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The relationships between seed fatty acids profile and seed germination in cucurbit species

Haluk Çağlar KAYMAK

Atatürk University
25240 Erzurum, Turkey
E-mail: hckaymak@atauni.edu.tr

Abstract

The present study was undertaken to determine not only the characterization of the total oil and fatty acid profile of cucurbit species but also the relations between the fatty acid profile and seed germination under controlled conditions. In this study, the germination percentage in the first count, last count, germination speed, total oil and the fatty acid profile of cucurbit species were determined. There were significant differences among species for seed germination in the first count, last count and germination speed. In addition, palmitic (C16:0), oleic (C18:1n-9) and linoleic (C18:2n-6) acids were sequentially the highest in concentration followed by stearic acid (C18:0) at less than 8% and miristic (C14:0), palmitoleic (C16:1n-7), margaric (C17:0), arachidic (C20:0) and erucic (C22:1n-9) acids at an even lower content (<1%). In addition to simple correlation coefficients (*r*) between the total oil, fatty acid composition, and germination percentage and speed of the cucurbits; similar results were obtained in stepwise multiple regression analysis. According to stepwise multiple regression analysis C14:0, C18:2n-6, and C20:0 clearly and significantly affected germination percentages in the first and last count as well as the germination speed. Simple correlation coefficients and stepwise multiple regression analysis showed that the low or high amount of fatty acids such as miristic (C14:0), oleic (C18:1n-9), linoleic (C18:2n-6) and arachidic (C20:0) acids in cucurbit seed might play a major role on germination percentage and speed.

Key words: cucurbits, total oil, fatty acid profile, germination.

Introduction

The melon, cucumber and snake cucumber, squash and pumpkin, watermelon fruits are classified into the botanical family of *Cucurbitaceae*, and the genus *Cucumis*, *Cucurbita* and *Citrillus*, respectively. The cucurbits are cultivated in different regions of the world and palatable fruits are eaten either raw (e.g., *Cucumis melo*) or cooked (e.g., *Cucurbita pepo*) with flavour. Similar to these, the seeds of cucurbits, especially pumpkin (*Cucurbita pepo* and *C. maxima*) are a common snack food in several countries and have also been used in traditional medicine (Dvorkin, Song, 2002; Applequist et al., 2006). Altering the content of oils and proteins for various purposes is of longstanding interest to plant breeders and the industry as a whole (Applequist et al., 2006). A certain amount of work on the composition of melon (*Cucumis melo*) seeds has been conducted, which reports the total amount of oil in the seeds, varying from 25–54% (Bora et al., 2000; De Mello et al., 2000). In addition, the total oil of watermelon, pumpkin or squash seeds ranged between 20% and 43% (Al-Khalifa, 1996; Idouraine et al., 1996). Furthermore, numerous studies have reported the content and ratios of fatty acids in seeds of cucurbits. For example, four major fatty acids in *Cucurbita* seeds, employing varieties of *C. pepo* or occasionally *C. maxima* are palmitic acid, strearic acid, oleic acid and linoleic acid (De Mello et al., 2000). Indeed, these are the four major fatty acids present in the oil extracted from the seed of *Cucurbitaceae* family members (Al-Khalifa, 1996; Idouraine et al., 1996; Bora et al., 2000; De Mello et al., 2000; Applequist et al., 2006; Glew et al., 2006).

Nevertheless, a complex series of metabolic processes such as water imbibition, respiration, mobilization of food reserves, nucleic acid and protein synthesis, as well as cell differentiation and growth play a major role of germination of higher plant seeds as vegetables (Wanasundara et al., 1999) and seeds are classified according to the main compounds stored into two distinct types, one of which accumulates mostly lipids and proteins (Mayer, Poljakoff-Mayber, 1989; Da Silva et al., 1998). Seeds belonging to the *Cucurbitaceae* family are also known to be as rich in oil as cottonseed, soy or corn (Badifu, 1993; De Mello et al., 2001). In addition, the great majority of seed oils are simple lipids, which include fats, fatty oils, and waxes. For oil-bearing seed germination, the first step in the utilisation of reserve storage materials also involves a hydrolytic reaction using the enzyme lipase to cleave the ester bonds and yield free fatty acids and glycerol. The free fatty acids are further degraded by one of two processes: 1) α-oxidation plays a minor role in germinating seeds, 2) β-oxidation plays a major role during the germination period with the aid β-oxidase, yielding acetyl coenzyme A and energy in the form of adenosine triphosphate (Copeland, McDonald, 1985). Similarly, Huang and Grunwald (1990) and Wanasundara et al. (1999) reported that during the germination of oilseeds, storage lipids are metabolized to supply

the required energy for the high-energy demanding processes and structural lipids also change quantitatively due to new membrane formation.

Although a number of papers exist regarding the characterization of the seeds oils and fatty acid composition of cucurbits as mentioned above, most do not cover the relations between the total oil, fatty acid composition and seed germination. Therefore, the present study was undertaken to determine not only the characterization of the fatty acid profile of some cucurbits but also relations between the fatty acid profile and seed germination under controlled conditions.

Material and methods

This study was conducted in growth chambers and Gas Chromatography-Mass Spectrometry Laboratory in Atatürk University, in 2010. In this study, cucumber (*Cucumis sativus* L. cvs. 'Fancipak' and 'Beith Alpha F_1'), for pickling (CSP) and fresh marketing (CS), respectively, pumpkin [*Cucurbita maxima* Duch. cv. 'African-97' (CM) and *Cucurbita pepo* L. cv. 'Sakız' (CP)], watermelon [*Citrillus lanatus* L. cv. 'Maxi Crimson' (CL)], melon [*Cucumis melo* L. var. *reticulatus* cv. 'Ananas' (CMR) and *Cucumis melo* L. var. *inodorous* cv. 'Kırkagac-637' (CMI)] and snake cucumber [*Cucumis melo* L. var. *flexuosus* (CMF)] seeds were used as plant material and seeds of the vegetable species were supplied by vegetable seed companies in Turkey.

Standard germination tests (SGT) were conducted using four replicates of 50 seeds from each species in Petri dishes in the dark. They were placed in a growth chamber for a period of 8 days for cucumber, pumpkin, melon and snake cucumber and 14 days for watermelon at 25°C (ISTA, 1996). The seeds were incubated between two filter papers saturated with water containing Benlate 1 g l^{-1} to prevent fungal growth.

Visible-radicle protrusion was the criterion of germination (Güvenç, Kaymak, 2006; Demir et al., 2008). The first count was verified on the 4th (cucumber, pumpkin, melon and snake cucumber) and 7th (watermelon) days (ISTA, 1996). Germinated seeds were recorded and discarded at 24 hour intervals during the 8 and 14 days (ISTA, 1996) and the results were expressed as the final germination percentage.

Germination speed (GS) was calculated according to the equation (germination speed = germination percentage on 1st day/1 + ….. + germination percentage nth day/n) of Kaymak et al. (2009).

Experiments of germination tests were conducted in a randomized complete block design, with each treatment replicated four times. The data were subjected to *ANOVA* and means were compared by using Duncan's multiple range test. Additionally, stepwise multiple regression and the correlation coefficients (*r*) among total oil, fatty acid profile, and germination percentage and speed were determined.

Folch et al. (1957) method was used for lipid extraction from the seeds of the *Cucurbita* species (*c.* 1 g). According to this method, the samples were homogenized in chloroform/methanol (2:1 v/v) containing 0.01% (w/v) of butylated hydroxytoluene ("Sigma", ≥99.0% (GC), product No. B1378) as antioxidant 20 vol. (w/v) for 1 min. Homogenization was carried out in ice and other mediums (filtration, incubation, etc.) at room temperature (20–22ºC). The organic solvent was evaporated under a stream of nitrogen and the amount of lipid was determined gravimetrically. Fatty acid methyl esters (FAMEs) were prepared from lipids according to the method of Metcalfe and Schmitz (1961). The crude lipid extract was saponified with NaOH in methanol and FAMEs were prepared by transmethylation with boron trifluoride (BF_3) in methanol. FAMEs were obtained on a HP ("Hewlet Packard", USA) "Agilent 6890 N" model gas chromatography (GC), equipped with a flame ionization detector and fitted with a DB 23 capillary column (60 m, 0.25 mm i.d. and 0.25 μm) ejector and detector temperature program was 190°C for 35 minutes then increasing at 30°C per minute up to 220°C, where it was maintained for 5 minutes. Carrier gas was hydrogen (2 ml min^{-1} and split ratio was 30:1). The individual fatty acids (FAs) were identified by comparing their retention times to those of a standard mix of FAs ("Supelco 37" component FAME mix, Cat. No. 47885-U) and quantified by comparing their peak (David et al., 2003).

Data were presented as mean ± standard deviation (SD) of the mean. Data were analyzed using one-way analysis of variance (*ANOVA*). The significant means were compared using Duncan's multiple range tests at $\alpha = 0.05$ level (n = 4).

Results and discussion

The major fatty acids of the oil that was extracted from the seeds from the eight cucurbit species are shown in Tables 1 and 2. The fatty acid contents were significantly different among the cucurbits' seed samples. Palmitic (C16:0), oleic (C18:1n-9) and linoleic (C18:2n-6), acids were sequentially the highest in concentration followed by stearic acid (C18:0) at less than 8% and miristic, palmitoleic, margaric, arachidic and erucic acids at an even lower content (<1%). In addition, miristic, margaric acids in CSP and CS and miristic, margaric and erucic acids in CSP, CS and CP were not determined. The levels of total polyunsaturated fatty accids (PUFA) were ranged between 44% (CP) and 70 % (CL and CMR), and monounsaturated fatty accids (MUFA) were ranging 11% (CS) to 26% (CM and CMI). In addition, cucurbit seed oils contained low amounts (14–19%) of totally saturated fatty acids. CM (35.8%) and CMF (30.7%) had sequentially the highest amount of total oil followed by CSP and CP (28.9%), CS (26.6%), CMR (26.4%), CMI (26.8%) and CL (22.9%).

Wide variations were determined among the contents of major fatty (palmitic, oleic, linoleic and stearic) acids. The total fatty accids: saturated (SFA), monounsaturated (MUFA), polyunsaturated (PUFA), and total oil were also different. Such differences, may be due to various factors including the harvest time, level of maturity, seasonal variation, drying conditions, variety, source, soil and storage conditions (Al-Khalifa, 1996; De Mello et al., 2000). In addition, some reports are available on the composition of fatty acids of cucurbit species from different regions of the world. For example, Al-Khalifa (1996) reported that the linoleic acid values changed according to the species and 68.5% in *Citrillus lanatus*, 65% in *Citrillus colocynthis*, 53% in *Cucurbita moschata*, and 43% in *Cucurbita pepo*. Similarly, fatty acid contents were found to be between 25% and 35.9% oleic and 40.4% and 55.6% linoleic acid; stearic and palmitic acids

typically ranged from 5.2% to 7.5% and 6.2% to 12.4%, respectively, in cucurbits (Applequist et al., 2006). According to De Mello et al. (2001) reports, linoleic acid was the principal fatty acid followed by oleic, palmitic and stearic acids with concentrations approaching 51%, 31%, 8.5% and 6.1%, respectively, in melon seeds. In addition to these reports about fatty acid contents, the reported oil contents vary from 40% to 47% in the seeds of melons grown in India (Teotia, Ramakrishna, 1984) and in general the total oil in the seeds of cucurbits varied from 21–54% (Kaur et al., 1988; Al-Khalifa, 1996; Bora et al., 2000; De Mello et al., 2000). The fatty acid profile of the cucurbit seed oils resembled those reported by other researhers; cucurbit seed oils evaluated in this work contained low amounts (14–19%) of totally saturated fatty acids and high amounts (44–70%) of unsaturated fatty acids, and this could be seen as an advantage since a diet low in saturated fat can benefit patients suffering from cardiovascular disease (Al-Khalifa, 1996).

Table 1. Total oil, SFA, PUFA and MUFA of different cucurbit species

Species	Species code	SFA	n-6 PUFA	MUFA	Total oil
Cucumis sativus L. cv. 'Fancipak'	CSP	19.441 ± 0.379 a	66.574 ± 0.433 b	13.984 ± 0.813 c	28.961 ± 0.745 c
Cucumis sativus L. cv. 'Beith Alpha F_1'	CS	19.087 ± 0.127 a	69.879 ± 0.249 a	11.033 ± 0.124 d	26.686 ± 0.998 d
Cucurbita maxima Duch. cv. 'African-97'	CM	17.526 ± 0.359 b	55.512 ± 3.633 d	26.962 ± 3.274 b	35.838 ± 0.887 a
Cucurbita pepo L. cv. 'Sakız'	CP	17.565 ± 0.329 b	44.954 ± 1.583 e	37.482 ± 1.912 a	28.976 ± 0.215 c
Citrillus lanatus L. cv. 'Maxi Crimson'	CL	16.692 ± 0.407 c	70.329 ± 0.744 a	12.980 ± 0.337 cd	22.992 ± 1.197 e
Cucumis melo L. var. *reticulatus* cv. 'Ananas'	CMR	14.877 ± 0.381 d	70.429 ± 0.941 a	14.695 ± 1.322 c	26.444 ± 0.347 d
Cucumis melo L. var. *inodorous* cv. 'Kırkagac-637'	CMI	14.795 ± 0.674 d	58.634 ± 2.009 c	26.572 ± 1.335 b	26.804 ± 0.970 d
Cucumis melo L. var. *flexuosus*	CMF	16.369 ± 0.450 c	58.206 ± 0.998 c	25.427 ± 0.548 b	30.701 ± 0.716 b

Notes. SFA – saturated fatty acids, n-6 PUFA – polyunsaturated fatty acids, MUFA – monounsaturated fatty acids. Means with different letters on column are significantly different at $P = 0.05$.

Table 2. Fatty acid profile of different cucurbit species (codes see in Table 1)

	CSP	CS	CM	CP	CL	CMR	CMI	CMF
C14:0	–	–	0.174 ± 0.032 c	0.227 ± 0.032 b	0.419 ± 0.064 a	0.254 ± 0.008 b	0.172 ± 0.031 c	0.211 ± 0.001 bc
C16:0	11.981 ± 0.338 a	11.261 ± 0.061 b	11.481 ± 0.451 b	10.144 ± 0.184 c	9.444 ± 0.185 d	8.997 ± 0.318 e	8.215 ± 0.397 f	10.151 ± 0.303 c
C16:1n-7	0.148 ± 0.001 a	0.058 ± 0.044 e	0.130 ± 0.001 ab	0.113 ± 0.004 bc	0.071 ± 0.003 de	0.092 ± 0.004 cd	0.047 ± 0.025 e	0.129 ± 0.009 ab
C17:0	–	–	0.086 ± 0.032 a	–	0.090 ± 0.003 a	0.067 ± 0.008 ab	0.076 ± 0.006 a	0.047 ± 0.035 b
C18:0	6.929 ± 0.092 a	7.128 ± 0.080 a	5.595 ± 0.156 cd	6.996 ± 0.501 a	6.488 ± 0.148 b	5.289 ± 0.057 d	6.150 ± 0.291 b	5.713 ± 0.183 c
C18:1n-9	13.836 ± 0.812 c	10.978 ± 0.079 b	26.709 ± 3.235 d	37.370 ± 1.908 a	12.838 ± 0.319cd	14.524 ± 1.323 c	26.466 ± 1.359 b	25.253 ± 0.536 b
C18:2n-6	66.574 ± 0.433 b	69.879 ± 0.249 a	55.51 ± 3.633 d	44.954 ± 1.583 e	70.329 ± 0.744 a	70.429 ± 0.941 a	58.634 ± 2.009 c	58.206 ± 0.998 c
C20:0	0.532 ± 0.051 b	0.699 ± 0.014 a	0.191 ± 0.002 d	0.198 ± 0.019 d	0.251 ± 0.008 c	0.271 ± 0.007 c	0.183 ± 0.012 d	0.247 ± 0.001 c
C22:1n-9	–	–	0.124 ± 0.039 a	–	0.072 ± 0.014 b	0.080 ± 0.003 b	0.059 ± 0.001 bc	0.046 ± 0.003 c

Notes. C14:0 – miristic acid, C16:0 – palmitic acid, C16:1n-7 – palmitoleic acid, C17:0 – margaric acid, C18:0 – stearic acid, C18:1n-9 – oleic acid, C18:2n-6 – linoleic acid, C20:0 – arachidic acid, C22:1n-9 – erucic acid. Means with different letters on line are significantly different at $P = 0.05$.

Means of the cucurbit species for seed germination in the first and last count and germination speed (GS) are shown in Table 3. There were significant differences ($P < 0.01$) among species for all parameters tested. The species germination percentages ranged from 20.0% (CMI) to 98.5% (CL) in the first count. However, in the last count, the species germination percentage was between 64.0% (CMR) and 98.5% (CMR and CL). While the germination percentage of CS for using fresh marketing was lower than CL in the first count, this also displayed the highest GS (42.4%) at the end of germination test (Table 3). The GS ranged from 17.0% (CMF) to 42.4% (CS).

It is known that the germination of seeds is the first developmental step in the life cycle of a plant to produce a new generation (Bewley, 1997). Vegetable seeds that had high germination under optimal laboratory conditions and the germination percentages of seeds under optimum conditions could provide 100% germination. Several investigations have reported the seed germinability of cucurbit species with different aims. If some examples are given regarding the germination percentages of cucurbits, significant interactions were reported between melon cultivars and the growing season with respect to germinability, and germination percentages ranged between 75% and 95% (Nerson, 2009). Hu et al. (2002)

reported that the germination percentage of watermelon seeds changed according to the moisture content and the highest germination percentage was 71.5%. Similarly, germination percentage of the cucumber was determined to be between 86% and 93% (Kretschmer, 1995). Conversely, the germinability of vegetable seeds depends on many factors such as maturity, water, oxygen, temperature, cultivar and species, drying conditions, harvest time, etc. (Copeland, McDonald, 1985) and the results from this study confirmed these researchers' findings.

Table 3. Mean seed germination in the first and last count and the germination speed (GS) of cucurbit species

Species	First count %	Last count %	GS %
Cucumis sativus L. cv. 'Fancipak'	72.0 bc	92.0 ab	33.5 b
Cucumis sativus L. cv. 'Beith Alpha F_1'	86.8 ab	86.7 abc	42.4 a
Cucurbita maxima Duch. cv. 'African-97'	72.0 bc	81.5 bc	31.9 b
Cucurbita pepo L. cv. 'Sakız'	64.0 c	77.3 c	29.9 b
Citrillus lanatus L. cv. 'Maxi Crimson'	98.5 a	98.5 a	38.5 a
Cucumis melo L. var. *reticulatus* cv. 'Ananas'	85.3 ab	98.5 a	33.5 b
Cucumis melo L. var. *inodorous* cv. 'Kırkagac-637'	20.0 d	93.3 ab	21.5 c
Cucumis melo L. var. *flexuosus*	32.0 d	64.0 d	17.0 d

Note. Different letters denote significant differences among cultivars at $P = 0.01$ probability level.

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The correlation coefficients (r) between the total oil, fatty acid composition, and germination percentage and speed of the cucurbit species used in this study are presented in Table 4. As seen in Table 4, C18:1n-9 (−0.544, $P < 0.01$), C18:2n-6 (0.483, $P < 0.01$), C20:0 (0.388, $P < 0.05$), SFA (0.377, $P < 0.05$), MUFA (−0.543, $P < 0.01$) and n-6 PUFA (0.483, $P < 0.01$), and C16:1n-7 (−0.399, $P < 0.05$), C18:1n-9 (−0.516, $P < 0.01$), C18:2n-6 (0.552, $P < 0.01$), MUFA (−0.517, $P < 0.01$), n-6 PUFA (0.552, $P < 0.01$) and total oil (−0.591, $P < 0.01$) were significantly correlated with the germination percentage in the first and last count, respectively. In addition, the GS was significantly correlated with C16:0 (0.358, $P < 0.05$), C18:0 (0.388, $P < 0.05$), C18:1n-9 (−0.579, $P < 0.01$), C18:2n-6 (0.500, $P < 0.01$), C20:0 (0.582, $P < 0.01$), SFA (0.482, $P < 0.01$), MUFA (−0.580, $P < 0.01$) and n-6 PUFA (0.500, $P < 0.01$).

Table 4. Simple correlation coefficients (r) among the total oil, fatty acid profile and seed germination in the first and last count and the germination speed (GS) of different cucurbits species

	First count	Last count	GS	C14:0	C16:0	C16:1n-7	C17:0	C18:0	C18:1n-9	C18:2n-6	C20:0	C22:1n-9	SFA	MUFA	n-6 PUFA
Last count	0.480**														
GS	0.910**	0.555**													
C14:0	0.122^{NS}	0.115^{NS}	−0.118^{NS}												
C16:0	0.333^{NS}	−0.251^{NS}	0.358*	−0.594**											
C16:1n-7	−0.002^{NS}	−0.399*	−0.163^{NS}	−0.155^{NS}	0.558**										
C17:0	−0.042^{NS}	0.231^{NS}	−0.175^{NS}	0.634**	−0.466**	−0.240^{NS}									
C18:0	0.177^{NS}	0.079^{NS}	0.388*	−0.366*	0.366*	−0.122^{NS}	−0.682**								
C18:1n-9	−0.544**	−0.516**	−0.579**	0.164^{NS}	−0.144^{NS}	0.208^{NS}	0.003^{NS}	−0.093^{NS}							
C18:2n-6	0.483**	0.552**	0.500**	−0.057^{NS}	−0.028^{NS}	−0.282^{NS}	0.114^{NS}	−0.036^{NS}	−0.983**						
C20:0	0.388*	0.152^{NS}	0.582**	−0.715**	0.563**	−0.077^{NS}	−0.607**	0.555**	−0.650**	0.534**					
C22:1n-9	0.031^{NS}	0.144^{NS}	−0.123^{NS}	0.520**	−0.224^{NS}	−0.014^{NS}	0.882**	−0.766**	0.073^{NS}	0.014^{NS}	−0.584**				
SFA	0.377*	−0.126^{NS}	0.482**	−0.585**	0.912**	0.345^{NS}	−0.629**	0.710**	−0.205^{NS}	0.019^{NS}	0.694**	−0.491**			
MUFA	−0.543**	−0.517**	−0.580**	0.165^{NS}	−0.143^{NS}	0.212^{NS}	0.006^{NS}	−0.097^{NS}	1.000**	−0.982**	−0.652**	0.078^{NS}	−0.206^{NS}		
n-6 PUFA	0.483**	0.552**	0.500**	−0.057^{NS}	−0.028^{NS}	−0.282^{NS}	0.114^{NS}	−0.036^{NS}	−0.983**	1.000**	0.534**	0.014^{NS}	0.019^{NS}	−0.982**	
Total oil	−0.247^{NS}	−0.591**	−0.300^{NS}	−0.172^{NS}	0.409*	0.566**	−0.172^{NS}	−0.068^{NS}	0.784**	−0.847**	−0.323^{NS}	0.069^{NS}	0.228^{NS}	0.786**	−0.847**

* – significant at $P = 0.05$, ** – significant at $P = 0.01$, NS – not significant.

It can be seen in Table 4 that there are a lot of significant correlations between the total oil, fatty acid composition and germination percentage and speed of the cucurbits. In the present study, oleic (C18:1n-9) and linoleic (C18:2n-6) acids, MUFA and n-6 PUFA content promoted the germination percentage in the first and last count and germination speed concomitant with palmitic (C16:0), palmitoleic (C16:1n-7), stearic (C18:0), arachidic (C20:0) acids, SFA and total oil. Palmitic, strearic, oleic and linoleic acids are the four major fatty acids present in the oil extracted from members of the *Cucurbitaceae* family (Al-Khalifa, 1996; Idouraine et al., 1996; Bora et al., 2000; De Mello et al., 2000; Applequist et al., 2006; Glew et al., 2006). For this reason, it can be clearly

defined that they play an important role during germination of cucurbits with the aid β-oxidase, yielding acetyl coenzyme A and energy in the form of ATP (Copeland, McDonald, 1985).

In addition to simple correlation coefficients (*r*) between the total oil, fatty acid composition and the germination percentage and speed of the cucurbits; similar results were obtained in stepwise multiple regression analysis (Table 5). In other words, a near to direct effect of total oil and fatty acid composition; indirect effect of total oil and fatty acid composition were determined. Regression equation and *R* square for the germination percentage in the first and last count and the germination speed were Y = 100.295 – (1.619 × C18:1n-9), R^2 = 0.273, Y = 38.531 – (0.776 × C18:2n-6), R^2 = 0.305 and Y = 9.460 + (45.899 × C20:0) + (37.577 + C14:0), R^2 = 0.489, respectively. According to stepwise multiple regression analysis C14:0, C18:1n-9, C18:2n-6 and C20:0 clearly and significantly affected the germination percentages in the first and last count and the germination speed (Table 5).

Table 5. Stepwise multiple regression analysis of the total oil, fatty acid profile, seed germination in the first and last count and the germination speed (GS) of different cucurbit species

		Unstandardized coefficients		Standardized coefficients		
		B	Std. error	β	*t*	*P* values
First count	Constant	100.295	10.373		9.669	0.000
%	C18:1n-9	−1.619	0.455	−0.544	−3.554	0.001
R^2 = 0.273						
Y = 100.295 − (1.619 × C18:1n-9)						
Last count	Constant	38.531	13.349		2.886	0.007
%	C18:2n6	0.776	0.214	0.552	3.626	0.001
R^2 = 0.305						
Y = 38.531 − (0.776 × C18:2n-6)						
GS	Constant	9.460	4.489		2.107	0.044
%	C20:0	45.899	8.270	1.019	5.550	0.000
	C14:0	37.577	11.291	0.611	3.328	0.002
R^2 = 0.489						
Y = 9.460 + (45.899 × C20:0) + (37.577 × C14:0)						

Near to significant correlation coefficients (*r*), indirect effect of total oil and fatty acids and regression equations are shown in Table 5. The statistical results according to the regression analysis clearly revealed that fatty acid composition had a significant effect on the germination percentage and the speed of the cucurbits and that the germination percentage in the first and last count and germination speed were closely related to extra or deficient fatty acids (Table 5). Similarly, researchers have shown relations between some physical and biochemical tests such as counting the number of seeds with broken coats, the electrical conductivity of seed leakage, and tetrazolium viability tests, are also considered as good measures of seed quality and correlated significantly with viability and vigour (Kolasinska et al., 2000; Kaymak, Güvenç, 2008; Palabiyik, Peksen, 2008).

Conclusion

It can be concluded that cucurbit seeds are rich sources of fatty acids, in particular for palmitic, oleic, linoleic and stearic acids. All the cucurbit seed oils that were evaluated in this research contained high percentage of unsaturated fatty acids, the most prominent of these being *Citrillus lanatus* L. (CL) and *Cucumis melo* L. var. *reticulatus* (CMR) with high linoleic acid (70%) and *Cucurbita pepo* L. (CP) with high oleic acid (37%). The total oil and fatty acid profile influences germination percentage and speed of seeds of cucurbit species. Simple correlation coefficients and stepwise multiple regression analysis showed that the low or high amount of fatty acids such as miristic acid (C14:0), oleic acid (C18:1n-9), linoleic acid (C18:2n-6) and arachidic acid (C20:0) might play a major role on germination percentage and speed of seed of cucurbit species.

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Moliūgų sėklų riebalų rūgščių profilio ir daigumo ryšys

H. Ç. Kaymak

Turkijos Atatürk universitetas

Santrauka

Tyrimo metu nustatytas ne tik kai kurių rūšių moliūgų sėklų aliejaus ir riebalų rūgščių bendras profilis, bet ir ryšys tarp riebalų rūgščių profilio ir sėklų daigumo kontroliuojamomis aplinkos sąlygomis. Taip pat pirmo ir paskutinio vertinimo metu nustatytas sėklų sudygimo procentas, sudygimo greitis, bendras aliejaus ir riebalų rūgščių profilis. Tirtų rūšių moliūgai iš esmės skyrėsi sėklų daigumu, nustatytu pirmo ir paskutinio vertinimo metu, ir sėklų sudygimo greičiu. Sėklose didžiausia koncentracija buvo palmitino (C16:0), oleino (C18:1n-9) ir linoleino (C18:2n-6) rūgščių, mažesnė (<8 %) – stearino rūgšties (C18:0), o miristino (C14:0), palmitoleino (C16:1n-7), margarino (C17:0), arachido (C20:0) ir eruko (C22:1n-9) rūgščių koncentracija buvo mažiausia (<1 %). Be koreliacijos koeficientų (*r*) tarp aliejaus, riebalų rūgšties sudėties ir moliūgų sėklų sudygimo bendro procento bei greičio, panašūs rezultatai gauti atlikus žingsninę daugialypės regresijos analizę. Pagal šią analizę C14:0, C18:2n-6 ir C20:0 iš esmės lėmė sėklų sudygimo procentą, nustatytą pirmo ir paskutinio vertinimo metu, ir sudygimo greitį. Koreliacijos koeficientai ir žingsninė daugialypės regresijos analizė parodė, kad mažas arba didelis riebiųjų – miristino (C14:0), oleino (C18:1n-9), linoleino (C18:2n-6) ir arachido (C20:0) – rūgščių kiekis moliūgų sėklose gali turėti didelę įtaką sėklų sudygimo procentui ir greičiui.

Reikšminiai žodžiai: moliūgai, aliejaus ir riebalų rūgščių bendras profilis, daigumas.