EFFECT OF ENVIRONMENT ON FATTY ACID COMPOSITION OF DEVELOPING SEEDS OF SUNFLOWER (**HELIANTHUS ANNUUS L.**)

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Abstract

The changes in the levels of fatty acids of non-polar and polar lipid fractions of developing seeds of sunflower (var. Romsun Record) as affected by position of the seeds (periphery, middle and centre) within the head and by season (winter and summer) were studied. Seed samples were collected at the interval of seven days after flowering (DAF). At the time of sampling, the temperature ranges were 18.9°C to 26.5°C and 41.7°C to 44.5°C in winter and summer, respectively. Palmitic acid was observed to decrease during development in both the fractions in both the seasons. It was higher in winter than in summer and was also higher in polar than in non-polar fraction during development. Stearic acid, after a sudden increase at 14 DAF showed a continuous decrease till maturity in winter while in summer it decreased continuously from 7 DAF. A pronounced effect of season (temperature) on oleic/linoleic acid ratio during development was observed. The extent of the effect of season could be well judged from oleic/linoleic ratio at maturity. In non-polar fraction, the ratios were 1:1.25 and 3.5:1 in winter and summer, respectively. In polar these were 1:2.5 and 1.5:1 in winter and summer, respectively. Positional effect was that the oleic acid decreased and linoleic increased from periphery towards centre. These observations suggest that a desired oleic/linoleic ratio in sunflower seed oil is possible by merely selecting the season.

Introduction

The quality of oil in sunflower seed has been reported to be under genetic control, therefore, a desired ratio of oleic to linoleic acid is possible by breeding practices (Putt et al., 1969). However, the degree of unsaturation also depends largely upon climatic conditions (Cummins et al., 1967; Goyne et al., 1979). Even the position of the seeds within sunflower head has also been shown to effect the chemical composition of sunflower seeds (Zimmerman and Fick, 1973). Of the fatty acids, oleic and linoleic acids are fairly sensitive to the variations of temperature (Canvin, 1965; Robertson and Green, 1981). Tremolieres et al., (1982) are of the view that fatty acid composition in sunflower seed is a result of interaction between the genetically programmed enzymes and environment. The present investigation was designed to study the effect of variables such as season (temperature) and position of the seeds within head on fatty acid composition of polar and non-polar lipid fractions of developing sunflower seeds.

Materials and Methods

Sunflower variety 'Romsun Record' was raised under field conditions both for winter as well as summer seasons. About 200 plants were tagged at initiation of flowering. Generally, the opening of disc florets started from periphery towards centre and two to three rows opened up each day. Sunflower heads were clipped at 7 days interval. Further according to Zimmerman and Fick (1973), at each stage the heads were divided into three concentric ring shaped zones namely periphery, middle and centre. Each zone was sampled for six adjoining seeds from 3,6,9 and 12°clock positions. After manually taking out the seeds from each zone, the pericarp (hull) was removed. The total lipids were separated into two polar and non-polar fractions by solvent partition method (Nichols, 1964). Fatty acid methyl esters were prepared by the method of Luddy et al (1968). Methylated fatty acids were analysed by GLC with a stainless

steel column (3.175 mm x 2 m) packed with 20% diethylene glycol succinate on chromosorb W(60-80 mesh), flame ionization detector, a carrier gas (N_2) flow rate 35 ml/min. The oven temperature was maintained at 190°C. The peaks were identified by comparison of their retension times with those of standard fatty acids. The area under the individual peak was calculated and converted directly into relative percentage.

Results

The temperature variations at the time of sampling during development of seeds were in winter maximum from 18.9°C to 26.5°C and minimum from 7.4°C to 11.5°C while in summer maximum ranged from 41.7°C to 44.5°C and minimum from 23.9°C to 30.6°C. The difference of temperature between the two seasons (winter and summer) were of considerable magnitude. The data regarding fatty acid composition of polar and non-polar lipid fractions in different positions of the seeds during development are presented in Tables 1 and 2. All fatty acids lower than C_{16} were grouped together since their quantities were very less and were termed as lower fatty acids. The total lower fatty acids, palmitoleic and linolenic acids were present in very small amounts and appeared only at 7 DAF and 14 DAF after which these were present in traces, however, palmitoleic acid appeared again in small but measurable quantity at maturity. During seeds development at different positions in polar and non-polar lipids fractions palmitic acid content was maximum at 7 DAF and then decreased upto 21 DAF. After this stage it almost attained the same level until maturity during both the seasons. However, within the positions at different stages of seed development palmitic acid increased from periphery towards centre at 7 and 14 DAF. At later stages its behaviour was somewhat erratic in both the seasons. In both fractions (polar and non-polar) it was not affected much by season. There were noticeable differences in concentration of this acid between the two fractions. Except at 7 DAF, at other stages of development its level was almost double in polar fraction than what was in non-polar fraction in winter as well as in summer even in the seeds of different positions. Stearic acid concentration in winter was minimum at 7 DAF and reached to the maximum level at 14 DAF, thereafter a gradual decrease was observed till maturity. Seed position and fraction showed similar trend. In summer, however, it decreased consistently from the maximum level at 7 DAF upto the last stage of development. Due to position of the seed, stearic acid increased from periphery towards centre until 14 DAF while at later stages the trend was not regular in both the fractions and seasons. The seasonal (temperature) effect was quite distinct at 7 DAF where the amount of this acid was appreciably higher in summer compared to winter in both the fractions. At other stages of seed development the effect of temperature was negligible.

Oleic and linoleic acids were the major acids and their levels were affected immensly by the position of the seed and season in polar as well as in non-polar fraction during seeds development. In winter, oleic acid accumulated rapidly at first but at the mid point of the seed development it was overtaken by linoleic acid which became the major component thereafter in both the fractions. Similar trend was observed in case of position of the seeds. However, in summer oleic acid was observed to accumulate rapidly at first and then declined at a very slow rate but was never overtaken by linoleic acid thus remained the major component upto maturity in non-polar fraction whereas in polar fraction at later stages of development these two acids were almost in equal levels. At all the stages of seed development during both the seasons in both the fractions the content of oleic acid decreased while linoleic acid increased from periphery towards centre. The two fractions also differed appreciably in amounts of oleic and linoleic acids. In winter as well as in summer during seed development the oleic acid content was higher in non-polar fraction while linoleic acid was higher in polar fraction. It was also true in case of position of the seeds.

Discussion

The effect of season (temperature) and position of the seeds within head on fatty acid composition of polar and non-polar lipids fractions in developing seeds of sunflower was studied. Total saturated acid decreased while unsaturated fatty acids increased during development of seeds in both the seasons and fractions. Of the two saturated fatty acids, palmitic acid was predominantly higher than stearic acid at all the stages, seasons, fractions and positions. However, an inverse relationship was observed between oleic acid and linoleic acid during seed development in all the variables (position, season and fraction). Our results are in agreement with those of Grewal et al. (1978) and Robertson et al (1978). They, however, conducted such studies during single season. In this regard, our results of two seasons differ only in the quantities of the fatty acids but the trend during development of seeds remained the same.

The position of the seeds within the head had a singificant effect on fatty acid composition during development in both the seasons and fractions. Of these oleic and linoleic acids are worth mentioning. Oleic acid content decreased while linoleic acid content increased from periphery toward the centre of the head. The observed changes in fatty acid composition due to seed position may be due to environment since the seed formation initiated at the periphery of the head and then progressed towards the centre. Therefore, the individual seed might have developed and matured under somewhat different climatic conditions. These findings lend support from the results of Zimmerman and Fick (1973). The two fractions (polar and non-polar) also differed appreciably in amounts of fatty acids. Palmitic acid was higher in polar fraction during both the seasons. Oleic acid was higher in non-polar fraction whereas linoleic acid was higher in polar fraction during development in both the seasons. Similar results have also been reported by Grewal et al (1978).

The effect of temperature (season) was very severe on oleic and linoleic acids while palmitic acid and stearic acids were least affected. The higher temperature (summer) favoured the accumulation of oleic acid while lower temperature (winter) favoured linoleic acid. The effect of the temperature could be judged in a better way from the ratios of oleic acid to linoleic acid at maturity irrespective of the seed position. In non-polar fraction the ratio of these two acids in winter was 1:1.25 while in summer it was 3.5:1. Similarly in polar fraction the ratio was 1:2.5 in winter and 1.5:1 in summer. These results suggest a positive relationship between temperature and oleic acid and a negative relationship between temperature and linoleic acid. It further suggests that by merely selecting the season of the year, a desired oleic to linoleic acid ratio of sunflower seed oil could be obtained. These results are in confirmity with the findings of Harris et al (1978) and Tremolieres et al (1982). The decrease in linoleic acid at high temperature and increase at low temperature is attributed to the regulation of desaturase enzyme (Oleyl-CoA desaturase) which is responsible for converting oleic to linoleic acid. Either the synthesis or the activity of this enzyme is enhanced at low temperature which results in increase in linoleic acid (Tremolieres et al., 1982). Since for dehydrogenation the enzyme essentially require co-factors such as O_2 and pyridine nucleotide (Nagai and Bloch, 1966), the reduction in formation of linoleic acid at higher temperature could also be due to the reduced tissue concentration of molecular oxygen (Harris and James, 1969). The metabolic rate is generally higher at elevated temperature which results in the decrease of availability of oxygen for reoxidizing the desaturase enzyme. However, the regulation of polyunsaturated fatty acids biosynthesis seems to result from the interaction of genetically controlled activation or synthesis of enzyme with environment.

Table 1 Fatty acid composition (per cent) of non-polar lipids fraction of developing seeds of sunflower as affected by position of the seeds within head and season.

DAF	Position	Fatty acids													
		LA		Palmitic		Palmitoleic		Stearic		Oliec		Linoleic		Linolenic	
		W	S	W	S	W	S	W	S	W	S	W	S	W	S
7	P	1.41	0.58	19.81	17.17	0.76	0.29	1.19	8.04	21.93	47.34	48.69	24.32	6.21	2.23
	M	-	0.88	-	18.70	-	0.29	-	5.07	-	36.86	-	34.81	-	3.40
	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	P	t	t	8.63	5.45	t	a	7.60	5.45	55.65	78.89	27.25	10.20	1.00	t
	M	t	t	8.82	6.88	t	a	7.15	6.50	50.56	74.57	32.66	12.05	0.81	t
	C	t	t	10.69	7.81	t	a	8.65	7.21	47.15	72.37	33.16	12.61	1.35	t
21	P	t	t	4.82	5.24	t	t	5.67	3.83	61.13	76.41	28.31	14.52	t	t
	M	t	t	6.47	6.75	t	t	5.13	3.31	59.82	74.88	28.57	15.06	t	t
	C	t	t	3.53	7.79	t	t	4.42	3.90	58.13	73.22	33.92	14.99	t	t
28	P	t	t	6.41	5.25	0.40	0.30	4.11	3.53	46.97	73.86	42.11	17.06	t	t
	M	t	t	4.62	5.64	0.38	0.25	3.88	3.18	43.44	70.38	47.68	20.81	t	t
	C	t	t	6.04	5.94	0.42	0.30	3.50	2.50	40.73	70.44	49.31	21.08	t	t
35	P	t	t	6.04	5.70	0.42	0.26	3.82	3.03	42.66	68.97	47.06	22.30	t	t
	M	t	t	7.24	5.19	0.37	0.32	3.39	2.95	39.00	64.70	50.00	27.15	t	t
	C	t	t	7.35	5.56	0.40	0.30	3.15	2.78	37.25	63.54	51.85	28.11	t	t
42	P	t	t	6.32	4.75	0.38	0.28	3.85	3.28	42.50	68.32	46.95	23.37	t	t
	M	t	t	7.00	5.00	0.40	0.26	3.33	3.10	40.75	66.16	48.52	25.48	t	t
	C	t	t	6.85	4.83	0.40	0.26	3.30	3.32	40.13	61.86	49.32	29.73	t	t

DAF = Days after flowering; P = Periphery; M = Middle; C = Centre; W = Winter; S = Summer;
LA = Total lower fatty acids; a = absent; t= traces; - = No seed initiation

Each sample was analysed in triplicate.

Table 2 Fatty acid composition (per cent) of polar lipids fraction of developing seeds of sunflower as affected by position of the seeds within head and season.

DAF	Position	Fatty acids													
		LA		Palmitic		Palmitoleic		Stearic		Oleic		Linoleic		Linolenic	
		W	S	W	S	W	S	W	S	W	S	W	S	W	S
7	P	0.81	1.26	22.10	22.02	a	a	1.95	5.05	28.58	39.14	42.20	29.02	4.34	3.11
	M	-	1.41	-	26.67	-	a	-	6.16	-	1.02	-	33.15	-	3.25
	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	P	t	t	12.57	10.00	a	a	4.26	4.21	44.75	55.21	35.72	29.68	2.75	0.65
	M	t	t	14.13	10.85	a	a	4.86	4.40	38.39	60.05	39.92	23.90	2.70	0.60
	C	0.43	t	17.50	12.09	a	a	4.93	5.36	31.24	51.31	42.92	30.64	3.01	0.60
21	P	t	t	9.65	9.85	t	a	2.92	4.12	45.44	64.12	42.99	21.91	t	t
	M	t	t	10.46	9.18	t	a	3.47	3.62	38.06	59.38	48.06	27.81	t	t
	C	t	t	10.97	10.01	t	a	2.87	4.89	36.00	55.25	50.16	29.85	t	t
28	P	t	t	11.91	9.10	0.55	t	2.88	3.26	32.40	60.53	52.26	26.61	t	t
	M	t	t	11.85	10.23	0.50	t	2.80	2.51	27.25	56.52	57.60	30.13	t	t
	C	t	t	11.57	13.07	0.63	t	2.25	4.04	26.03	52.62	59.60	29.67	t	t
35	P	t	t	11.40	12.58	0.60	0.35	2.97	4.33	26.92	52.26	58.11	30.54	t	t
	M	t	t	12.98	14.66	0.65	0.40	3.12	3.94	26.04	48.18	57.20	32.82	t	t
	C	t	t	13.92	12.50	0.55	0.30	3.12	3.56	20.91	48.05	61.55	35.60	t	t
42	P	t	t	12.00	11.35	0.70	0.41	3.12	3.03	24.51	55.32	59.65	29.09	t	t
	M	t	t	12.86	11.75	0.55	0.45	2.87	3.36	24.32	50.26	59.40	34.18	t	t
	C	t	t	11.95	13.26	0.63	0.36	3.10	2.56	19.14	48.53	65.70	35.29	t	t

Each sample was analysed in triplicate.

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