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«MEDICAL AND BIOLOGICAL SCIENCES : AN INTERDISCIPLINARY ASPECT»

PLANT OILS : FROM PLANT TO NUTRITION

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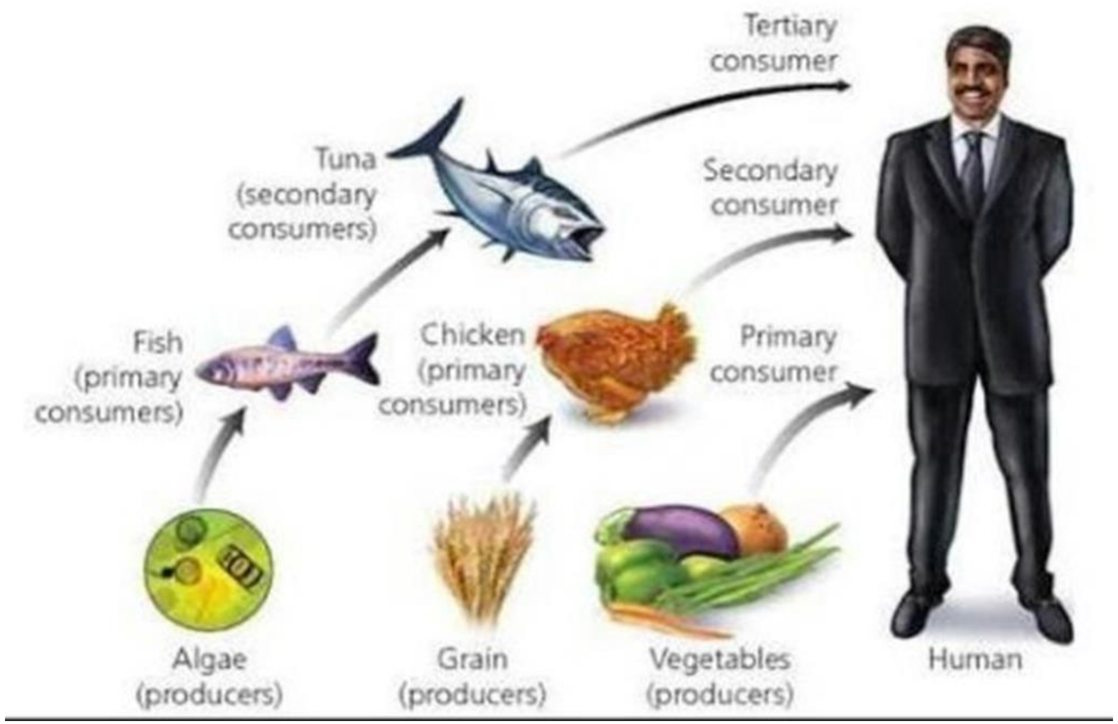


The human diet is the only source of energy and nutrients that ensure the normal functioning of the body and its ability to counteract the development of a wide range of pathologies

Namely it is a practical means of implementing the fundamental principle of Hippocrates "It is easier to prevent a disease than to treat it."

However, even in the presence of pathologies, an adjusted diet facilitates and sometimes completely eliminates the need for drug treatment.

Man is an omnivore and he receives the necessary energy and nutrients from various food sources. And in food chains a person occupies a very specific place, being at the same time a consumer of the first, second and third orders.

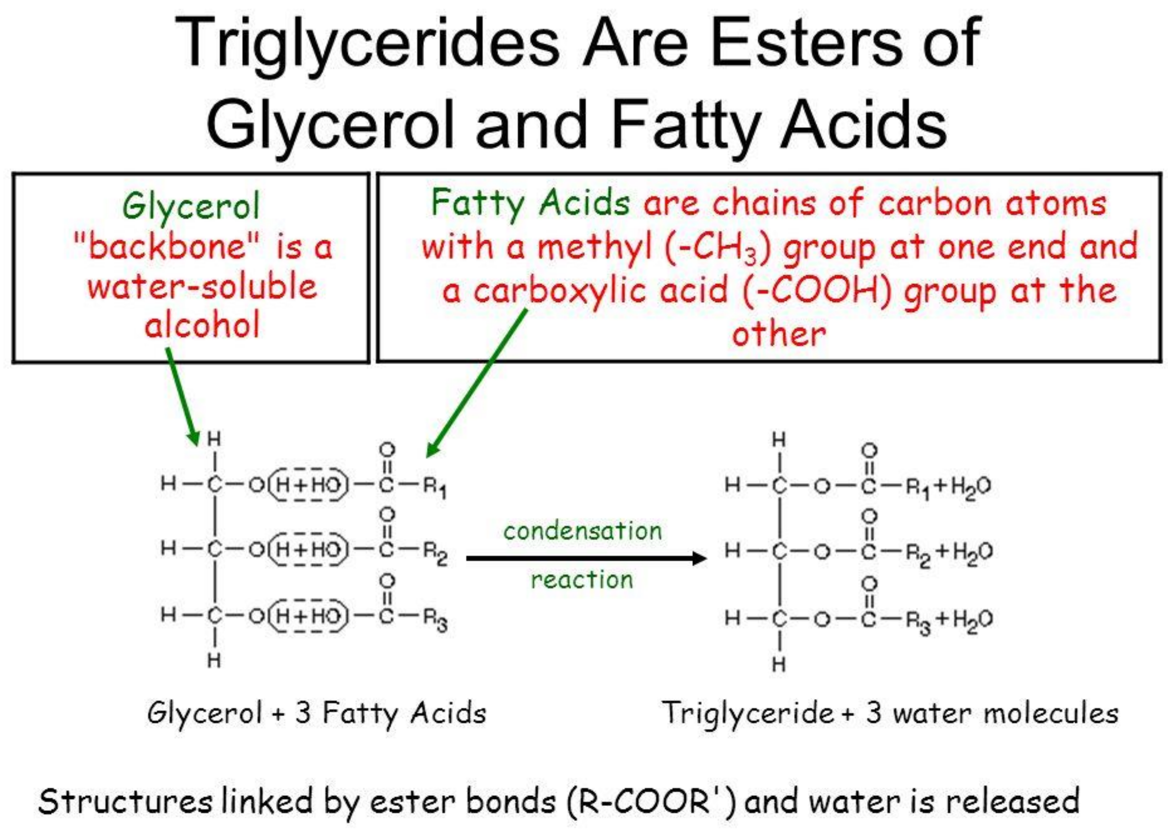
The basis of all food chains are producers - autotrophic organisms that are able to absorb solar energy and, using it, synthesize organic substances necessary both for their own growth and development, and that form the trophic basis for consumers.

Producers in food chains can be both autotrophic representatives of wild flora (including terrestrial and aquatic) and cultivated plants adapted to growing in anthropogenic culture. Only they are the sources of renewable systems for obtaining food products and only thanks to them such systems exists at all.

Among the producers of food chains, the leading place is occupied by cultivated plants. Their species have gone through a long period of evolution and, thanks to genetic variability, adaptation to soil-climatic zones of cultivation and intuitive and then directed genetic improvement, have made great progress.

Modern species of cultivated plants are well adapted to growing in anthropogenic culture and are provided with reliable infrastructures for the reproduction of seed material, modern industrial technologies for growing and industrial processing of crops into food, pharmaceutical and technical products.

All types of cultivated plants and products obtained from them deserve attention, but we will focus only on the problem of creating biogenic sources of vegetable oils. This is due to the exceptional role that this group of nutrients plays in human health.



The lipid composition of vegetable oils is quite polymorphic, but triglycerides (neutral lipids) are its main component. Their part in the lipid composition of vegetable oils is 95-97%.

Chemically, this group of lipids are esters formed as a result of the condensation of higher carboxylic (fatty) acids and the trihydric alcohol glycerol.

Since the alcohol component of triglycerides is the same, their chemical and biological properties are determined by the composition and ratio of fatty acids that close the ester bonds and, to a lesser extent, by the positional arrangement of the acyls of these fatty acids.

Therefore, the main direction of improving the quality of vegetable oils is to optimize their fatty acid composition.

Essential fatty acids that make up triglycerides

Saturated:

Lauric	C 12:0	$CH_3\text{-}(CH2)_{10}\text{-}COOH$
Myristic	C 14:0	$CH_3\text{-}(CH2)_{12}\text{-}COOH$
Palmitic	C 16:0	$CH_3\text{-}(CH2)_{14}\text{-}COOH$
Stearic	C 18:0	$CH_3\text{-}(CH2)_{16}\text{-}COOH$
Arachidic	C 20:0	$CH_3\text{-}(CH2)_{18}\text{-}COOH$
Behenic	C 22:0	$CH_3\text{-}(CH2)_{20}\text{-}COOH$

Monounsaturated:

Palmitoleic	C 16:1	$CH_3\text{-}(CH_2)_5\text{-}CH{=}CH\text{-}(CH_2)_7\text{-}COOH$
Oleic	C 18:1	$CH_3\text{-}(CH_2)_7\text{-}CH{=}CH\text{-}(CH_2)_7\text{-}COOH$
Eicosenoic	C 20:1	$CH_3\text{-}(CH_2)_7\text{–}CH{=}CH\text{-}(CH_2)_9\text{-}COOH$
Erucic	C 22:1	$CH_3\text{-}(CH_2)_7\text{-}CH{=}CH\text{-}(CH_2)_{11}\text{-}COOH$

Diunsaturated:

Linoleic	C 18:2	$CH_3\text{-}(CH_2)_3\text{-}(CH_2\text{-}CH{=}CH)_2\text{-}(CH_2)_7\text{-}COOH$

Triunsaturated:

Linolenic	C 18:3	$CH_3\text{-}(CH_2\text{-}CH{=}CH)_3\text{-}(CH_2)_7\text{-}COOH$

Fatty acids (FAs) are a fairly polymorphic class of lipids, representatives of which can exist both in free form and be included in other compounds. The composition of triglycerides includes aliphatic monobasic fatty acids, as a rule, with an unbranched chain, represented by an even number of carbon atoms.

Structural differences between the individual FAs that make up triglycerides consist in the different lengths of the carbon skeleton (usually C12 - C24) and the different number of unsaturated (diene) bonds in it.

There are saturated fatty acids (not containing diene bonds), monounsaturated fatty acids (having one diene bond) and polyunsaturated fatty acids (having two or more diene bonds - up to three in plants). In some crops (castor bean) the composition of triglycerides also includes hydroxy acids, e.g. ricinoleic (Δ9,hydroxy12-octa-decenic).

Physical Properties of Fatty Acids

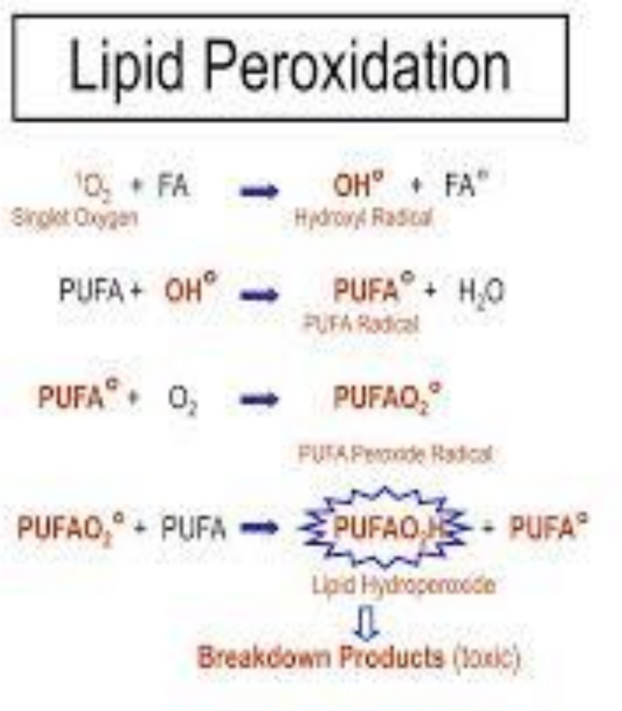
1. Solubility in water:

fatty acids are insoluble in water but soluble in fat solvents.

2. Physical state at room temperature:

The saturated fatty acids are solid at room temperature

Unsaturated long chain fatty acids are liquids due to the presence of cis double bonds.



The most significant physical, chemical and biological properties of FAs:

- with an increase in the length of the carbon skeleton the melting point of the LC increases also;

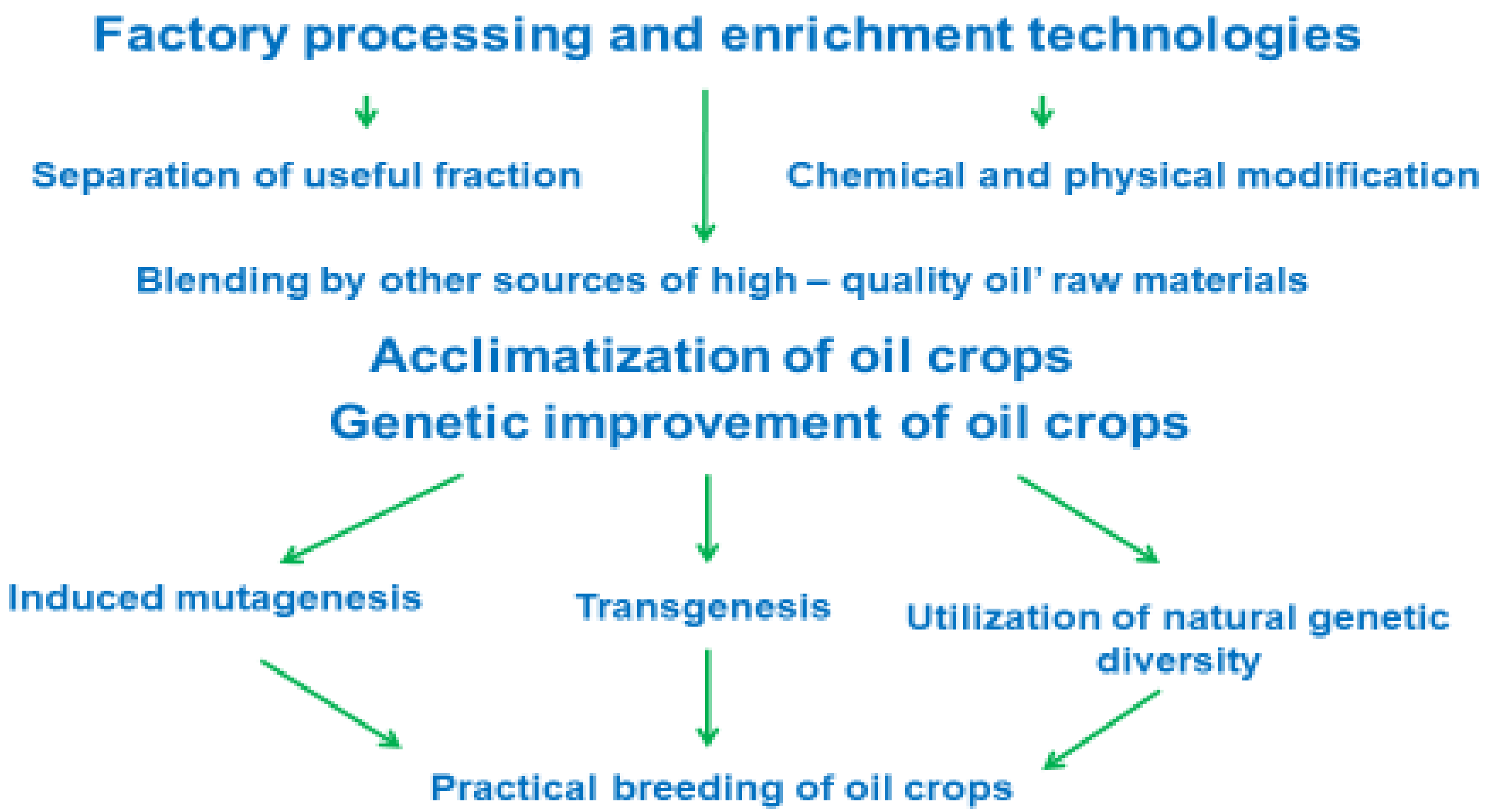
- with an increase in the number of diene bonds the melting point of the LC decreases;

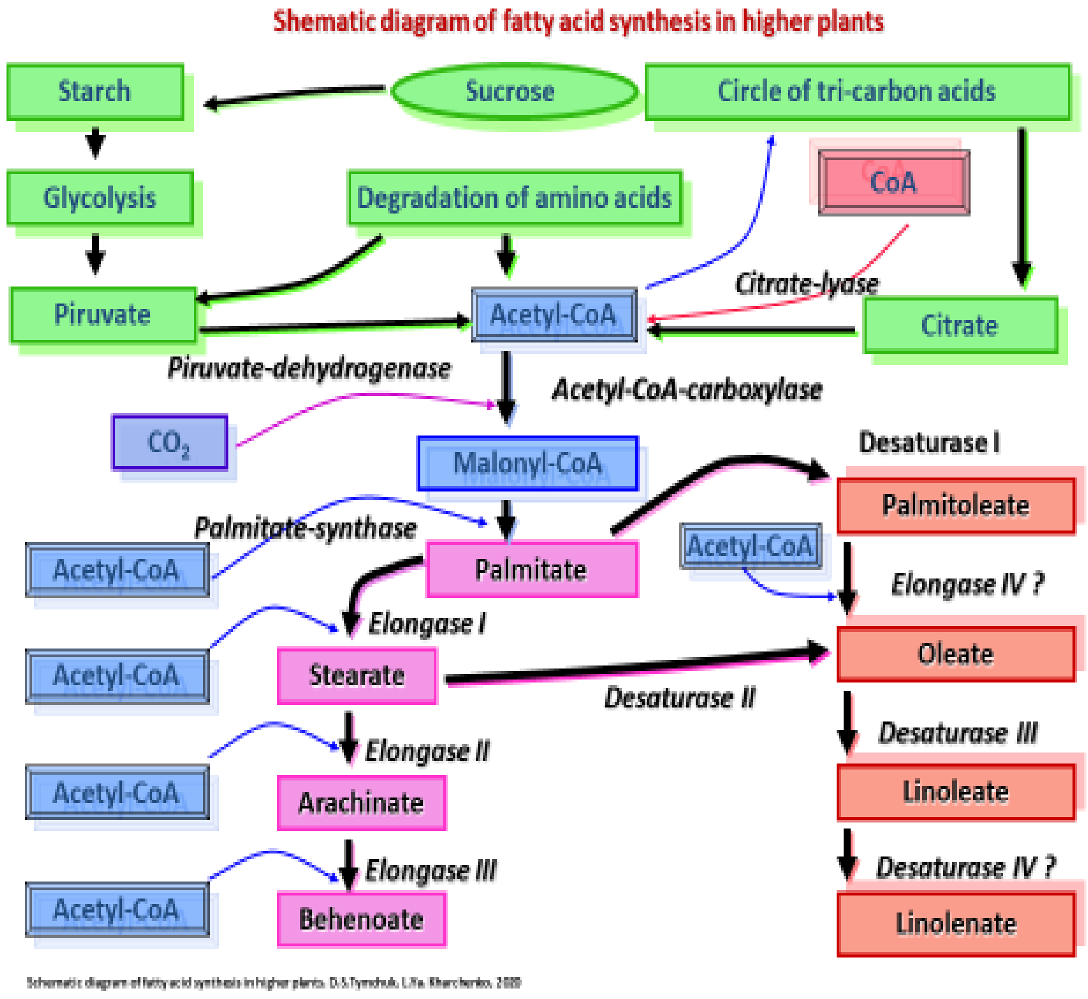
- with an increase in the number of diene bonds the intensity of peroxidation (PO) of FAs increases. According to the intensity of PO, oleic acid practically does not exceed saturated acids, this is 12 times inferior to linoleic and 25 times to linolenic;

- linoleic acid (Ω-6) has the highest F-vitamin activity. In this regard this is significantly superior not only to saturated and monounsaturated acids, but also to linolenic (Ω-3);

- fatty acids with the location of diene bonds distal to the carbon atom Δ9 cannot be synthesized by human and animal organisms and their sources are exclusively vegetable oils.

General methods for production the sources of high-quality vegetable oils





The synthesis of fatty acids in higher plants can be represented as follows. Palmitic acid is formed first, and all subsequent processes of fatty acid formation are carried out in the course of two jointly occurring processes - elongation of the carbon skeleton and desaturation of saturated bonds. The first of these processes is catalyzed by specific elongases and the second by specific desaturases.

Unsaturated acids can be formed from both saturated and unsaturated, but with fewer diene bonds. During each desaturation reaction only one saturated bond is formed and with the help of a desaturase that attacks the saturated bond at a certain position. The desaturation of another saturated bond in the same molecule is catalyzed by another form of the enzyme. Therefore, the isozyme composition of desaturases in plants is characterized by pronounced polymorphism.

This mechanism of fatty acid formation is universal and conservative. This feature allows the development and use of a common genetic enhancement technology of fatty acid composition in different crops.

Vegetable oils with different fatty acid composition also have different effects on human health.

With a similar energy potential, oils with a high content of saturated fatty acids (palmitic and stearic) are highly resistant to peroxidation, but their consumption increases the risk of coronary thrombosis and atherosclerosis, as well as diseases that provoke these pathologies.

Oils with a high content of unsaturated fatty acids, primarily linoleic (Ω-6) and linolenic (Ω-3), on the contrary, prevent the occurrence of blood vessel thrombosis, but they have low resistance to peroxidation, the intermediate products of which cause a multifunctional effect, consisting in the occurrence of a wide range of diseases up to oncology.

High oleic oils are recognized as the best option for oils, which reduce the risks of cardiovascular and oncological diseases, obesity and type II diabetes. At the same time, the entire spectrum of diseases in relation to which oleate exhibits a protective function has not yet been fully established. Very active research is being carried out in this direction.

Vegetable oils are not only a direct food product, but also an important raw material for various industries. And most industrial productions put forward their own specific requirements for the quality of this raw material.

Therefore, when creating biogenic sources of vegetable oils, it is advisable to single out several types of oils, each of which has its own sphere of practical use.

These include, in particular:

- ***oils with a high content of palmitate;***
- ***oils with a high content of stearate;***
- ***oils with a high content of oleate;***
- ***oils with a high content of linoleate;***
- ***oils with a high content of linolenate.***

Of course, among the variety of cultivated plants, there are species whose oils correspond to these types without special improvement. However, these species, as a rule, have a limited distribution area and are very rarely introduced in areas with other climatic conditions.

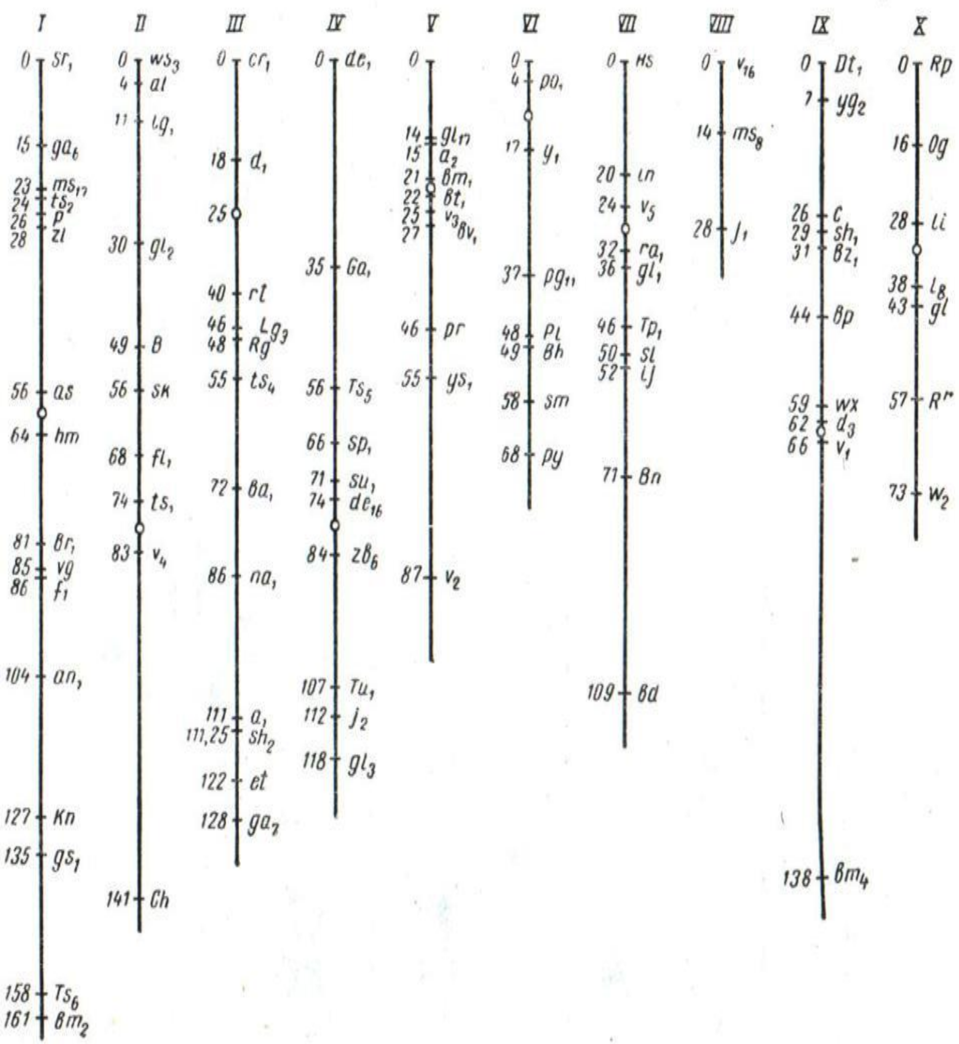
At the same time, for economic reasons, it is beneficial for specific types of oil to form species adapted to growing in these particular conditions. But it would be even better if one oilseed provided obtaining several industrial types of oils.

The most efficient, cost-effective and environmentally friendly method of improving the fatty acid composition of oil in cultivated plants is genetic improvement using the natural species diversity of each oilseed.

The experience of practical work in this direction is a good proof of the practical significance of research in the field of Genetics, the founder of which was the outstanding Czech biologist Gregor Mendel. We are celebrating the 200th anniversary of his birth this year.

Genetic studies of the fatty acid composition of oil in cultivated plants have shown that this trait is hereditary in nature and differs in each oil crop with a wide hereditary variability, creating the basis for practical improvement.

It has been shown that the high content of each fatty acid in glycerides is of a quantitative nature, controlled by recessive alleles of genes located on different chromosomes. This type of regulation is typical for oilseeds belonging to different botanical taxa. That's why homology can be traced in various oilseeds' systems of genetic regulation of oil fatty acid composition.



The genetic improvement of the fatty acid composition of the oil can be carried out in any oilseed crop, but the greatest effectiveness of this process should be expected in corn.

This crop not only has a high practical significance and a wide area of distribution, but also makes it possible to obtain a wide range of industrially significant products, including oils, within one technological processing cycle.

In addition, among of all cultivated plants, maize is the most genetically mapped and has the widest diversity in terms of product quality.

In this crop, the main loci providing the genetic regulation of the fatty acid composition have already been identified.

The main problem when using their effect is the complexity of phenotypic identification. And interesting possibilities for solving this problem can be created by using the effect of spatial linkage of loci that control the fatty acid composition with loci that control the structure of the endosperm.

Endospermic mutations, in addition to their beneficial effect of improving the quality of protein or carbohydrates, form specific visually diagnosable grain phenotypes that can be used for identification of the allelic state of loci that control fatty acid composition, in particular, palmitate- and oleate- coding loci.

Fatty acid composition of oils in maize endospermic mutants

Mutants	*Content of fatty acids' glycerides, % to the sum*				
	C 16:0	C 18:0	C 18:1	C 18:2	C 18:3
Wild type	12,1	0,9	22,2	61,6	0,6
o2	11,2	0,9	23,4	59,5	0,4
sh1	14,3	1,1	25,6	50,9	0,5
sh2	14,0	1,6	29,6	53,4	0,5
su1	11,1	1,5	43,4	39,1	0,4
se	11,6	1,5	44,2	37,8	0,5
su2	11,9	0,8	22,6	58,4	0,7
ae	11,7	1,0	35,7	47,2	1,1
wx	14,6	0,7	23,8	54,3	0,6
$LSD_{0,05}$	0,2	0,1	0,3	0,5	0,1

Oil crops, in which the orthologous mutations improved the fatty acid composition have been identified:

Orthologues of mutations that increase palmitate content:

Sunflower, Soybean, Rape, Linseed

Orthologues of stearate-increasing mutations:

Sunflower, Soybean, Rape, Safflower

Orthologues of mutations that increase oleate content:

Sunflower, Soybean, Rape, Mustard, Sufflower

Genetic diversity of sunflower on the fatty acid composition

Type of oil	*Content of fatty acids' glycerides, % to the sum*					
	C 16:0	C 16:1	C 18:0	C 18:1	C 18:2	C 18:3
Common	6,1	Trace	3,0	24,5	66,1	0,3
Palmitic	39,6	7,2	3,7	12,2	35,0	Trace
Stearic	5,3	0,8	10,3	25,0	58,5	Trace
Oleic	2,1	Trace	1,4	95,3	0,7	0,5
Linoleic	1,3	Trace	0,8	10,2	87,7	Trace

Genetic diversity of soybean on the fatty acid composition

Type of oil	Content of fatty acids' glycerides, % to sum					
	C 16:0	C 16:1	C 18:0	C 18:1	C 18:2	C 18:3
Common	11,9	Trace	4,0	20,3	53,8	10,0
Palmitic	16,3	Trace	5,2	22,5	49,1	6,9
Oleic	12,6	Trace	3,6	33,8	45,8	3,4
Linoleic	12,8	Trace	3,0	15,7	58,3	10,2

Genetic diversity of rape on the fatty acid composition

Type of oil	*Content of fatty acids' glycerides, % to sum*					
	C 16:0	C 18:0	C 18:1	C 18:2	C 18:3	C 22:1
Common	3,4	1,0	16,2	14,2	9,7	37,2
Oleic	3,7	2,0	72,0	12,7	6,9	Trace
Erucic	2,7	0,8	13,8	12,3	7,7	52,7

Content and composition of tocopherols in the seeds of oil crops of Ukraine

Oil crops	Content of toco-pherols in the oil, мg%	Content of tocopherol forms, % to sum			
		α-	β-	γ-	δ-
Soybean	110-250	13,0	2,7	57,1	27,2
Maize	90-150	23,4	1,7	71,7	3,3
Rape	60-90	32,5	1,6	64,3	1,5
Sunflower common	50-90	89,0	7,2	1,7	2,1
Sunflower mutant tph1		50,0	50,0		
Sunflower mutant tph2		5,0		95,0	

Another promising method for improving the quality of vegetable oils can be recognized as an increase in the content of tocopherols and an increase in their complex of forms with the highest antioxidant activity, especially γ- and δ-.

It is known that tocopherols have a pronounced antioxidant, antisterile and antidystrophic function.

This method is not undisputed. Firstly, the content of tocopherols in oils is quite low and secondly, there is a point of view that they can act as pro-oxidants.

However, practically significant mutants with an increased proportion of antioxidant forms of tocopherols were identified.


THANK YOU
FOR YOUR
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