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Fatty acid composition and some quality parameters of olive oils at green ripeness of genotypes obtained by cross breeding

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ABSTRACT

Fatty acid composition is one of the important criteria for olive oil quality determination and selection for breeding program. In this study, fatty acid compositions of olive oils obtained from 22 olive genotypes cultivated in same conditions were evaluated. Also total saturated monounsaturated and polyunsaturated fatty acids, linoleic acid / linoleic acid ratio, iodine content and quality index value of olive oils were calculated. These genotypes were obtained by advanced olive selections after the cross breeding program. GU410 and LT011 showed also high oleic and low linoleic acids content, whereas GK024 showed low oleic, high linoleic and high linolenic acid content. GK024 and BK013 had remarkable high PUFA content and IC but LT017 and GU404 had lowest polyunsaturated fatty acid content and iodine content. GU410, LT011 and LT017 showed high quality index value. LT017 stood out by its high quality index and monounsaturated fatty acid content, low IC, linoleic acid/linolenic ratio and polyunsaturated fatty acid content. Some olive oil of genotypes such as GU410, LT011, LT017 and GE015 showed better oil characteristics in terms of fatty acid composition and fatty acid parameters than olive oil of Gemlik cultivar which was used to compare.

Keywords: Quality index, iodine content, oleic acid, advanced selection

1. INTRODUCTION

Olive and olive oil production is an economically important activity in Mediterranean countries (Toker et al., 2015). Also health benefits of olive oils are important for world wide. Developing new olive cultivar will be increase grower and producer profit and meet health benefit expectation of consumer (Toker et al., 2015; Padula et al., 2006). Cross breeding has been considered the best method to obtain new olive genotypes with improved characteristics. (Ranalli et al., 2008). Olive breeding through traditional crossing still represents the most important means of breeding new olive cultivars, allowing to explore the great genetic variability of the species (Ranalli et al., 2008; Padula et al., 2006).

Cross breeding can be used to increase the genetic variability in olive, in order to select new genotypes oils of high and stable quality. However, olive breeding is known to be particularly difficult, due to long juvenility and a high level of heterozygosis, which hinders the expression of recessive genes, reducing the heritability of desired characters. The heritability of characters in olive is not well known. For these reasons, olive breeding programs have been limited (Bellini et al., 2003). Fatty acid composition of olive oils was used as important selection criteria in cross breeding studies and they were also reported in great variability according to genetic diversity (Ripa et al., 2008; Padula et al., 2006).

An olive breeding program initiated at Ataturk Central Horticultural Research Institute (Turkey) in 1990. From the initial 5000 seedlings, 393 selections had been chosen and were currently cultivated in the

observation parcel. Some of them had potential for registration as a new olive cultivar according to agronomic characteristics. This research was aimed to determine the fatty acid composition and some fatty acid parameters of oils of olives of 22 genotypes which harvested at green maturation season. They were grown in same parcel with same cultivation techniques.

2. MATERIAL AND METHODS

In this study, olive oils of 22 genotypes were evaluated which were given in Table 1. These genotypes were chosen on the basis of their high productivity, resistance to diseases and low periodicity among 492 olive genotypes. They come from the crosses of foreign (Ascolana, Belle d'Espagne, Manzanilla and Lucques) and national olive cultivars (Gemlik, Edinciksu, Karamürselsu, Tavşanyüreği and Uslu). These trees were planted at a 1,5 m x 3 m distance in olive genotype observation orchard of Ataturk Central Horticultural Research Institute (Yalova/Turkey). These genotypes were chosen on the basis of their high productivity and resistance to diseases and low periodicity. Olive oil of Gemlik cultivar was used to compare. All olives were grown in same parcel with same cultivation techniques. Olives were randomly hand-picked at 1-1,5 ripening index (when the skin color of olives was straw yellow) from this observation orchard.

Table 1 Olive genotypes and their origins

No	Origins	Genotype code	No	Origins	Genotype code
1	Ascolana X Tavşan yüreği	AT 007	12	Gemlik X Karamürselsu	GK 132
2	Ascolana X Tavşan yüreği	AT 056	13	Gemlik X Karamürselsu	GK 146
3	Ascolana X Uslu	AU 019	14	Gemlik X Uslu	GU 118
4	B. D'espagneX Karamürselsu	BK 013	15	Gemlik X Uslu	GU 404
5	B. D'espagne XKaramürselsu	BK 022	16	Gemlik X Uslu	GU 410
6	B. D'espagne X Uslu	BU 015	17	Lucques X Tavşan yüreği	LT 011
7	B. D'espagne X Uslu	BU 016	18	Lucques X Tavşan yüreği	LT 017
8	Gemlik X Edinciksu	GE 015	19	Lucques X Tavşan yüreği	LT 019
9	Gemlik X Karamürselsu	GK 024	20	Lucques X Tavşan yüreği	LT 032
10	Gemlik X Karamürselsu	GK 036	21	ManzanillaX Tavşan yüreği	MT 038
11	Gemlik X Karamürselsu	GK 131	22	Manzanilla X Tavşan yüreği	MT 162

Olives were washed without delay and diseased and damaged olives were removed. Then olives were turned into paste by laboratory scale hammer (100 rev / min) and kneader (45 minutes) after that crushed olives were dried. Oil of the dried olive paste was extracted by soxhlet apparatus for at least 8 hours with petroleum ether extraction at 50°C. Oil content of the olives was calculated at fresh weight (Cemeroglu, 2007).

Fatty acid composition was determined by gas chromatography. 0.2 g oil and 10 ml of hexane were put into a vial and shaken. After that 0,5 ml of a methanolic KOH solution (2N) was added and stirred. 0.5 µl was taken from the upper phase and injected into the gas chromatography (Anonymous, 2014).

Saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), MUFA / PUFA, linoleic acid (LA) / linoleic acid (LnA) and iodine content (IC) values were determined by using fatty acid composition of olive oil according to Kyriakidis and Katsiloulis (2000).

The formulas used in the calculation are given below;

SFA (% in fatty acids) = palmitic acid +stearic acid+ arachidic acid + margaric acid + behenic acid + lignoseric acid

MUFA (% in fatty acids) = palmitoleic acid + oleic acid + eicosenoic acid+ Heptadecanoic acid

PUFA (% in fatty acids) = linoleic acid + linolenic acid

IC = 0,93 x (palmitoleic acid + oleic acid + eicosenoic acid+ heptadecanoic acid) + 1,35 x (linoleic acid) + 2,62 x (linolenic acid)

Quality index (QI) was calculated according to Bongi (2004) by ratio between the oleic acid (%) and the sum of palmitic and linoleic acids to simplify qualitative evaluation of the oils.

Research plan was performed according to the randomized experimental design. Three replicates were tested for each parameter. Analysis of variance was applied with the Duncan multiple comparison test of the means ($p<0.01$) to determine the presence of significant differences among the samples. Statistical analysis was performed by using the JMP v. 5.0 statistical package program (SAS Institute, Cary, N.C., U.S.A.).

3. RESULTS AND DISCUSSION

Fatty acid composition of olive oil is important in terms of its nutrition physiology, stability and shelf life (Boskou 2006, Lopez-Miranda ve ark. 2010). Major and minor fatty acid compositions of oils were given in Table 2 and 3.

Table 2 Major fatty acids of oils (palmitic, palmitoleic, stearic, oleic, linoleic and linolenic acids) (% in fatty acids)

Samples	Palmitic acid (16:0)	Palmitoleic acid (16:1)	Stearic acid (18:0)	Oleic acid (18:1)	Linoleic acid (18:2)	Linolenic acid (18:3)
AT007	12,85±0,33 h-j	1,30±0,16cd	1,79±0,26j	73,27±0,81g	8,52±0,34g	1,03±0,11ab
AT056	14,52±0,30cd	1,66±0,18bc	2,52±0,30d-f	72,06±0,84g	7,5±0,23hi	0,73±0,06gh
AU019	13,29±0,321-h	0,92±0,13e-g	2,14±0,23gh	70,33±0,92h	11,01±0,47f	0,87±0,10d-f
BK013	12,4±0,26i-k	0,57±0,11i-k	2,70±0,31b-d	76,35±0,57e	15,79±0,51c	1,02±0,13ab
BK022	12,46±0,26i-k	0,67±0,13h-j	3,42±0,27a	77,17±0,64e	4,47±0,22k	0,78±0,08e-g
BU015	12,21±0,38jk	0,7±0,14g-j	2,34±0,25e-g	76,63±0,75e	5,65±0,20j	1,01±0,07ab
BU016	14,38±0,45c-e	1,25±0,23cd	1,99±0,07h-j	69,85±0,20i	10,47±0,31f	0,92±0,04b-d
GE015	13,92±0,36d-f	1,51±0,25bc	1,82±0,13ij	76,12±0,43e	4,66±0,33k	0,98±0,05a-d
GK024	12,94±0,43h-j	0,66±0,12h-j	1,97±0,18h-j	59,19±0,59n	23,26±0,56a	0,98±0,07a-c
GK036	12,52±0,43ij	0,98±0,14ef	2,0±0,20h-j	74,71±0,81f	7,78±0,30h	0,78±0,08e-g
GK131	14,77±0,35bc	1,16±0,16de	2,56±0,20c-e	63,82±0,94k	15,84±0,41bc	0,72±0,06g-i
GK132	10,83±0,30m	0,50±0,14jk	2,13±0,12gh	72,05±0,67g	12,46±0,38e	1,05±0,15a
GK146	13,1±0,26g-i	0,82±0,17f-h	2,16±0,13gh	70,23±0,65h	11,73±0,39e	0,87±0,08c-e
GU118	15,43±0,25b	2,01±0,22a	1,75±0,15j	68,46±0,66i	10,9±0,24f	0,75±0,09gh
GU404	20,28±0,31a	1,63±0,23b	2,21±0,32f-h	60,01±0,6mn	13,9±0,33d	0,98±0,11a-d
GU410	10,06±0,37n	0,75±0,11f-i	1,80±0,22J	81,16±0,63a	4,57±0,20k	0,53±0,06kl
LT011	11,5l±0,36m	0,98±0,20ef	2,61±0,19c-e	79,52±0,76b	3,49±0,26n	0,73±0,09gh
LT017	13,09±0,50g-i	1,13±0,25de	2,39±0,26c-f	79,27±1,02bc	2,34±0,21p	0,64±0,05h-j
LT019	11,75±0,41kl	0,87±0,17f-h	2,51±0,25c-f	76,19±0,93e	7,02±0,28i	0,62±0,07i-k
LT032	12,76±0,28h-j	0,36±0,11k	2,09±0,27g-i	66,42±0,62i	16,63±0,53bc	0,75±0,08f-h
MT038	13,74±0,33e-g	1,76±0,18ab	1,99±0,31h-j	67,07±0,63hi	13,73±0,44d	0,77±0,08e-g
MT162	12,38±l0,30m	0,85±0,13f-h	2,82±0,09b	78,05±0,94d	4,07±0,37o	0,65±0,05j-l
Gemlik	13,74±0,32eg	1,74±0,14ab	2,30±0,14e-g	73,02±0,72g	7,12±0,32i	0,47±0,04l

Different letter refers statistical significant difference in same colon

High MUFA and PUFA content is required for nutrition physiology of consumer (Boskou 2006, Lopez-Miranda et al., 2010). Therefore higher mono and polyunsaturated fatty acids content such as oleic and linoleic acid were required in olive oil of new genotypes when comprises with standard cultivar (Lopez-Miranda et al., 2010; Harwood and Yaqoop, 2002). In this research olive oils of GU410 and LT011 had highest oleic acid beside this olive oil of GK024 had highest linoleic acid content. GU410 and LT011 showed also high oleic and low linoleic acids content, whereas GK024 showed low oleic, high linoleic and high linolenic acid content.

Sánchez de Medina et al. (2015) reported that oleic and palmitic acid content of olive oil in fatty acids has critical for the quality and fatty acid composition has been reported to be an important parameter used to decide the selection of olive genotypes in olive breeding program. BK013, BK022, BU015, GE015, GK036, GU410, LT011, LT017, LT019 and MT162 had higher oleic acid and AT007, AU019, BK013, BU016, GK024, GK036, GK131, GK132, GK146, GU118, GU404, LT032 and MT038 had higher linoleic acid content than olive oil of Gemlik.

Table 3 Minor fatty acids of oils (margaric, heptadecanoic, arachidic, eicosenoic, behenic and lignoceric acid) (% in fatty acids)

Samples	Margaric acid (17:0)	Heptadecanoic acid (17:1)	Arachidic acid (20:0)	Eicosenoic acid (20:1)	Behenic acid (22:0)	Lignoseric acid (24:0)
AT007	0,12 bc	0,28 bc	0,38 f-h	0,34 a-d	0,10 e-g	0,03 f
AT056	0,12 bc	0,31 b	0,37 gh	0,24 gh	0,06 h	ND
AU019	ND	0,15 e	0,41 c-g	0,35 a-d	0,14 a-c	0,07 c
BK013	0,1 c	0,13 ef	0,41 c-g	0,37 a-c	0,10 g	0,03 f
BK022	0,05 f-h	0,07 hk	0,54 a	0,31 c-g	0,12 b-e	ND
BU015	0,24 a	0,46 a	0,41 d-g	0,33 b-d	0,11 d-g	0,03 f
BU016	0,10 c	0,22 d	0,35 gh	0,25 e-h	0,09 gf	0,03 f
GE015	0,06 ef	0,11 fg	0,38 e-h	0,28 d-h	0,10 e-g	0,05 de
GK024	0,04 g-i	0,05 kl	0,39 d-g	0,36 a-d	ND	0,05 de
GK036	0,13 b	0,26 cd	0,36 gh	0,32 b-e	0,10 e-g	0,05 de
GK131	0,05 f-h	0,07 i-k	0,45 b-e	0,24 f-h	0,11 d-g	0,05 de
GK132	ND	ND	0,40 d-g	0,41 a	0,17 a	ND
GK146	ND	0,07 jk	0,41 d-g	0,37 a-c	0,12 b-e	0,06 cd
GU118	ND	ND	0,31 hi	0,24 f-h	0,07 hi	0,03 f
GU404	0,06 fg	0,09 g-ı	0,44 b-f	0,21 h	0,11 c-g	0,17 a
GU410	0,08 d	0,17 e	0,25 ij	0,39 ab	0,10 e-h	ND
LT011	0,11 c	0,24 d	0,40 d-g	0,34 b-e	0,09 gh	ND
LT017	0,03 i	0,08 g-j	0,41 d-g	0,33 b-e	0,09 gh	0,09 b
LT019	0,04 g-i	0,08 g-j	0,44 b-f	0,25 f-h	0,11 b-g	0,04 ef
LT032	0,01 j	0,02 lm	0,20 j	ND	ND	ND
MT038	0,04 hi	0,10 gh	0,37 gh	0,30 b-e	0,10 d-g	0,04 ef
MT162	0,04 g-i	0,06 h-k	0,50 a-c	0,33 b-f	0,14 ab	0,07 cd
Gemlik	0,08 de	0,22 d	0,53 a	0,31 c-g	0,08 hi	0,04 ef

ND: Not Detected, Different letter refers statistical significant difference in same colon

Heptadecanoic acid has been reported as undetected in some varieties (Seyran 2009). Boskou (1996) reported heptadecanoic acid lesser than 0.6% in different olive oils. In this research heptadecanoic acid content was determined in the range of 0.06 to 0.47% and heptadecanoic acid could not be detected in some oils.

Fatty acid distribution and ratios of olive oil effects its oxidative stability and nutritional physiology (Kyriakidis and Katsiloulis, 2000). SFA, MUFA, PUFA, MUFA / PUFA, IC, QI and linoleic acid / linolenic acid (LA/LnA) values were given in Table 4.

Table 4 SFA, MUFA, PUFA, MUFA / PUFA, IC, linoleic acid / linolenic acid (LA/LnA) and QI values of olive oil samples

Sample	SFA	MUFA	PUFA	IC	MUFA/PUFA	LA/LnA	QI
AT007	15,27	75,19	9,55	84,13	7,87	8,27	3,43
AT056	17,59	74,27	8,23	81,11	9,02	10,27	3,27
AU019	16,05	71,75	11,88	83,87	6,04	12,66	2,89
BK013	15,74	77,42	16,81	95,99	4,61	15,48	2,71
BK022	16,59	78,22	5,25	80,82	14,90	5,73	4,56
BU015	15,34	78,12	6,66	82,93	11,73	5,59	4,29
BU016	16,94	71,57	11,39	83,11	6,28	11,38	2,81
GE015	16,33	78,02	5,64	81,42	13,83	4,76	4,10
GK024	15,39	60,26	24,24	90,01	2,49	23,73	1,64
GK036	15,16	76,27	8,56	83,48	8,91	9,97	3,68
GK131	17,99	65,29	16,56	83,99	3,94	22,00	2,08
GK132	13,53	72,96	13,51	87,42	5,40	11,87	3,09
GK146	15,85	71,49	12,60	84,60	5,67	13,48	2,83
GU118	17,59	70,71	11,65	82,44	6,07	14,53	2,60
GU404	23,27	61,94	14,88	78,94	4,16	14,18	1,76
GU410	12,29	82,47	5,10	84,26	16,17	8,62	5,55
LT011	14,72	81,08	4,22	82,03	19,21	4,78	5,30
LT017	16,10	80,81	2,98	79,99	27,12	3,66	5,14
LT019	14,89	77,39	7,64	83,07	10,13	11,32	4,06
LT032	15,06	66,80	17,38	86,54	3,84	22,17	2,26
MT038	16,28	69,23	14,50	4,94	4,77	17,83	2,44
MT162	15,95	79,29	4,72	80,94	16,80	6,26	4,74
Gemlik	16,77	75,29	7,59	80,86	9,92	15,15	3,50

Fatty acid composition is one of the key parameters used to characterize of olive oils (Sánchez de Medina et al., 2015). Stoll 2001 and Simopoulos (2002) reported that omega-6 / omega-3 fatty acid ratio of consumed fatty acids in dietary habits of people should be approximately 1 for healthy life whereas this ratio of dietary habits in Western countries was reported in the range 15/1 to 16,7/1 (Simopoulos, 2002; Allport, 2007). For olive oils, omega-6 / omega-3 fatty acid ratio is mostly depending on LA/LnA ratio (Simopoulos, 2008). In this research, LT017 has a remarkable balanced on LA and LnA with a ratio 3,66 it is an important feature in terms of disease prevention. GK024 and BK013 had remarkable high PUFA content and IC but LT017 and GU404 had lowest PUFA content and IC.

Telli Karaman et al. (2010) reported MUFA/PUFA, LA/LnA and IC of olive oils belongs genotypes obtained from Gemlik x Memecik cross breeding between 4,55-13,85, 8,35-19,08 and 82,07-95,00. In this research, SFA, MUFA, PUFA, IC, MUFA/PUFA, LA/LnA and QI of olive oil belonging to these genotypes were detected between 12,29-17,99, 60,26-82,47, 2,98-24,24, 78,94-95,99, 3,84-27,12, 3,66-23,73 and 1,64-5,55. Olive oil of GU410 and LT017 had highest MUFA (82,47) and MUFA / PUFA (27,12) respectively. Lowest IC was detected in olive oils of LT017, MT162 and BK022. Only olive oils of BK022 and LT017 had lower IC than olive oil of Gemlik. According to evaluation of

calculated parameters olive oils of GU410, LT011, LT017 and GE015 were detected as higher quality than olive oil of other genotypes.

4. CONCLUSION

In this research fatty acid compositions of olive oil of 22 genotypes were determined. Also some parameters which were calculated by using fatty acid distribution is used as indicator for nutrition physiology, resistance for oxidation and shelf life of olive oils. LT017 has a remarkable balanced on LA and LnA with a ratio 3,66 that is an important feature in terms of disease prevention. GK024 and BK013 had remarkable high PUFA content and IC but LT017 and GU404 had lowest PUFA content and IC. The GU410, LT011 and LT017 showed high QI value. LT017 stood out by its high QI and MUFA content, low IC, LA/LnA ratio and PUFA content. These results were beneficial for researcher which works on final selection stage of cross breeding project. As a result of the overall evaluation of fatty acid and calculated parameters GU410, LT011, LT017 and GE015 were identified as valuable and preferential genotypes. Determined fatty acid content and parameters will be used in registration and certification procedures of these genotypes as a new olive cultivar and these genotypes will be advised to grower and olive oil producer.

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