) composition was significantly highest in NGB00116 (0.57%) and lowest in NG/MR/11/11/060 (0.10%). Similarly, NG/SA/JAN/09/48 (1.60%) and TGX 1485-1D (1.60%) had significantly highest Calcium compositions. This value was not significantly different from 1.57% and 1.56% recorded for TGX1987-62F and NGB00111 respectively (Table 3). Magnesium (Mg %) composition varied from 0.84% significantly highest in TGX1951-3F to 0.15% lowest in TGX 1019-2EB and TGX1987-62F (Table 3). NGB00113 (0.85%) was significantly highest for Phosphorus (P %) followed by 0.78% in TGX 1019-2EN. TGX 1019-2EB (0.26%) and TGX1987-10F (0.27%) had the least Phosphorus contents.

**Table 2:** Proximate composition of 20 soybean genotypes in Nigeria.

| Genotype           | Dry matter (%) | Moisture (%) | Ash (%) | Crude fat/oil (%) | Crude protein (%) | Crude fibre (%) | CHO (%) | Energy value Kcal/g |
|--------------------|----------------|--------------|---------|-------------------|-------------------|-----------------|---------|---------------------|
| NG/AA/SEP/09/166   | 96.45          | 3.44         | 3.75    | 25.36             | 41.31             | 4.72            | 21.33   | 479.60              |
| NG/MR/11/11/060    | 95.53          | 4.12         | 4.53    | 28.44             | 32.50             | 4.98            | 26.38   | 488.89              |
| NG/SA/07/100       | 96.54          | 3.69         | 4.31    | 23.12             | 16.06             | 5.06            | 48.00   | 462.61              |
| NG/SA/JAN/09/48    | 97.20          | 2.60         | 3.34    | 21.12             | 23.94             | 4.64            | 44.43   | 468.12              |
| NGB 00111          | 95.30          | 4.74         | 5.12    | 27.65             | 20.48             | 5.11            | 36.63   | 479.39              |
| NGB 00113          | 96.20          | 3.69         | 4.11    | 22.39             | 12.96             | 4.92            | 52.74   | 464.68              |
| NGB 00116          | 96.42          | 3.66         | 5.36    | 26.93             | 41.92             | 5.32            | 15.83   | 477.17              |
| NGB 01318          | 96.49          | 3.45         | 4.26    | 22.46             | 33.38             | 5.12            | 31.26   | 461.39              |
| TGX 1019-2EB       | 96.52          | 3.55         | 3.97    | 26.07             | 22.39             | 5.32            | 38.55   | 478.92              |
| TGX 1019-2EN       | 97.25          | 2.75         | 4.57    | 23.40             | 18.24             | 4.28            | 46.64   | 470.4               |
| TGX 1440-1E        | 95.25          | 4.75         | 4.12    | 24.30             | 32.56             | 6.09            | 28.57   | 459.97              |
| TGX 1448-2E        | 96.35          | 3.68         | 4.31    | 25.39             | 39.98             | 5.60            | 21.24   | 473.50              |
| TGX 1485-1D        | 96.62          | 3.82         | 4.11    | 23.54             | 27.31             | 5.11            | 36.40   | 468.93              |
| TGX 1835-10E       | 95.90          | 4.10         | 3.88    | 23.52             | 40.32             | 4.95            | 22.55   | 465.21              |
| TGX 1904-6F        | 96.42          | 3.62         | 4.19    | 28.11             | 36.30             | 4.18            | 23.54   | 484.44              |
| TGX 1951-3F        | 95.45          | 4.47         | 5.02    | 26.22             | 35.11             | 6.12            | 23.06   | 468.11              |
| TGX 1987-62F       | 98.34          | 1.88         | 5.11    | 25.15             | 31.43             | 5.12            | 31.50   | 476.04              |
| TGX 1989-19F       | 94.64          | 5.12         | 4.22    | 30.45             | 39.31             | 4.12            | 16.72   | 496.37              |
| TGX 923-2E         | 93.48          | 6.12         | 4.54    | 24.82             | 37.06             | 3.75            | 23.83   | 464.48              |
| TGX1987-10F        | 96.02          | 3.99         | 4.05    | 25.28             | 41.33             | 5.34            | 20.27   | 474.83              |
| SE±                | 0.57           | 0.24         | 0.29    | 0.60              | 0.56              | 0.32            | 0.48    | 6.33                |
| LSD (P = 0.05) SNK | 1.15           | 0.48         | 0.58    | 1.21              | 1.12              | 0.64            | 0.97    | 12.78               |

**Table 3:** Mineral composition of 20 soybean genotypes in Nigeria.

| Genotype           | K(%) | Na(%) | Ca(%) | Mg(%) | P(%) |
|--------------------|------|-------|-------|-------|------|
| NG/AA/SEP/09/166   | 1.76 | 0.47  | 0.99  | 0.47  | 0.62 |
| NG/MR/11/11/060    | 1.76 | 0.10  | 0.58  | 0.81  | 0.59 |
| NG/SA/07/100       | 1.36 | 0.23  | 1.48  | 0.58  | 0.44 |
| NG/SA/JAN/09/48    | 1.99 | 0.53  | 1.60  | 0.39  | 0.46 |
| NGB 00111          | 1.72 | 0.20  | 1.56  | 0.82  | 0.45 |
| NGB 00113          | 1.45 | 0.26  | 0.86  | 0.45  | 0.85 |
| NGB 00116          | 1.72 | 0.57  | 1.24  | 0.45  | 0.72 |
| NGB 01318          | 1.58 | 0.51  | 1.06  | 0.54  | 0.34 |
| TGX 1019-2EB       | 1.68 | 0.46  | 1.09  | 0.15  | 0.26 |
| TGX 1019-2EN       | 1.39 | 0.44  | 0.94  | 0.21  | 0.78 |
| TGX 1440-1E        | 1.67 | 0.24  | 0.76  | 0.65  | 0.46 |
| TGX 1448-2E        | 1.84 | 0.54  | 0.96  | 0.15  | 0.55 |
| TGX 1485-1D        | 1.86 | 0.48  | 1.60  | 0.27  | 0.50 |
| TGX 1835-10E       | 1.83 | 0.18  | 0.86  | 0.34  | 0.58 |
| TGX 1904-6F        | 1.46 | 0.19  | 0.70  | 0.49  | 0.44 |
| TGX 1951-3F        | 1.85 | 0.19  | 0.95  | 0.84  | 0.54 |
| TGX 1987-62F       | 1.52 | 0.18  | 1.57  | 0.15  | 0.74 |
| TGX 1989-19F       | 1.45 | 0.15  | 0.86  | 0.75  | 0.58 |
| TGX 923-2E         | 1.09 | 0.10  | 0.66  | 0.55  | 0.50 |
| TGX1987-10F        | 1.68 | 0.54  | 1.23  | 0.08  | 0.27 |
| SE±                | 0.05 | 0.04  | 0.06  | 0.05  | 0.04 |
| LSD (P = 0.05) SNK | 0.10 | 0.09  | 0.13  | 0.099 | 0.09 |

## Discussions

The low moisture content observed in all the genotypes (Table 1), 1.88% in TGX1987-62F through 6.12% in TGX923-2E shows these genotypes have less moisture due to more concentrates of other nutrients. This is an indication that all the genotype can be stored for a very long time since moisture which is an important medium for multiplication of microorganisms is very low in the genotypes. These results are in agreement with Davies (2008) who reported lower moisture content in full-fat soybeans. Etiosa *et al.* (2017) on the other hand reported higher moisture content in contrast to the findings of this experiment. The ash contents ranging from 3.34% to 5.02 for the genotypes under study is an indication that the genotypes could be important sources of minerals. Saulawa *et al.* (2014); Siulapwa and Mwambungu (2014); Edema *et al.*, (2005) in all reported higher ash contents, but reports of ranges of 1.01%-1.67% for ash content (Eshum, 2012) was lower than those observed by the researchers. The high crude fat content observed in the genotypes NG/SA/JAN/09/48 (21.12%) through TGX1989-19F (30.45%) are in agreement with that reported by Ogbemudia *et al.* (2017) and much higher than those reported by Adie *et al.* (2015) who reported oil content range of 7.0 – 25% for all 78 soybean varieties registered by Ministry of Agriculture Republic of Indonesia. Liu (2000) also reported that soybean seed contain 18% – 21% oil. This suggests that the genotypes may be a viable source of higher oil quantity, going by their crude fat contents. Soybean crude fat is reported to have cholesterol reducing ability thereby making it essential oil for obese people diet. Balasubramaniyan and Palaniappan (2003) reported that the oil in soybean consists of 85% unsaturated fatty acid with two essential fatty acids (linoleic and linolenic acid) which are not synthesized by the human body, thus highly desirable in human diet. Seeds from these exceptional genotypes could be used in weight-loss drinks, sport drinks, as low-fat substitute in hamburger, in commercial bakery industry to aid in dough conditioning and bleaching, as it possesses excellent moisture-holding qualities that helps to retard staling in

bakery products. Greater cultivation and consumption of these high oil containing genotypes will go a long way in improving diet and food security of the Nigerian populace.

The high protein content obtained in the following genotypes ranging from highest NGB 00116 TGX 1987-10F, NG/AA/SEP/09/166, TGX1835-10E, TGX1448-2E (39.98%), TGX1989-19F are higher than the reported values 37.69% by Siulapwa and Mwambungu (2014); 36.27% Liu (2000); 38.42% Stein *et al.*, (2008). The above genotypes are of nutritional importance to sub-Saharan Africa where protein energy malnutrition is a menace. They can be incorporated into diet formulations for weaning foods in infant and as an alternative to animal proteins which has problem low density lipoprotein that have adverse health effect such coronary diseases. Moreover, the health benefits of soy protein related to the reduction of cholesterol levels, menopause symptoms and reduction in risk for several chronic disease i.e., cancer, heart disease and osteoporosis have been reported (Potter, 1998). The genotypes with lower protein contents can be channel into oil production and animal feed stock. The crude fibre of the genotypes with values ranging from 3.75% to 6.009% are relatively low as compared to Madgi (2004) but similar to that of Okoye *et al.*, (1980), The presence of fibre in foods is known to be beneficial. Fibre has some physiological effects in the gastrointestinal, tract. These effects include variation in faecal water, faecal bulk and transit time and elimination of bile acids and neutral steroids which lower the body cholesterol pool. The high carbohydrate contents ranging from 15.83% to 52.74% of the genotypes suggests that the genotypes could be used in managing protein-energy malnutrition since there is enough quantity of carbohydrate to derive energy from in order to spare protein so that protein can be used for its primary function of building the body and repairing worn out tissues rather than as a source of energy. Genotypes having carbohydrates percentage above 25% are in agreement with the report of Ogbemudia *et al.* (2017). This could be as result of the location or environment of cultivation and the type of nutrient supply in the course of production.

The minerals (calcium, potassium, sodium magnesium and phosphorus) contents of the genotypes are appreciably high but they are consistent with the findings of Madgi (2004) who found high level of these minerals. The above mineral are required in large quantity by man thus processing is needed to be adopted in making them available for use. High calcium suggests that the genotypes could be used in complementary foods to help build the bones and teeth since calcium is one of the main components of teeth and bones. Calcium also plays a role in blood clotting. Magnesium is involved in making proteins and releasing energy and helps hold calcium in the enamel of the teeth. Phosphorus is closely linked with calcium. The two minerals combine to form calcium phosphate, which gives bones their rigid structure. Sodium is needed in the body in a small amount to help maintain normal blood pressure and normal function of muscles and nerves. Potassium helps in lipid metabolism and energy transduction in cellular membrane function Mehas and Rodgers (2012).

Though it is a fact that mineral nutrients of plant origin are not readily available to man as a result of the inability to be absorbed in the small intestine, but complement those from animal origin Agbaire and Emoyan (2012).

## CONCLUSIONS

The genotypes studied have shown good nutritional qualities especially for protein and oil contents. The information contained in this paper will provide long needed bases for soybean quality improvement. The previously uncharacterised accessions NGB00116 and NG/AA/SEP/09/166 could be further evaluated by NACGRAB in collaboration with soybean

breeding institutes for possible registration and release for exceptional quality of high protein content and NG/MR/11/11/060 for high oil content.

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## BIOACTIVE PEPTIDES FROM OILSEED MEALS

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### ABSTRACT

Oilseed meals contain a high amount of proteins, fibers, and phenolic compounds. These compounds are used with different purposes in the food industry. Consumer trends show that healthy and functional foods have been requested. So oilseed meals are the potential sources of these compounds which have positive effects on human health. Especially bioactive peptides have different bioactive effects such as antioxidant, antihypertensive, antimicrobial, anticancer, anti-inflammatory, immunomodulatory, opioid, etc. In the parent molecule peptides are not active and specific peptides can be released during gastrointestinal (GI) digestion, hydrolysis by proteolytic microorganisms and through the action of proteolytic enzymes derived from microorganisms or plants and food processing.

In this study, release mechanisms of bioactive peptides from oilseed meals and bioactivities of peptides will be reviewed.

**Keywords:** *Bioactive, Oilseed, Peptides*

### INTRODUCTION

There is growing interest tend to determine the bioactive peptides from different sources such as animal, plant, microorganisms, etc. Bioactive peptides are oligopeptides they contain 2-20 amino acid sequences and inactive in the protein molecules. Bioactive peptides formed after enzymatic hydrolysis by endogen enzymes, digestion, fermentation (Piovesana et al., 2018). Milk proteins, casein and whey, egg, meat, fish and marine sources like oyster, squid, sea urchin, macroalgae (Udenigwe & Aluko, 2012; Piovesana et al., 2018) are sources of bioactive peptides are more investigated but vegetable-derived peptides such as soy, pulses, oat, wheat, hemp seed, canola, flaxseed have interest too in recent years. Vegetables and especially agro-industrial wastes are important protein sources with some advantages such as low price, lower environmental effects (Piovesana et al., 2018). Oil seeds contain important nutritional components especially proteins after extraction of oils from the seed. The proteins and peptides in the oilseed meal (soybean (Rayaprolu et al., 2013), rapeseed (Xie et al., 2015) are active and they show bioactivities such as hypertensive, antioxidative, anticancer, anti-inflammatory, immunomodulatory and hypocholesterolemic (Deepak & Lele, 2018).

### Bioactive Peptides from Oilseed Meals

Protein hydrolysis is the most important factor for production. For producing bioactive peptides some different technics were developed. Enzymatic hydrolysis, fermentation, food processing conditions, digestion are responsible for the production of bioactive peptides and also new technics could be combined with industrial methods for better and efficient hydrolysis. Some of these technics are electric field, ultrasound, infrared and microwave irradiation (Deepak & Lele, 2018).

Plant proteins such as legumes, cereals, and oilseeds are alternative to animal proteins because of the renewability of plants, variety of sources and widespread of plants (Moure, Sineiro, Domínguez, & Parajó, 2006). According to Piovesana et al. (2018) quotes the production of bioactive peptides from wastes or by-products from vegetables and enzymes used for hydrolysis doesn't differ significantly. Some plant proteins are deficient in sulfur amino acids compared to animal proteins and also may contain anti-nutrient factors. This limitation can be easily overcome by supporting other proteins. Oilseed proteins contribute to human dietary protein intake (Moure et al., 2005).

The most produced oilseeds are soybean, rapeseed, cotton, peanut, sunflower, etc. Soybean belongs to the family of the *Fabaceae* and used for animal and human nutrition. Rapeseed belongs to the *Cruciferae* family also known as rape. Extracted rapeseed oil used for human nutrition (Rodrigues, et al., 2012).

After the extraction process from the oilseeds, the obtained by-product is defatted seed meal. The defatted meal contains protein and carbohydrate with a high ratio and has an important nutritive value (Rodrigues et al., 2012). For example; rapeseed contains 40 % protein on dry basis and have an amino acid composition similar to the cereals. To increase the value of products, extraction, concentration, and isolation of protein and carbohydrate fractions from defatted seed meals are essential (Rodrigues et al., 2012). Bioactive peptide generation from defatted seed meals is an important way to valuation of proteins (Wu et al., 2019).

The classical method of bioactive peptide producing is;

- 1- Protein preparation from the sources
- 2- Hydrolysis of proteins
- 3- Screening of bioactive properties
- 4- Isolation and enrichment of peptides
- 5- Amino acid sequence analysis and validation (Li-Chan, 2015).

The type of enzyme plays a critical role in the generation of peptides. Activities of the peptides also affected from the type of enzyme. There are several reports have found about the enzymes used such as trypsin, Flavourzyme®, alcalase, thermolysin, pronase, pepsin, ficin, papain, pancreatin, Thermoase® (Wu et al., 2019).

Hydrolysis time and enzyme/ substrate ratio affect the formation of the peptides.

**Table 1.** Some researches about bioactive peptides from oilseed meal proteins

| Material                           | Preparation of protein hydrolysates   | Analysis   | References   |
|------------------------------------|---|--|--|
| Pine nut                           | Alcalase (7%, w/)   | ACE-inhibitory, DPPH, Reducing power, $\beta$ -Carotene-linoleic Acid Assay  | (Cai, Xiao, Liu, & Ying, 2013)                           |
| Flaxseed                           | Whole ground, Mucilage removed and ground flaxseed, Mucilage and oil-removed and ground flaxseed, Baked and ground flaxseed, Boiled and ground flaxseed, Isolated flaxseed protein  | Simulated gastrointestinal (GI) digestion  | (Marambe, Shand, & Wanasundara, 2013)                    |
| Rapeseed, flaxseed                 | <i>Lactobacillus helveticus</i> CNRZ32, <i>Lactococcus lactis</i> ssp. <i>lactis</i> 20481, <i>Kluyveromyces marxianus</i> ATCC 28244, and <i>Bacillus subtilis</i> ATCC 21394  | ACE-inhibitory, inhibitory activity on lipid peroxidation  | (Pihlanto & Mäkinen, 2012)                               |
| Soybean                            | Alcalase (1, 3.5, and 5 Anson units)  | Colon cancer cell growth inhibition (Caco-2 and HCT-116), Liver cancer cell growth inhibition (HepG-2), Lung cancer cell growth inhibition (NCL-H1299) | (Rayaprolu SJ, Hettiarachchy NS, Chen P, Kannan A, 2013) |
| Cottonseed                         | <i>Bacillus subtilis</i> BJ-1/ Solid-state fermentation   | DPPH, Hydroxyl radical-scavenging, Metal-chelating, Reducing power, Cell culture and cell viability assay  | (Sun et al., 2015)                                       |
| Pine nut (pilot scale)             | Alcalase  | ACE-inhibitory   | (White et al., 2013)                                     |
| Aflatoxin contaminated peanut meal | Alcalase  | ACE-inhibitory   | (White, Sanders, & Davis, 2014)                          |
| Peanut                             | <i>Lactobacillus reuteri</i> 62, <i>L. fermentum</i> B45, <i>L. helveticus</i> C14, <i>Bifidobacterium bifidum</i> B04, <i>L. plantarum</i> Lp1, <i>L. plantarum</i> Lp2, <i>L. plantarum</i> Lp3, <i>L. plantarum</i> Lp6, <i>L. delbrueckii</i> subsp. <i>bulgaricus</i> L2, <i>Streptococcus thermophilus</i> S5, <i>L.casei</i> LC35, <i>L. casei</i> LC2, <i>L. acidophilus</i> LA1, <i>L. acidophilus</i> LA4 | ACE-inhibitory   | (Zeng, Naifu, & Qian, 2013)                              |

### Antioxidant and Anti-hypertensive activities of oilseed meals

Oxidative stress is a biological condition that normally occurs during cell metabolism and leads to the generation of reactive oxygen species (ROS) and reactive nitrogen species (RNS). The body also exhibits a defense mechanism by producing antioxidant compounds and enzymes that neutralize these reactive species and prevent the development of the chronic disease. Special attention focused on the antioxidant activities of peptides from different protein sources (Deepak & Lele, 2018).

### Anti-hypertensive activity

Hypertension is a physiological stress state where the pressure in the blood vessels is very high and causes the pressure to rise in each heartbeat. It is an important risk factor for heart attack and stroke. Angiotensin-converting enzyme (ACE) increases blood pressure by inhibiting the binding of blood vessels to inactive decapeptide angiotensin I by angiotensinogen. The angiotensin-converting enzyme (ACE) also separates the C-terminal dipeptide from Angiotensin I to form an active octapeptide angiotensin-II, which is an effective vasoconstrictor and inactivates bradykinin in the renin-angiotensin system (Deepak & Lele, 2018).

### CONCLUSION

Protein fractions and hydrolysates from oilseed meals are created value-added products in food, cosmetics, and pharmaceutical industries. Oilseed meals obtained after the oil extraction as a byproduct is an important source of bioactive peptide production. After the modification of the protein isolates from oilseed meals contain bioactive peptides with different bioactive properties.

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## MOLECULAR CHARACTERIZATION OF CLADOSPORIUM CLADOSPORIODES ON SOYBEAN SEED

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### ABSTRACT

*Cladosporium* is a significant genera of fungi widely distributed around the world. It is generally considered as a secondary invader after the plants infected by the pathogens. This study was carried out to detect the seed borne diseases associated with soybean seeds. For this target, soybean seeds displaying disease symptoms were collected from the experimental field of Akdeniz University, Antalya, Turkey. For identification, symptomatic soybean seeds were first surface sterilized using 10% NaClO for 1 min, rinsed with sterile water for 1 min and then placed on Petri plates containing potato dextrose agar (PDA) and incubated at 24°C for 7 days for sporulation. Colonies of the fungus on PDA were dark-green and showed a smooth texture when examined under the light microscope. Based on the morphological observations the fungus was identified as *Cladosporium* sp. To further confirm morphologic identification, genomic DNA was extracted and amplified with ITS 1 and ITS 4 primers. Amplified PCR product was sequenced and the sequences were aligned using the MEGA7 software. The fungus was identified as *Cladosporium cladosporiodes* based on the analysis of the sequence data. Phylogenetic analysis were also made using the neighbour joining method and compared with *Cladosporium* isolates deposited in Genbank.

**Keywords:** *Cladosporium cladosporiodes*, Soybean, Seed, ITS region

### INTRODUCTION

Soybean (*Glycine max* L. Merr.) is one of the most widely consumed foods in the world. It is beneficial for human health due to it contains essential fatty acids and amino acids. According to the USDA National Nutrient Database, it contains many vitamins (K, B6, C and etc.) and minerals (calcium, zinc, magnesium, iron and etc.). Soybean is the most produced plant with more than 60 percent production in oil crops in the worldwide. (SOYSTAT 2018). *Cladosporium* is one of the most common saprophytic fungi and is widely distributed in the world. This genus is morphologically largest and mostly heterogeneous (Sandoval-Denis et al. 2015). Dugan et al. (2004) reported that it contains over the 700 different groups. Saprophytic, endophytic, mycophilic and human and plant pathogenic *Cladosporium* spp. was indicated in the literature (Bensch et al., 2015). It generally survives as a secondary invader on plant material. However, it caused the disease in many plants. Generally; leaf spot, scab, fruit rot and other disease symptoms causing the economic losses on agricultural crops were observed for infected plants. *Identification of Cladosporium* is morphologically difficult and also morphologic

characters in this genus are overlap among the species. Thus, molecular studies have been conducted to the identification of *Cladosporium* species.

It was reported that *C. cladosporioides* complex was molecularly discriminated using the Internal transcribed spacers (ITS), actin (ACT) and translation elongation factor (EF-1 $\alpha$ ) regions in order to explain the genetic diversity within this taxa (Bensh et al. 2012). In a similar study ITS, ACT and EF-1 $\alpha$  regions were used to explain evolutionary process in this genus (Torres et al. 2017). The aim of this study was to identify *Cladosporium spp. on soybean seed in molecular level*.

## MATERIALS AND METHODS

### Isolate

The symptomatic soybean seeds were harvested in the experimental field of Akdeniz University, Antalya, Turkey. These seeds were first surface sterilized using 10% NaClO for 1 min, rinsed with sterile water for 1 min and then placed on Petri plates containing potato dextrose agar (PDA) or malt extract agar (MEA) and incubated at 24°C for 7 days for sporulation. After incubation period, the fungus was morphologically identified (Schubert et al. 2007).

### DNA isolation, amplification and sequence analysis

To confirm morphological observation, genomic DNA of the fungus was extracted using the modified CTAB method (Catal et al. 2010). DNA was checked on the 1% agarose gel for 30 min at 90 V. For the PCR amplification, stock primer solution was diluted 10  $\mu$ M. DNA was amplified with the primers ITS1 and ITS4 (Table 1).

**Table 1.** Primers used in this study

| Primer | Sequence 5'-3'       | Reference         |
|--------|----------------------|-------------------|
| ITS1   | TCCGATGGTGAACCTGCGG  | White et al. 1990 |
| ITS4   | TCCTCCGCTTATTGATATGC |                   |

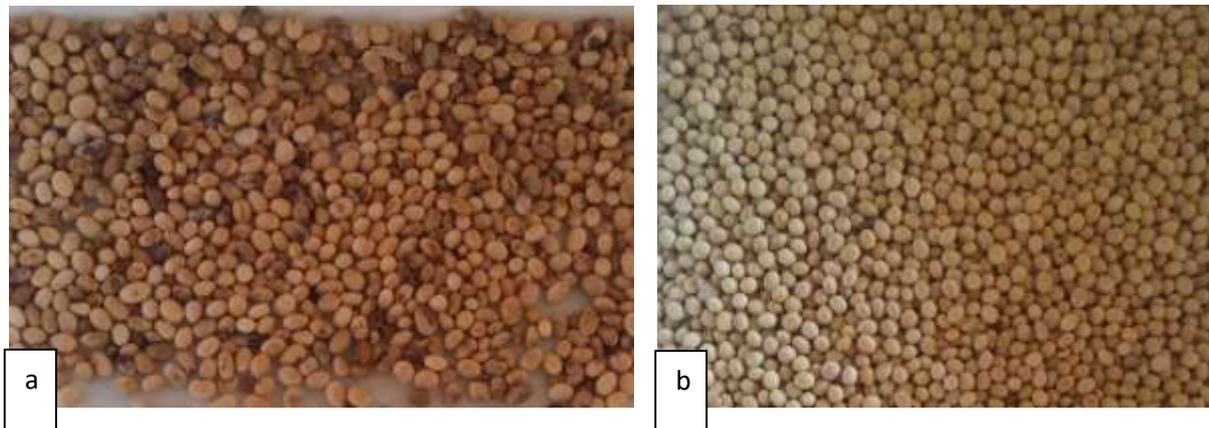
PCR product was electrophoresed on a 1.5% agarose gel in 1% TBE buffer for 30 min at 90 V and stained with ethidium bromide. Bands were detected under UV light in gel analysis system. Amplified PCR product was sequenced and then blast analysis were made with the other *Cladosporium* isolates obtained from GenBank. The phylogenetic tree was created by using the Neighbor-Joining method (Saitou and Nei, 1987). The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (10000 replicates) are shown next to the branches (Felsenstein 1985). The tree is drawn to scale, with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree. The evolutionary distances were computed using the Maximum Composite Likelihood method (Tamura et al. 2004) and are in the units of the number of base substitutions per site. The analysis involved 10 nucleotide sequences. Codon positions included were 1st+2nd+3rd+Noncoding. All positions containing gaps and missing data were eliminated. There were a total of 405 positions in the final dataset. Evolutionary analyses were conducted in MEGA7 (Kumar et al. 2016). *Cladosporium* isolates included in the sequence analysis were given (Table 2). In addition, *Fusarium oxysporium* was used as out group for phylogenetic analysis.

**Table 2.** *Cladosporium* isolates used in the phylogenetic analysis

| Species                         | GenBank No. | Country      |
|---------------------------------|-------------|--------------|
| <i>C. cladosporioides</i>       | MH125284    | Turkey       |
|                                 | HM148003    | Germany      |
|                                 | MH790419    | Uruguay      |
|                                 | HM148004    | USA          |
|                                 | HM148011    | South Africa |
|                                 | HM148014    | Israel       |
|                                 | HM148024    | South Korea  |
| <i>C. pseudocladosporioides</i> | MH864012    | Netherlands  |
| <i>Fusarium oxysporum</i>       | HM148157    | Germany      |
|                                 | AY714094    | USA          |

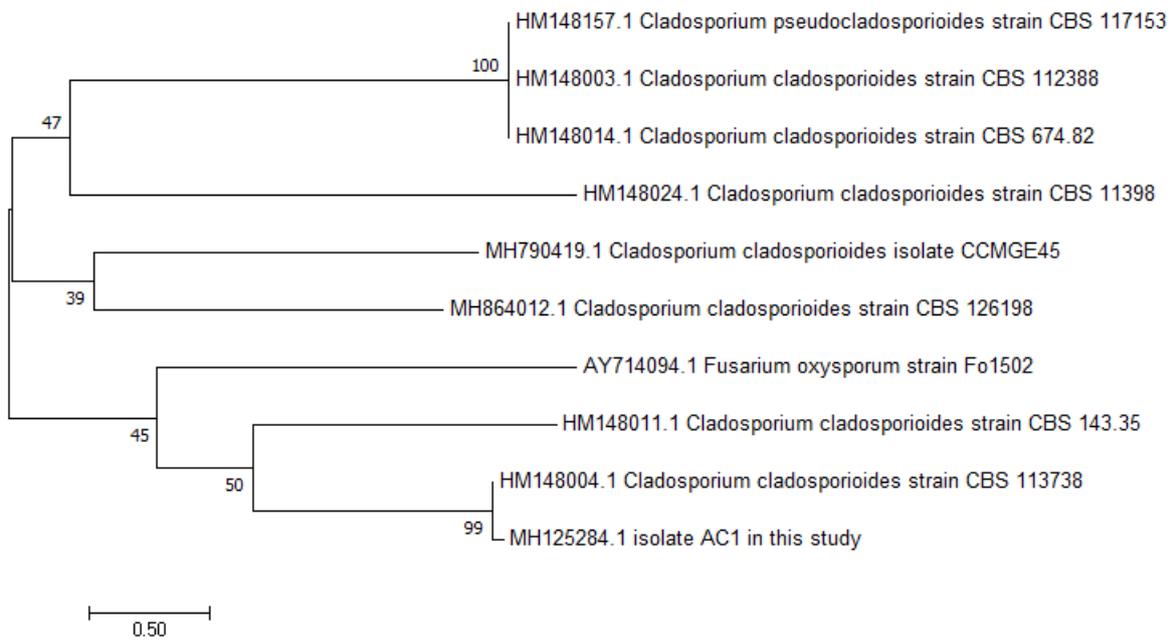
## RESULTS

In the current study, diseased and healthy seed genotypes were observed at harvest time (Figure 1). The infected soybean seeds were selected to detect disease agent microorganism. The isolate obtained from the soybean seed was identified as *Cladosporium* spp. according to the morphological observations such as conidia, culture and colony structure. Colonies of the fungus on PDA were dark-green and showed a smooth texture when examined under the light microscope (Figure 2). Additionally, in order to confirm the morphologic data, genomic DNA of the isolate was amplified with *ITS 1* and *ITS 4* primers. Amplified PCR product was sequenced and the sequences were aligned using the MEGA7 software. The fungus was identified as *Cladosporium cladosporioides* based on the Blast analysis of the ITS region (Figure 3).

**Figure 1.** Disease infected seeds (a) and healthy seeds (b)



**Figure 2.** *Cladosporium* spp. culture



**Figure 3.** Phylogenetic analysis of *C. cladosporioides* isolates

## DISCUSSION

Bensch et al. (2010) reported that the genus *Cladosporium* has been studied extensively with morphologic examinations and molecular analysis. In recent years, the nucleotide sequences

obtained from the different gene regions ITS, ACT and TEF have been used to identify on the *Cladosporium cladosporioides* complex. Among them, the nuclear rDNA-ITS region is generally used to identify for many fungal species. Likewise, ITS region was used to determine of the *C. cladosporioides* in the present study. Several species of *Cladosporium* spp. have been identified morphologically and molecularly (Bensch et al., 2012). In other study, it was described another 19 new species belonging to *Cladosporium* complex (Bensch et al. 2015; 2018). Bensch et al. (2015) showed that the sequence of the ITS, ACT and EF-1 $\alpha$  region can be used distinguish species from *Cladosporium* complex. Additionally, ACT and EF-1 $\alpha$  sequences are more effective than ITS sequences at distinguishing these species. In the present study, we used ITS region to the identification of the cladosporium. Accordingly, The phylogenetic analyses indicated that AC1 isolate in this study belong to the *C. cladosporioides* complex.

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**(28315) RAPESEED AS A SOURCE OF VEGETABLE PROTEIN IN UKRAINE**

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**ABSTRACT**

Oil meals are an important source of protein for animal diets. High feed value, all-year availability and competitive price of these feed components caused a steady increase in their production and use. In recent years, oil meals constitute about 1/3 of the total production of the forage crops in the European Community and are the basis of protein animal feeds in the advanced countries, which, mostly due to this fact, provide the high growth rates of productivity in animal breeding and poultry farming. Eight products dominate in the world production and trade of oil meals. They are soybean (63.4%), rape (10.7%), cotton (7.1%), sunflower (5.3%), peanut (3.7%), palm (2.0%), coconut (1.1%), and linseed (0.6%) oil meal. The role of price leader in the international trade belongs to soybean oil meal, which quantity is 1.5 times more than the following peanut oil meal and is 3 times more than sunflower one, in particular. The use of oil meals in animal feeding is restricted not only by their prices but also by a feed value of protein for animals. The feed value is mainly determined by digestion of protein and limitation of a share of oil meal in the diets of different animals. Thus, soybean oil meal is used for feeding the cattle stock, pigs and poultry in the EU member-states. Due to high feed value, the oil meal almost does not have any feeding limitations, so its cost determines a share of oil meal in the diet. Rapeseed meal of "00"-quality is used for feeding cattle stock up to 25%, broilers 2-3%, pigs up to 6%. At the same time, we cannot use rapeseed meal with a high content of glucosinolates (the old varieties from India and China) for feeding pigs and poultry in the amount exceeding 2% of the mass of the diet. Due to high fiber content, the EU member-states mainly use sunflower oil meal for feeding the cattle stock (up to 10%), avoiding its introduction in the diets of poultry and restricting in the diets of pigs 5%. As gossypol is present in cotton oil meal, it is limited in feeding cattle stock by 15-20%. Aflatoxin contamination has reduced the use of peanut oil meal, which is restricted up to 10% in feeding cattle stock. The EU member-states also use palm and coconut oil meal for feeding cattle stock only, introducing them in diets up to 15% and up to 5% respectively. Because of the relatively high price, the EU member-states use linseed oil meal for feeding calves up to 15-20%. Due to imperfect patterns of oilseed and grain crops as well as due to inadequate export policy, oil meals are produced by 2.5-3 times less than the animal breeding demands in the internal market of Ukraine. This is even though the areas with sunflower, the main oil-protein crop, exceed scientifically based standard more than doubled. In this regard, we have to expand the areas and production of such crops like soybean and rape significantly. In relation to the abovementioned, there is a steady tendency to expand the areas with rape in Ukraine. Thus, while in 2000 these areas averaged 300-400 thousand hectares, then in 2011 -2017 they were 500-800 hectares and in 2018-2019 the areas take over 1 million hectares. Increase in cultivation areas with rape up to 1.5 million hectares will give us the possibility to yield about 2.0 million tons of oil meal to balance nearly 20 million tons of concentrated feeding stuff.

**Keywords:** *Rapeseed, Oil, Meal, Protein, Feeding.*

## INTRODUCTION

The cultivation of rape plants is a traditional economic sector in Ukraine. A new stage of its development connected with the creation and introduction of new varieties suitable for the production of edible oil and high-quality concentrated feedstuff commenced in the early 80s of the previous century. By that time, those varieties have been created and widely spread in production in the world and Europe in particular. From year to year, the areas under this crop plant were expanding and yield of seeds increased. Now, the rape plants take second place among the oil plants, second only to soybeans. Besides, the gross production of rape has exceeded 70 million tons (Report by USDA).

The rape plants take a special place among main crop plants grown in Ukraine. On the one hand, it is a significant source of vegetable oil. On the other hand, the rape plants are valuable fodders for livestock as the rape seeds contain 40-47% of fat and more than 20% of protein. An increase in the production of the livestock products requires the manufacturing of fodders (the concentrated ones, first), improvement of their quality and decrease in the specific gravity of grain.

It can be achieved by extensive use of complete feed additives, by which we can solve the known problem of feed protein deficiency. Resources of high-protein fodders of animal origin (meat, bone, blood and fish flour, skimmed milk powder) and the products of microbiological synthesis are very limited and expensive. In this regard, special attention is paid to the manufacturing of vegetable feed protein, the rape one in particular, which has a high nutritional value and relatively low cost.

Currently, the rape plants grow on almost all continents. Main producers of the rapeseed in the world market are China, the EU member-states, India, Canada and the countries of Eastern Europe. The increased interest in rape is due to good adaptation of the plant to the temperate climate, high productivity of modern varieties, the progressive need for vegetable oil and high-protein fodders. The latter are well-balanced by amino acid composition while their bioavailability, as well as the content of methionine and cysteine, prevails over even soybean fodders.

However, while feeding livestock one should consider that the rape fodders contain toxic substances; therefore, their inclusion into the diets must be limited. The presence of different varieties of the rape, which are characterized by an unequal level of anti-nutrients, as well as selection work aimed at reducing their content, require carrying out the analysis of the rape-products for the content of these compounds and exclusion of harmful effects on the livestock (Shumacher, 1992).

## MATERIAL AND METHODS

Varieties of the rape seeds zoned in Ukraine were presented by originating institutions. Oil meal and press cake obtained from processing the rape seeds were selected at processing facilities in Ukraine. There conducted zoo-technical feed evaluation that determined dry substance, fat, fibre, protein, ash, phosphorus, calcium by conventional methods (Alikaiiv, 1982). The content of alkenyl glucosinolate was detected by the photo colourimetry analysis (Demianchuk et.al, 1987). The fatty acid content of the rapeseed oil was determined using *Chrom-5* gas chromatograph. The amino acid composition of the rape protein was determined under State Standard of Technical Specification 13903:2005 "Components of feedstuffs for livestock – Determination of amino acid composition".

## RESULTS AND DISCUSSION

### *Manufacturing of the rape in Ukraine*

One of the factors of expanding the rape cultivation area is an increase in demand for it by the global agricultural market. In this regard, the rape cultivation area will increase in Ukraine (table 1).

**Table 1.** Cultivation area, crop yield and gross output of the rape in Ukraine (State Service of Statistics)

| Indexes                                   | Years |       |        |        |        |        |        |        |  |
|---|-------|-------|--------|--------|--------|--------|--------|--------|--|
|   | 2000  | 2005  | 2010   | 2014   | 2015   | 2016   | 2017   | 2018   |  |
| Cultivation area, thousands of hectares   | 214   | 207   | 907    | 882    | 682    | 455    | 789    | 1042   |  |
| Crop yield, hundred kilograms per hectare | 8,4   | 14,6  | 17,0   | 25,4   | 25,9   | 25,7   | 27,9   | 26,5   |  |
| Gross output, thousand tons               | 131,8 | 284,8 | 1469,7 | 2198,0 | 1737,6 | 1153,9 | 2194,8 | 2750,6 |  |

Not only the cultivation area but yield and gross output of this crop have recently increased in Ukraine. Besides, the cultivation area amounts to 1.3 million hectares for the crop of 2019, which is 28% higher than the previous year index (Semenda et.al., 2019).

These indexes indicate the process of the intensification of rape production in Ukraine. However, in practice, the average yield of the rape is twice as little as the potential level of plants. So, according to our data, as well as the information of the selection enterprises and manufactures of original seeds, the potential yield of modern rape varieties of the domestic selection may reach over 50 hundred kilograms per hectare, while the potential yield of foreign rape hybrids is more than 65 hundred kilograms per hectare.

The rape yield in the EU is 28.5-35.9 hundred kilograms per hectare over the previous 10 years while it is 17.0-27.9 hundred kilograms per hectare in Ukraine. The main reasons of low yield of the rape in Ukraine remain adverse weather conditions, poorly equipment available for agricultural manufacturers, non-compliance with the technologies of cultivation of the rape plants, using low-quality seeds and cultivation of the rape plants in unsuitable climatic conditions. If stabilizing the average yield at the level of 25-26 hundred kilograms per hectare in Ukraine and the rape cultivation area within 2 million hectares, we may obtain the gross outfit over 5 million tons of these seeds annually (Maslak, 2012).

Unfortunately, the vast majority of the Ukrainian rape is just exported, without processing for the oil or biodiesel as in the leading countries of the world. We remain a raw material appendage of Europe supplying not the finished products but raw materials with the lower added value and potentially losing significant funds (Tokarchuk, 2015).

### *Variety composition of rape seeds produced in Ukraine*

The main ways to solve the problem of reducing the content of anti-nutrients in products of processing the seeds of rape are technical and selection ones. Thanks to the latter, there was a possibility to create varieties and hybrids with the low content of glucosinolates (so-called "00" varieties). It promotes a significant expansion of their use in fodder conservation and fattening in agricultural production. Analysis of the State Register of plants in Ukraine in 2018 showed 262 varieties and 114 hybrids of the winter rape, of which only three are single zero that are low erucic but high glucosinolate ones and only one is high erucic and low glucosinolate. All other varieties are two zero, it means they are low erucic and low glucosinolate.

All varieties (57 pieces) and hybrids (16 pieces) of the spring rape included in the register are two-null ones. The share of the winter rape of the domestic selection amounts to 18.6%

while the spring rape share is 26.0% in the State Register (State Register of Plant Varieties of Ukraine). The content of glucosinolates in the seeds of the product category will not exceed 25 micromoles per gram if the content of glucosinolates in the seed material does not exceed 18 micromoles per gram.

Almost all “00” varieties of the winter and spring rapes selected by Precarpathian State Agricultural Research Station of the Institute of Agriculture of the Carpathian Region of the National Academy of Agrarian Science (former Ivano-Frankivsk Research Station of Cruciferous Crops, Institute of Cruciferous Crops, Ivano-Frankivsk Institute of Agricultural Production) Tysmenytskyi, Svieta, Dangal, Dembo, Cheremosh, Dema, Modelini, Smaragd, Mykytynetskyi, Arion, Luzhok, Maryne, Liga meet the specified requirements. It is confirmed by the results of the glucosinolate analyses in the samples of commercial seeds supplied for processing to the three main companies in Ukraine ('ViOil', 'Oliyar', 'Agrotehnika' LLC); the content ranges from 19.4 -25.2 micro Moles per gram.

This makes it possible to increase the rate of the rape oil meals/press cake in the diets of the livestock and poultry by 1.5-2 times, in comparison with the one-null varieties. Besides, we should search for further ways to reduce the glucosinolate content to a level lower than 20 micro moles per gram (Demianchuk et.al., 1987).

**Table 2.** Biochemical composition of varieties of the rape grown in Precarpathian State Agricultural Research Station of the Institute of Agriculture of the Carpathian Region of the National Academy of Agrarian Science

| Name of variety    | Fatty acid composition, % |                   |                   |                   |                   |                   | Oil percentage % | Glucosinolates, micro Moles per gram |
|--------------------|---------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|------------------|--------------------------------------|
|                    | C <sub>16:0</sub>         | C <sub>18:1</sub> | C <sub>18:2</sub> | C <sub>18:3</sub> | C <sub>20:1</sub> | C <sub>22:1</sub> |                  |                                      |
| <b>Winter rape</b> |                           |                   |                   |                   |                   |                   |                  |                                      |
| Tysmenytskyi       | 4,18                      | 66,88             | 19,07             | 9,22              | 0,65              | none              | 44,5             | 22,1                                 |
| Ivanna             | 3,25                      | 69,12             | 17,41             | 9,20              | 1,02              | none              | 43,8             | 25,0                                 |
| Svieta             | 6,25                      | 69,40             | 18,22             | 5,58              | 0,55              | none              | 45,0             | 18,0                                 |
| Galytskyi          | 4,43                      | 70,59             | 19,04             | 5,68              | 0,26              | none              | 43,8             | 60,0                                 |
| Dangal             | 5,55                      | 70,58             | 14,86             | 8,08              | 0,93              | none              | 44,5             | 18,5                                 |
| Demerka            | 2,25                      | 18,04             | 12,22             | 8,71              | 5,69              | 53,09             | 44,0             | 18,2                                 |
| Dembo              | 4,75                      | 70,75             | 20,02             | 3,54              | 0,94              | none              | 46,9             | 20,0                                 |
| Cheremosh          | 3,90                      | 67,65             | 21,25             | 6,68              | 0,52              | none              | 47,0             | 11,8                                 |
| Dema               | 5,74                      | 70,19             | 18,18             | 5,39              | 0,50              | none              | 46,5             | 16,0                                 |
| Modelini           | 2,81                      | 68,61             | 23,93             | 3,85              | 0,80              | none              | 42,3             | 18,4                                 |
| Smaragd            | 3,39                      | 67,27             | 20,69             | 7,40              | 1,29              | none              | 41,5             | 18,7                                 |
| <b>Spring rape</b> |                           |                   |                   |                   |                   |                   |                  |                                      |
| Mykytynetskyi      | 3,09                      | 69,63             | 19,40             | 7,42              | 0,46              | none              | 42,0             | 19,0                                 |
| Arion              | 5,94                      | 64,85             | 21,29             | 7,26              | 0,66              | none              | 41,8             | 16,5                                 |
| Luzhok             | 4,19                      | 68,87             | 16,61             | 9,84              | 0,49              | none              | 43,0             | 20,0                                 |
| Maryne             | 2,80                      | 70,14             | 21,05             | 5,61              | 0,40              | none              | 43,0             | 18,6                                 |
| Liga               | 5,19                      | 69,59             | 15,87             | 8,56              | 0,71              | 0,08              | 42,5             | 15,0                                 |

### ***Biochemical composition of the oil meals produced in Ukraine***

Biochemical analysis of the oil meals showed that protein of the rape contains a number of all amino acids and is close to soybeans in many of them. The protein of the rape slightly exceeds features of soybean by the ratio of non-replaceable amino acids to replaceable ones. Thus, the side-products of processing of the rape seeds of modern “00”- varieties (press cake and oil meal) may be effectively used in the feeding of all livestock and poultry. So, one ton

of the rape press cake or rape oil meal can balance in average 8 tons of grain fodder by protein content and ensure high productivity of livestock breeding.

**Table 3.** Chemical composition of oil meals of main oil crops in Ukraine

| Indexes   | Oil meals    |              |              |
|---|--------------|--------------|--------------|
|   | Sun flower   | Rape         | Soybean      |
| Humidity, %   | 7,56         | 7,32         | 8,80         |
| Dry substance, %  | 92,44        | 92,68        | 91,20        |
| Crude protein, %  | 34,63        | 34,63        | 39,57        |
| Crude fat, %  | 1,20         | 2,71         | 4,13         |
| Crude fibre, %  | 13,06        | 12,50        | 5,52         |
| Crude ash, %  | 7,75         | 6,80         | 7,91         |
| Calcium, %  | 0,43         | 0,80         | 0,33         |
| Phosphorus, %   | 0,88         | 0,90         | 0,66         |
| <b><i>Amino acid composition, mg/100g of natural moisture</i></b> |              |              |              |
| Aspartic acid   | 2,22         | 2,05         | 3,99         |
| Threonine   | 0,74         | 0,89         | 1,54         |
| Serine  | 1,05         | 0,81         | 1,97         |
| Glutamic acid   | 4,68         | 3,87         | 6,58         |
| Proline   | 1,44         | 1,27         | 1,23         |
| Cysteine  | -            | 0,31         | 0,33         |
| Glycine   | 1,29         | 1,27         | 1,88         |
| Alanine   | 1,65         | 1,09         | 1,98         |
| Valine  | 1,46         | 1,29         | 0,28         |
| Methionine  | 1,87         | 2,69         | 1,74         |
| Isoleucine  | 2,13         | 2,30         | 1,39         |
| Leucine   | 2,05         | 2,26         | 1,66         |
| Tyrosine  | 0,49         | 1,33         | 1,29         |
| Phenylalanine   | 0,74         | 1,21         | 1,97         |
| Histidine   | 0,46         | 0,53         | 0,91         |
| Lysine  | 4,27         | 2,63         | 2,44         |
| Arginine  | 2,74         | 3,70         | 2,44         |
| <b>Total</b>  | <b>29,28</b> | <b>29,50</b> | <b>33,62</b> |

#### ***Use of the rape oil meal/press cake in feeding livestock and poultry***

On the basis of many year research conducted by scholars of Precarpathian State Agricultural Research Station of the Institute of Agriculture of the Carpathian Region of the National Academy of Agrarian Science and some other authors, it is established the effective ways of using of the rape oil meal/press cake of the domestic production in feeding large cattle, pigs and poultry (Clandinin et al., 1981; Mykytyn et al., 2008; Mykytyn et al., 2009; Mykytyn, 2012; Thomke, 1981). The glucosinolate content in the products of rape processing is 25-53 micro Moles per gram.

**Table 4.** Recommended levels of inclusion of the rape seed meal/press cake of the domestic production in feed diet

| №   | Types and groups of livestock                 | Share of the rape oil seed/press cake in diet, % |
|-----|---|--|
| 1.  | Calves  | 20,0   |
| 2.  | Dairy cows                                    | 25,0   |
| 3.  | Meat cattle                                   | 20,0   |
| 4.  | Starter piglets                               | 8,0  |
| 5.  | Weaning piglets                               | 8,0  |
| 6.  | Feeding piglets                               | 10,0   |
| 7.  | Breeding pigs                                 | 8,0  |
| 8.  | Starter poultry                               | 5,0  |
| 9.  | Weaning poultry                               | 10,0   |
| 10. | Egg production chickens and breeding chickens | 5,0  |

## CONCLUSIONS

Thus, the analysis of indexes of cultivation area and gross output indicates the process of intensification of manufacturing the rape in Ukraine. The biochemical evaluation of seeds, press cake and oil meal originated from varieties and hybrids of rape, registered in Ukraine, indicating their high quality, which allows increasing the rate of the rape oil meal and press cake in the diets of livestock and poultry by 1.5-2 times in comparison with one zero varieties. However, we should further search for ways to improve the nutritional value of the rape-products.

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## 28317) CHARACTERISTIC FEATURES OF THE BIOCHEMICAL COMPOSITION OF WINTER RAPE SEEDS RESISTANT TO POST-EMERGENT HERBICIDES

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### ABSTRACT

Growing the modern hybrids of winter rape is one of the main ways for attaining greater crop productivity. They must have a high potential of the crop yield, be suited to environmental conditions and highly tolerated to diseases, lodging and shattering. One priority direction of selective breeding of rape is the creation of winter rape hybrids resistant to post-emergent herbicides. Clearfield® production system for rape is a combination of Nopasaran® herbicide and high-yielding rape hybrids that are resistant for that herbicide. A single introduction of Nopasaran® herbicide (with Metolat® sticking agent) helps to destroy not only the weeds that grew before treatment but to create a soil herbicide screen, which inhibits the further waves of weeds. Clearfield® production system is suitable for rape cultivation technologies for classic and minimal or zeroes soil processing. We may achieve good results even on the soils with high organic content, on the rocky soils, at moisture deficit and other difficult circumstances. Clearfield® production system simplifies the weed control for farmers due to reduction of herbicide treatments. As a result, they have more time to focus on other factors reducing the crop yield. Selection breeding of winter rape hybrids is conducted in this direction in Precarpathian State Agricultural Research Station of the National Academy of Agrarian Sciences of Ukraine since 2015. There was created a working commission by involving the best national and foreign samples within the specified period. The available material has a high resistance to the specified herbicide and the crop yield no less than four hundreds kilograms per hectare. The resistance of rape hybrids to Nopasaran® herbicide was obtained by traditional selection without genetic engineering method. The oil content in seeds of the testing samples fluctuates from 37.85% in a sample UG-165 to 48.52% in a sample UG-112. The four fatty acids that are palmitic acid, oleic, linoleic, linolenic conclude the basis of this vegetable oil. However, their content in the oil is significantly different. Oleic acid accounts for the largest share among all listed acids. The acid content ranges from 60.22% in sample UG-124 to 82.05% in sample UG-147. The most samples of the testing collection are characterized by a content of linolenic acid, which ranges from 9.31% in sample UG-127 to 20.58% in sample UG-95. The greatest changeability is peculiar to linolenic acid, which content in the seeds of tested selection material ranges from 3.45% in sample UG-42 to 7.21% in sample UG-54. Palmitic acid is the less variable among the fatty acids included in the oil. We may find the minimal content of the acid in sample UG-27, which ranges from 2.38% to 4.92% in seeds of sample UG-18. No seed samples include erucic acid and the content of glucosinolates does not exceed 18 micro molar units per gram. The plants of the collection are quite different in structure and colour of leaves (from light green to dark green), the colour of flowers (light yellow, golden yellow, dark yellow).

Keywords: *Acids, Breeding, Glucosinolates, Herbicides, Hybrids, Oil, Rape.*

### INTRODUCTION

Seeds of oil crops are a unique raw material for manufacturing edible and technical oils, cheap dietary and feed proteins with special biological and functional properties, high content of biologically active substance and wide range of macro, micro and ultra-micro-elements. Vegetable oils are in need in all sectors of the economy. They can be a reliable source of inflow of foreign currency.

The sunflower, soybean and rape, among the Ukrainian oil plants, are of great importance for the above purpose. The oil plants are inferior to cereal crops (wheat, barley) by cultivation areas.

The growing of the modern hybrids of winter rape is one of the main ways to increase the yield of this crop. They should have high yield potential, be adaptive to environmental conditions and highly tolerant to diseases, and have a high resistance to lodging and shattering. Weeds are one of the main problems that agricultural producers face while growing the rape plant. Significant losses are pretty common instead of the expected high yields and considerable profits. The key to solving this problem, at the present stage of agricultural production, is a technology named “Clearfield”, which means a clear field.

The Clearfield system for the rape is a combination of Nopasaran herbicide and high-yielding rape hybrids resistant to this herbicide. Active selection work as to creating the relevant winter rapeseed hybrids is being conducted in Precarpathian State Agricultural Research Station of the Institute of Agriculture of the Carpathian Region of the National Academy of Agrarian Science. The resistance of the rape hybrids to Nopasaran herbicide was obtained by the traditional method of selection, without genetic engineering methods. The Clearfield rape hybrids are not transgenic.

The single application of Nopasaran herbicide (with a sticking agent of Metolat) helps to destroy not only the weeds have grown before processing but to create a soil herbicide screen, which inhibits the growth of further waves of weeds. The Clearfield system is suitable for technologies of the rape plant growing with both classic and minimal or zero soil cultivation. Good results are possible even in soils with a high content of the organic substances, in the rocky soils, in the absence of moisture and under other adverse conditions. The Clearfield system significantly simplifies the weed control for farmers due to reducing the number of herbicide treatments. From the Ukrainian existing collection of varieties and hybrids of the winter rape, we have not fully studied the forms resistant to the specified herbicide nor established the genetic nature of resistance of this group and further decomposition of the features in progeny.

The oil content is one of the main indexes for the economic value of a variety or a hybrid in any oil crop. In addition to the oil content, the value of the sample and direction of the relevant selection work depend on the quality of the oil in seeds. Selection practice needs to combine in the genotype the maximum oil content with the increased content of essential fatty acids in the seeds. The essential fatty acids, on the ratio of which the properties and applications of rapeseed oil as food or technical one depend, are palmitic, oleic, linoleic, and linolenic ones. Erucic and eicosanoic acids are undesirable for food intake. Selection of plants, for improving the quality of oil in many varieties of Brassica, has almost reduced to zero the content of erucic acid. Reducing the content of erucic and eicosanoic acids caused significant changes in the content of other fatty acids. The amount of oleic acid increased to 80%, linoleic acid - to 20%. That is why the cruciferous oil crops became almost ideal for food use in comparison with the other vegetable oils.

## MATERIALS AND METHODS

In 2017, we used as a research material 32 samples, in 2018 – 75 samples and in 2019 – 115 samples of the winter rape (*Brassica napus L.*), which were taken from selection seedbed of the second year study and showed resistance to post-emergence herbicide of the Clearfield system. We gathered them by selection samples ( $F_3$ ) from the winter rape seedbed of the first year of study. The samples were chosen by a complex of economically valuable features (Briggs et.al., 2000).

We laid five-row plots in four repetitions, in random places and within the area of 10 m. The standard seeds were sown through every 10 plots. We conducted the comparative evaluation of pooling the best families and selection ( $F_4$ ) of elite plants for further study and reproduction by using the main economically valuable features (Molotskyi et.al., 1984).

We used the following methods:

Field method – for phenological observations, biometric measurements (Dospekhov, 1979; Kogan, 1975);

Laboratory method – for evaluation of producing capacity and quality of the studies material, determination of biochemical parameters (Demianchuk et.al., 1987; Demianchuk et.al., 1988);

Mathematical and statistical method – for evaluation of the credibility of the findings;

We applied the herbicide when the winter rape plants were in the phase having two to six true leaves while the weeds were in the initial stages of development, such as a seed-lobe in dicotyledonous plant and cereals with 1- 4 leaves.

Evaluation of resistance to herbicides is carried out by eye, through 3, 7, 14, 21 days after the application of herbicides, when we can distinguish the living plants from the dead ones, consecutively inspecting one after the other in all treated plots. Based on the calculation results, we may develop the percentage ratio between the living and dead plants.

We have evaluated the phytotoxicity of the rape plants under the influence of herbicide according to our developed grade scale:

- 0 – no damages;
- 1 – very slight damages (0-10% burns of the leaf surface);
- 2 – slight damages (10 – 25% burns of the leaf surface);
- 3 – average damages (26 – 50% burns of the leaf surface);
- 4 – severe damages (51- 75% burns of the leaf surface);
- 5 – very severe damages (more than 75% burns of the leaf surface).

## RESULTS AND DISCUSSIONS

In the current 2019, the selection seedbed of the second year of the study included 115 perspective samples of winter rape resistant to post-emergent herbicides, which differed in crop structure, biochemical parameters and morphological features. We divided in half each plot where the hybrid populations were grown. One half of the plot was subject to treatment with Nopasaran herbicide (Metazachlor (375 grams per hectare) Imazamox (25 grams per hectare) with the expenditure rate of 1.2 litres per hectare + PAR Menolate 1.2 litres per hectare. Another was left without treatment. Winter rape plants were in a phase of 6-8 true leaves during herbicide application.

After the end of the vegetation period, we have selected the individual plants from the hybrid seedbed. We chose the plants on the plots, where the stable forms were found, threshed and weighed them. All obtained materials underwent analysis for the content of glucosinolates and fatty acid compositions in the seeds. At the first stage of biochemical studies, the obtained the seeds underwent the glucosinolate analysis, after which we have detected a low content of glucosinolates: no more than 15 micro Moles per gram were found in 24 samples - in 2017; in 43 samples – in 2018; in 67 samples - in 2019. The oil content in seeds of the studied winter rape samples varied from 37.6 % (sample UG-121) to 49.7% (sample UG-93).

The further stage was to establish the fatty acid composition in selected after the previous analysis samples of available working collection of the selected winter rape materials resistant to post-emergent herbicides. As a result of the conducted research, we have identified 22 the most valuable, in the sense of selection, Bezrukov's selection samples. (see Table 1).

As a result of the study of the fatty acid composition in the oil of the winter rape samples, we detected the wide amplitude of variability of the fatty acid content. None of the analysed samples contained erucic acid. All other acids were present in the oil of the studied winter rape samples but by different degrees. The largest mass fraction in the seeds of the analysed samples accounted for oleic acid, where it was detected from 60.22% in sample UG-124 to 82.05% in sample UG-147. The samples with oleic acid content over 70% may be of interest as a starting material for selection to increase this index.

Most of the samples of the studied collection are characterized by the content of linoleic acid, which ranges from 8.08 to 18.3%. Palmitic acid has the least variability among the fatty acids in the oil. The minimum content of the acid may be detected in sample UG-149, which is 2.08 % to 4.48% in sample UG-73. Linolenic acid has insignificant variability. The acid content in the seeds ranged from 3.21% to 4.85%. The analysed material was characterized by a low content of eicosenic acid, which ranged from 2.13% to 4.38%. A small amount (less than one) was the mass fraction of palmitoleic, stearic and eicosanoic acids. Efficient selection work needs to determine how the change in the parameters will affect the other characteristics of genotype.

Determining the nature of the relationship with the content of certain fatty acids, namely due to what acids the amount of one or another particular component increases or decreases, shall be a required

condition for efficient selection work. As a result of conducted correlation analysis, we have established that there is a close negative relationship between the content of oleic acid and other components of the fatty acid composition of oil of all mustard types. Regarding the prospects of a selection of varieties and hybrids of winter rape of food quality, the increase in oleic acid content is due to linolenic and erucic acid with which there is a negative relationship. At the same time, the content of linolenic acid will increase. The direct interrelationship is established between these fatty acids.

Table 1. Characteristic features of the fatty acid composition of the best 22 samples of the winter rape seeds of selection seedbed (2017-2019)

| Number | Cipher of sample | Palmitic | Palmitoleic | Stearin | Oleic | Linoleic | Linolenic | Eicosanoic | Eicosenic | Erucic |
|--------|------------------|----------|-------------|---------|-------|----------|-----------|------------|-----------|--------|
| 1      | UG-147           | 2,46     | 0,21        | 0,87    | 82,05 | 8,08     | 3,45      | 2,13       | 0,75      | 0,0    |
| 2      | UG-155           | 2,55     | 0,14        | 0,75    | 79,75 | 11,05    | 3,21      | 2,32       | 0,34      | 0,0    |
| 3      | UG-151           | 2,61     | 0,25        | 0,64    | 78,47 | 11,78    | 3,21      | 2,34       | 0,70      | 0,0    |
| 4      | UG-51            | 2,91     | 0,28        | 0,83    | 78,13 | 9,36     | 4,11      | 3,87       | 0,51      | 0,0    |
| 5      | UG-27            | 3,39     | 0,33        | 0,45    | 77,10 | 12,20    | 3,42      | 2,93       | 0,18      | 0,0    |
| 6      | UG-162           | 3,11     | 0,29        | 0,87    | 76,64 | 12,53    | 3,71      | 2,42       | 0,43      | 0,0    |
| 7      | UG-149           | 2,08     | 0,24        | 0,69    | 76,33 | 13,08    | 3,36      | 3,21       | 1,01      | 0,0    |
| 8      | UG-153           | 3,44     | 0,31        | 0,67    | 75,32 | 13,09    | 3,29      | 3,38       | 0,50      | 0,0    |
| 9      | UG-53            | 2,89     | 0,28        | 0,71    | 75,04 | 13,80    | 4,01      | 3,11       | 0,16      | 0,0    |
| 10     | UG-79            | 2,65     | 0,27        | 0,65    | 74,75 | 14,37    | 3,39      | 3,58       | 0,34      | 0,0    |
| 11     | UG-49            | 2,38     | 0,34        | 0,67    | 74,28 | 14,61    | 3,25      | 4,32       | 0,15      | 0,0    |
| 12     | UG-26            | 3,15     | 0,21        | 0,73    | 74,15 | 13,18    | 4,75      | 3,51       | 0,32      | 0,0    |
| 13     | UG-145           | 2,43     | 0,24        | 0,79    | 73,75 | 13,62    | 4,03      | 4,12       | 1,02      | 0,0    |
| 14     | UG-148           | 4,15     | 0,21        | 0,64    | 73,50 | 13,71    | 3,26      | 3,43       | 1,10      | 0,0    |
| 15     | UG-18            | 3,12     | 0,23        | 0,56    | 73,38 | 13,23    | 4,74      | 4,01       | 0,73      | 0,0    |
| 16     | UG-43            | 4,13     | 0,25        | 0,67    | 72,94 | 13,50    | 4,18      | 3,74       | 0,59      | 0,0    |
| 17     | UG-12            | 3,75     | 0,41        | 0,75    | 72,89 | 14,58    | 3,23      | 3,95       | 0,44      | 0,0    |
| 18     | UG-105           | 3,19     | 0,22        | 0,45    | 72,87 | 14,31    | 4,45      | 3,98       | 0,62      | 0,0    |
| 19     | UG-33            | 4,12     | 0,24        | 0,71    | 72,49 | 14,05    | 4,81      | 3,31       | 0,27      | 0,0    |
| 20     | UG-133           | 4,21     | 0,29        | 0,65    | 72,45 | 14,11    | 4,20      | 3,35       | 0,73      | 0,0    |
| 21     | UG-115           | 3,46     | 0,45        | 0,94    | 71,53 | 15,22    | 4,15      | 3,01       | 1,25      | 0,0    |
| 22     | UG-97            | 4,25     | 0,33        | 0,75    | 70,24 | 17,12    | 3,45      | 3,18       | 0,95      | 0,0    |

## CONCLUSIONS

Thus, our obtained data as to the fatty acid composition of the oil testify about the great genetic diversity of the selected material of winter rape, which is resistant to post-emergent herbicides and includes contrast forms by the content of essential fatty acids. The selected samples may be applied as sources of the low and high content of essential fatty acids in the selections of winter rape varieties and hybrids with the improved characteristics of oil and high resistance to the herbicides of imidazole group. We have found that there is a direct relationship between the content of oleic and linoleic acids beneficial to human nutrition. Linolenic acid is characterized by a negative correlation.

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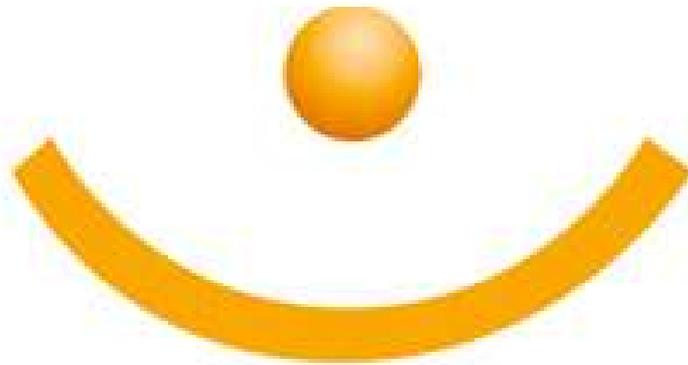
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