The Influence of Climatic Factors on the Composition of Lipid Acids in Sunflower Oil

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Abstract

The development of sunflower production not only amply supplies Chinese people with a superior edible vegetative oil, but also greatly changes the composition of edible oils of Chinese people. However, Chinese usual cooking practice -- shallow-fry, stir-fry, quick-fry and deep-fry -- imposes various demands on chemicophysical properties of edible oils.

In the experiment, we analyzed the change in lipid acid composition of the sunflower varieties tested in the trial spots situated in different latitudes in 1986 and in the trails of different sowing dates during 1994--1995, and concluded that the change in the level of oleic and linoleic acid intimately correlates with air temperature. The authors consider it to be necessary to satisfy the different demands supposed by cooking and industrious use by breeding the sunflower varieties stable in genetics and differing each from other in lipid acid composition, and think it to be feasible to harvest sunflower seeds of high oleic acid content by adjusting the sowing dates based on the ecological conditions in different regions of China. Southwest, Midsouth, and East China should be the suppliers of the vegetative oil of high oleic acid level, hence are of potential value to be exploited.

Introduction

The development of sunflower production amply supplies a superior edible vegetative oil and greatly changes the composition of edible oils for Chinese people. However, Chinese usual cooking practice -- swallow-fry, stir-fry, quick-fry and deep-fry -- imposes different demands on oil chemicophysical properties.

Great attention has always been paid to breeding of sunflower for oil quality improvement by plant breeders all over the world. The composition of fatty acids determines the utilization value of an oilseed crop variety. The oil, extracted from the sunflowers grown mainly under the cool climatic conditions in Northeast, Northwest and North China, contains generally 70 or more percent of linoleic acid, hence our study aims at enhancing oleic acid content to satisfy the demand of Chinese cooking practice.

(1)

Saldotov, a sunflower breeder in VNIIMK of pre-Soviet Union, bred a sunflower cultivar rich in oleic acid through breeding and selection, hence greatly contributed to the sunflower breeding for oil quality improvement. The sunflower variety Pervenets, bred by him through chemical mutation, contains 80--90 percent of oleic acid, and therefore became a valuable breeding material. Based on it, the integrated varieties rich in oleic acid, maintaining line, restoring line and hybrids have been bred in U.S.A. and the hybrids have been put into production commercially. The like varieties have also been bred in pre-Yugoslavia. A sunflower variety AOP-1 bred in Holland contains more than 90 percent of oleic acid. A sunflower hybrid rich in oleic acid Krasnodarskiy-885 bred in VNIIMK of pre-USSR is almost equivalent to olive oil in fatty acid composition and nutritive value: it contains 70--75 percent of oleic acid and high level of tocopherol (being 5--6 times that in olive oil). A sunflower cultivar rich in oleic acid PAC3542 has been bred in Australia. In addition, the good result has been achieved in stabilizing oil chemical composition by enhancing tocopherol level. Sunflower inbred lines LG-15 and LG-17 have been bred in VNIIMK which can be utilized as donors of alpha- and beta-vitamin E of high content and are highly stable to oxidation. The above-mentioned demonstrated that the establishment of genotypes high in oleic acid and special oils and stable in genetics by crop breeding had come to the preliminary result.

(2)

Our experiments aim at the formation of donors of high oleic acid by cultivation measures because of the absence of sunflower germplasm resources rich in oleic acid.

The experiments have proved that there is a high negative correlation between the content of oleic acid and that of linoleic acid, and the content change of both acids is mainly influenced by environmental conditions among which the air temperature during seed development is of special importance, that is, high air temperature can increase the content of oleic acid and decrease that of linoleic acid. The anchors cultivated a single stable selection 75-1 (Paixuan No.1) in eight experimental spots situated in the main sunflower production zone of China (north latitude 37° 18′--46°12′) and analyzed the sample harvested by gas-chromatography. The result shows that fatty acid composition of sunflowers varies greatly with the production spots. On the one hand, the composition is influenced by latitudes; for example, sunflowers grown in high latitudes (Kangjin town of Heilongjiang Province and Baicheng city of Jilin Province, situated in north latitude 46°12′ and 45°38′ respectively) contain 69.27 and 64.96 percent of oleic acid. On the other hand, it is influenced by the altitude as reflected by the oleic content of the sunflowers produced in Hohhot (north latitude 40°59′) -- 62.90 percent which is more than that of the sunflower produced in Shenyang situated in a higher latitude (north latitude 41°46′) because that the altitude of Hohhot (1063 meters) makes the climate here cooler than that of Shenyang. The change pattern of linoleic acid content is reverse to that of oleic acid content (refer to table 1).

In order to determine further the influence of air temperature, we carried out the experiments on spring sowing (25th of April) and summer sowing (10th of July) in Shenyang area during 1994--1995, the material being Liaokuiza No. 3 (for oil) and Liaoshi No.1 (for confection). The result of gas-chromatographic analysis reveals that summer-sowing sunflower cultivars contain more oleic acid (65.5, 66.7, and 76.4 percent respectively), and that spring-sowing sunflower cultivars contain more linoleic acid (66.3, 48.8 and 46.7 percent respectively, refer to table 2), showing that the sunflower grown under cooler climatic conditions contains more linoleic acid. Linoleic acid content of sunflower hybrid Liaokuiza No.3 sown in spring of 1994 amounted up to 66.3%. The result is confirmed further by the analysis of meteorological data (refer to table 3). In the case of spring-sowing sunflowers, the average air temperature amounted to 26.3 °C and accumulative temperature amounted to 1080.5 °C from flowering to harvesting (from 15th of July to ninth of August), and the days whose highest air temperature exceeded 30°C amounted to twenty during the period, while in the case of summer-sowing sunflowers the average air temperature amounted to about 16 °C from flowering to harvesting (September to the first ten days of October). The analysis of data shows that the air temperature during the development of sunflower seed can change the proportion of fatty acids in oil, hence the quality of sunflower oil can be improved by adjusting the sowing date.

The authors have described the influence of latitude and altitude on the formation of fatty acid in their assay "Environmental modification variation of sunflower oil" : the higher latitude is, the higher the oil content is, and the more oleic acid component is; in the same latitudes, the sunflowers grown in the areas of high altitudes contain more oil; in the same altitudes, the oil content increases with latitudes, and the influence of altitude is stronger than that of latitude, showing that the main influential factor is still air temperature.

(3)

We are breeding and selecting the sunflower varieties stable in genetics and differing each from other in fatty acid composition through conventional breeding to satisfy the different demands suggested by food and industrial use. Based on this breeding aim, we have analyzed the various ecological conditions in China to project the production zones for the sunflower oils of various fatty acid composition.

In China, the main production zones of sunflower are distributed in the north latitudes from 35° to 55°. The meteorological study shows that, on average, a difference of a degree in the latitude makes a difference of 1.5 °C in air

Table 1 Fatty acid composition of a sunflower selection Paixuan 1 in different latitudes and altitudes

Trial spots	latitude	altutude (meters)	palmitic acid (%)	C18 (%)	$C18^{-1}$ (%)	$C18^{-2}$ (%)	$C18^{-3}$ (%)
Fenyang, Shanxi	37˚18′	500	5.70	5.11	34.71	54.48	trace
Yinchuan, Ningxia	33˚29′	1111.5	5.53	6.03	35.66	50.38	0.17
Hohhot, Inner Mongolia	40˚49′	1063	6.36	5.93	23.97	62.96	0.46
Shenyang, Liaoning	41˚46′	41.6	4.31	4.04	34.63	56.17	0.02
Shihezhi, Xinjiang	44˚12′	500	5.60	4.15	35.97	54.15	0.06
Baicheng, Jilin	45˚38′	155.4	5.34	4.43	24.50	64.95	0.15
Kangjin, Heilongjiang	46˚12′	200	4.76	4.70	21.33	69.21	trace

temperature. In Northwest of China, both latitude and altitude are high, and air temperature is relatively low and the temperature difference between day and night is relatively large during plant growing period, so the sunflowers grown there contain more oil and more linoleic acid in fatty acid composition of the oil. Northeast is situated in relatively high latitudes and a relatively low altitude, and the oil content of the sunflower grown there varies with latitudes and contain more linoleic acid. In North China, exclusive of Inner Mongolia (situated in a high altitude), for such regions as Beijing, Tianjin and Shanxi to harvest sunflower seeds rich in oleic acid the sowing date should be adjusted. Southwest, Midwest and East China of potentially exploitation value should be the suppliers of sunflower oils rich in oleic acid.

Table 2. Fatty acid composition of sunflower varieties Liaokuiza 3 and Liaoshi 1 sown in different date

sowing date	C16	C18	C18 -1	C18 -2	C18 -3
Liaokuiza 3 sown in spring, 1994	4.9	4.2	66.3	22.4	0.5
Liaokuiza 3 sown in summer, 1994	4.6	5.8	21.8	65.6	0.7
Liaokuiza 3 sown in spring, 1995	4.7	4.8	48.4	40.6	0.6
Liaokuiza 3 sown in summer, 1995	6.7	4.9	20.2	66.7	0.4
Liaoshi 1 sown in spring, 1994	4.8	2.8	46.7	45.0	--
Liaoshi 1 sown in summer, 1994	5.3	3.7	13.7	76.4	0.3

Table 3. Meteorological data during the period from July to the first ten days of August.

year	average air temperature	accumulative temperature	lighting time
1981-1982	24.75	1020.5	272.15
1994	26.3	1080.5	192.2
1995	23.2	951.4	140.8

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