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COMPARISON OF THE VIRGIN OLIVE OILS OBTAINED FROM DIFFERENT POINTS OF COMMON OIL PRODUCTION SYSTEMS

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Abstract

Virgin olive oil samples were obtained from different sites (exit of malaxer, decanter and centrifuge) of different oil production systems (2- and 3-phase centrifugation and classical press systems). Physical (turbidity, instrumental color and smoke point) and chemical properties (antioxidant capacity, total phenolics and free fatty acid) and sensory bitterness values of the samples were measured. Total phenolic contents and antioxidant capacities were found to be significantly different among the samples obtained from different production sites. In general, samples collected from the malaxer exits were more turbid, higher in total phenolics and antioxidant capacity values. There were statistically significant relations between bitterness and total phenolic content of the samples.

Keywords: Olive oil, different production point, bitterness, quality

YAYGIN ÜRETİM SİSTEMLERİNİN FARKLI NOKTALARINDAN ALINAN NATÜREL ZEYTİNYAĞLARININ KARŞILAŞTIRILMASI

Özet

Natürel zeytinyağı örnekleri farklı üretim sistemlerinin (klasik pres sistemi, iki ve üç faz kontinü sistem) farklı noktalarından (malaksör, dekantör ve santrifüj) alınarak elde edilmiştir. Elde edilen örneklerin fiziksel (bulanıklık, renk ve dumanlanma noktası), kimyasal özellikleri (serbest yağ asitliği, toplam fenol içeriği ve toplam antioksidan kapasitesi) ile duyusal olarak acılık düzeyleri belirlenmiştir. Genel olarak, malaksör çıkışından alınan örneklerin daha bulanık, toplam fenol içeriğinin ve antioksidan kapasitelerinin daha fazla olduğu belirlenmiştir. Toplam fenol içeriği ile acılık arasında istatistiksel olarak doğrusal bir ilişkinin bulunduğu belirlenmiştir.

Anahtar kelimeler: Zeytinyağı, farklı üretim sistemleri, acılık, kalite.

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INTRODUCTION

Virgin olive oil (VOO) is one of the few edible plant oils which is produced only by mechanical processes. The production of VOO follows either classical pressing or modern extraction systems. However, both methods are generally based on three operations; malaxation, decantation and separation. Subsequent unit operations in different countries yield olive oils that are compositionally different. Chemical composition and sensory quality of VOO are heavily influenced by the production systems and process conditions (1, 2). Free fatty acid level is an important quality criterion in the classification of olive oils. Free acidity, peroxide value, total phenolic content and antioxidant capacity of olive oils is found to vary significantly in different production systems (3). The level and composition of the phenolics in olive oil depends on cultivar, climatic conditions, harvesting time and processes used for oil extraction. It is widely accepted that phenolic contents are related to the bitterness, oxidative stability and health related aspects of olive oils (1, 2, 4).

Freshly produced VOO is mostly cloudy in appearance due to the presence of suspended particles and some minor constituents. Physical parameters of oils related to appearance such as color, turbidity and luminosity affect consumer attitudes towards VOO (1, 5).

The goals of this study were to investigate the differences in the quality parameters of VOO samples obtained from different sites within different olive oil production systems. There are many studies comparing olive oils produced in different production systems, but this study compares the samples obtained from different points in the processing line of different processing systems. These types of oil samples are bottled and sold locally with different trade names in Turkey.

MATERIALS AND METHODS

Materials

Samples of virgin olive oils (n=14) were collected from village co-operatives and industrial oil mills using different extraction systems (dual-phase,

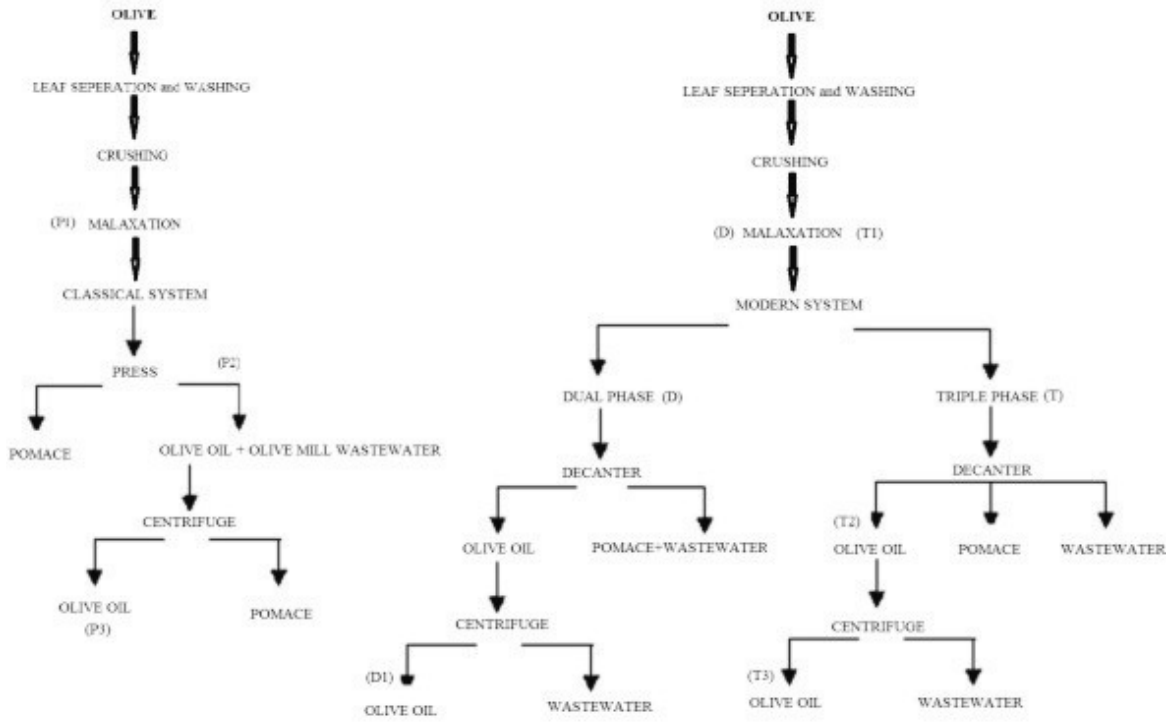

Fig. 1 The sampling points of VOO in different production systems.

triple-phase and pressure) located in the provinces of Çanakkale / Bayramiç, during 2010/2011 crop seasons. VOO samples obtained at different sites (exit of malaxer, decanter and centrifuge) in the 3 common olive oil production systems, namely dual-phase (D), triple-phase (T) centrifugation and classical pressing system (P) used in Turkey. Only dual-phase system samples were gathered from the centrifuge exit. The sampling points of the collected samples were schematized in Fig. 1. The sampling was replicated over one week by collecting samples at the same production sites. For all factories, it was known that the same olive cultivar (Ayvalık) was being processed. All chemicals used for the analysis of the samples were of analytical grade and purchased from Sigma Chem. Co. (St. Louis, MO, USA) and Merck Co. (Darmstadt, Germany) companies.

Physico-Chemical Analysis

Free fatty acid of the oil samples were determined following AOCS method Ca 5a-40 (6). Smoke points of the samples were measured following AOCS method Cc 9a-48 (6). Total phenolic compounds were extracted from oil samples twice using water: methanol (60:40 v/v) mixture and total phenolic content of oils were determined by the Folin-Ciocalteu technique according to Spanos and Wrolstad (7). Total phenolic values were calculated as mg gallic acid per kilogram of oil. The antioxidant capacities of oils were evaluated according to Rice-Evans et al. (8). Total antioxidant capacity was expressed by the Trolox equivalent antioxidant capacity (TEAC) defined as the mmol Trolox/kg of oil.

Bitterness Measurement

The bitterness values of the samples were measured by the following sensory technique. There were seven voluntary panelists (2 females and 5 males, aged between 20-30 years) trained for at least three sessions during 3 days for a total of 6 h/day. Sensory evaluation of olive oil bitterness was developed from the sensory evaluation guide of the International Olive Oil Council (IOOC) (9). The olive oil samples were placed in special glasses having a round bottom and thinner head closed with a metal lid. The three-digit coded glasses were filled to 3/4 level with the olive oil samples and heated in a water bath around 28±2 °C, and evaluated by the panel immediately. Duplicate samples were served in different sessions in a randomized order. The scale was a 10 cm non-structured scale, in which the previous panel educations were carried out with 0.05% caffeine solution. The intensity of bitterness is expressed as the mean score of the panelists.

Instrumental Analysis

Instrumental color values (L, a* and b*) of the samples were measured by a Minolta Camera CR-200 (Minolta Camera Co., Osaka, Japan) (3). Turbidity was measured at 25 °C using a Micro T100 Lab Turbidimeter (HF Scientific Inc, US) according to the instructions of the instrument.

Statistical Analysis

There were three replicates of analyses for the physicochemical and sensory parameters. All data were evaluated using the statistical program SPSS (ver. 18). Multidimensional Scaling (MDS) and correlation analysis were used to describe the relationship between the measured properties in samples (10).

RESULTS AND DISCUSSION

Turbidity of oils at the final point (exit of centrifuge) in the three production systems ranged from 3.62 to 2966.5 NTU (Table 1). The highest turbidity values were in the samples collected at the triple-phase decanter exit and the pressing system press exit (+ 7500 NTU).

On the other hand, the lowest turbidity value was in the centrifuge exit (D1) of the dual-phase system. The turbidity of oils from classical pressing system was in general higher than that from modern centrifugation systems. These differences might be directly related to processing conditions of the olive oils. A possible explanation for this might be that oil from classical system contains much more sediment. In modern processing systems there is at least one decantation and/or centrifugation operation in which the suspended particles can be easily separated by the force applied. Also, in classical pressing system, the pressure force, amount of added water, longer extraction time and increased temperature may

Table 1. Physical parameters (Mean±Sd) of olive oils produced within different production systems

Production Place	Sampling Point[a]	Turbidity (NTU)	L	a*	b*	Smoke Point (°C)
Pıtıreli	T3	362±8.00	48.11±0.65	1.57±0.16	2.33±0.01	175
Pıtıreli	T2	+ 7500	43.49±0.65	2.93±0	-5.31±0.12	84
Ahmetçeli	T3	988±15.00	43.55±0.02	2.71±0.03	-4.82±0.03	179
Ahmetçeli	T2	3828±2.00	43.41±0	2.75±0.03	-5.40±0.01	133
Ahmetçeli	T1	222.50± 16.50	48.16±0.07	1.16±0.01	3.00±0.10	189
Zeytinli	T3	143.50±5.50	44.94±0.23	2.20±0.07	-2.66±0.22	193
Zeytinli	T2	1867±28.00	43.52±0.31	2.55±0.55	-5.35±0.02	127
Zeytinli	T1	363±10.00	43.78±0.43	2.31±0.01	-3.56±0.06	189
Ayvacık	P3	2966.50±83.50	44.59±0.34	2.65±0.04	-5.05±0.15	179
Ayvacık	P2	+7500	43.29±0.50	3.09±0.14	-3.95±0.17	80
Ayvacık	P1	4009±9.00	43.33±0.10	2.69±0.03	-5.34±0.11	192
Gökçeada	D1	3.62±0.01	47.29±0.29	0.36±0.06	10.39±0.30	178

[a]The sampling points of olive oil within each production systems are shown in Fig.1. Sd: Standard deviation T: triple-phase system; (T1): exit of malaxation, (T2): exit of decantation, (T3): exit of centrifugation, P: classical system; (P1): exit of malaxation, (P2): exit of pres, (P3): exit of centrifugation and D: dual-phase system; (D1): exit of centrifugation.

yield more suspended materials in the oil phase. In a recent study (11), the relationship between olive oil turbidity and color was investigated. It was shown that oils having deep green color with more transparency and saturation contain higher amounts of filtered oil, while yellowish, darker and less saturated oils are composed of more turbid oils. Although VOO turbidity is not a sensory definition term in IOOC (9) standard, it has been reported that oil appearance is an important factor in the consumer perception (5). In Turkey, VOO are filtered or naturally settled to remove solid suspended materials in the fresh oils for international and national markets. On the other hand, for some special consumer demands, fresh oils are sold in turbid state, especially for some restaurants and boutique sellers. The quality of VOO samples collected from different points of a production line and bottled for sale has been reported (12). These reported products are usually very turbid, have a bold flavor and believed to promote health.

Instrumental color values of the samples are shown in Table 1. Luminosity (L) values of the samples were between 43.29 and 48.16, and were not significantly different. Interestingly, there was no relationship between L value and turbidity measures. The values of a* (-green/+red) ranged from 0.34 to 3.09. As oil processing proceeds, the a* value usually decreases. On the other hand, b* values (-blue/+yellow) of the samples ranged from -5.40 to 10.39. These results show that b* values of samples from exit of dual-phase centrifugation system and last season oils were higher than that from new season classical and triple phase oils. In a previous study (11), the turbidity values of VOO samples were found to have univariate correlations with instrumental color parameters, especially with chroma and hue values.

Smoke point is an important parameter when oil is intended to be used in frying or other high temperature cooking processes (13). There was a significant negative correlation between turbidity and smoke point values of the samples ($r=-0.70$; $p=0.001$). This means that when a VOO sample includes larger amounts of solid suspended materials, its smoke point decreases. Hence, fresh turbid olive oils should not be used in frying process, instead refined olive oils or at least filtered virgin olive oils would be better if used as frying oil.

Some chemical parameters and sensory bitterness value of the VOO samples are shown in Table 2. Total antioxidant capacities of the oil samples ranged between 0.08-1.40 mmol trolox/kg oil (TEAC). The total antioxidant capacity of the samples collected at the end-point of pressure system (P3) was greater than that of the samples collected from the triple-phase system and clearly

Table 2. Chemical parameters (Mean±Sd) of olive oils produced within different production systems

Production Place	Sampling Point	TEAC (mmol Trolox/kg)	Total Phenolics (mg GA / kg oil)	Free Fatty Acid (% Oleic acid)	Bitterness
Pıtıreli	T3	0.16	15.35±2.24	1.42±0.10	0.42±0.13
Pıtıreli	T2	1.40	227.13±2.94	1.64±0.17	0.92±0.20
Ahmetçeli	T3	0.13	32.39±1.87	1.45±0.01	0.70±0.32
Ahmetçeli	T2	0.48	84.54±3.87	0.92±0.03	0.79±0.25
Ahmetçeli	T1	0.27	57.44±1.53	0.83±0.04	0.79±0.33
Zeytinli	T3	0.08	18.14±0.97	0.79±0.03	0.83±0.19
Zeytinli	T2	0.22	33.88±7.82	1.16±0.55	0.80±0.24
Zeytinli	T1	0.19	24.79±1.95	0.57±0.07	0.88±0.21
Ayvacık	P3	0.49	107.55±3.19	0.73±0.01	0.63±0.21
Ayvacık	P2	0.56	819.6±15.48	0.85±0.03	1.92±0.20
Ayvacık	P1	0.79	134.32±5.12	1.12±0.00	0.93±0.43
Gökçeada	D1	0.67	94.47±4.19	1.30±0.02	1.08±0.26

T: triple-phase system; (T1): exit of malaxation, (T2): exit of decantation, (T3): exit of centrifugation, P: classical system; (P1): exit of malaxation, (P2): exit of pres, (P3): exit of centrifugation and D: dual-phase system; (D1): exit of centrifugation.

lower than that of the dual-phase system. The highest antioxidant capacity value was in the decanter exit sample (T2), and the lowest was in the centrifuge exit sample (T3) of the triple phase production system. Therefore, it can be said that more processing causes some loss of the activity. The highest total phenolic contents (819.6 mg GA/kg oil) were measured in samples from the exit of the press (P2), while the lowest (15.35 mg GA/kg oil) was in the samples from the centrifuge exit (T3) of the triple-phase system. These results also indicate the aforementioned trend that further processing of olive can cause some loss of phenolic compounds. It can be explained that water soluble fractions of phenolic compounds might get lost together with added water. Total phenolic content of oils from classical pressure system was generally higher than that from modern system oils. Similar results were reported in literature (14) indicating that pressure system yields higher phenolics than three-phase centrifugation system.

The mean bitterness scores are also shown in Table 2. It is indicated that bitterness is one of the very important sensory characteristics of VOO, and valued as a positive attribute in sensory evaluations (5, 9). Bitterness scores of the dual-phase extraction system samples were usually higher than that of the triple-phase and pressure extractions systems. The highest bitterness score was in the press exit of Ayvacık sample (P2). This sample also had the highest total phenolics content, indicating that the two parameters are somewhat related. The previous finding of Salvador et al (2) supports our findings.

Free fatty acid is the most important parameter in VOO classifications almost in all producing countries. In general, there were no definite patterns of change in the free acidity values within both production systems and different sites of sampling in each system.

The relationship of all measured parameters in the VOO samples is shown in Fig. 2. There is a distinct group of bitterness, total phenolics and turbidity values. Although the TEAC value is close to this group, it was not placed in the same dimensions. On the other hand, smoke point located as a very separate parameter, opposite of the defined group. This means that when a VOO sample contains larger amounts of suspended particles (indicated by higher turbidity), it might have higher values of total phenolics and antioxidant capacity, but cannot be a good candidate for frying operations due to the decreased smoke point. From this MDS map it can be concluded that VOO bitterness and total phenolics are closely related parameters. In a previous study (15) conducted in our laboratory, close relationship of bitterness and total phenolic content was revealed.

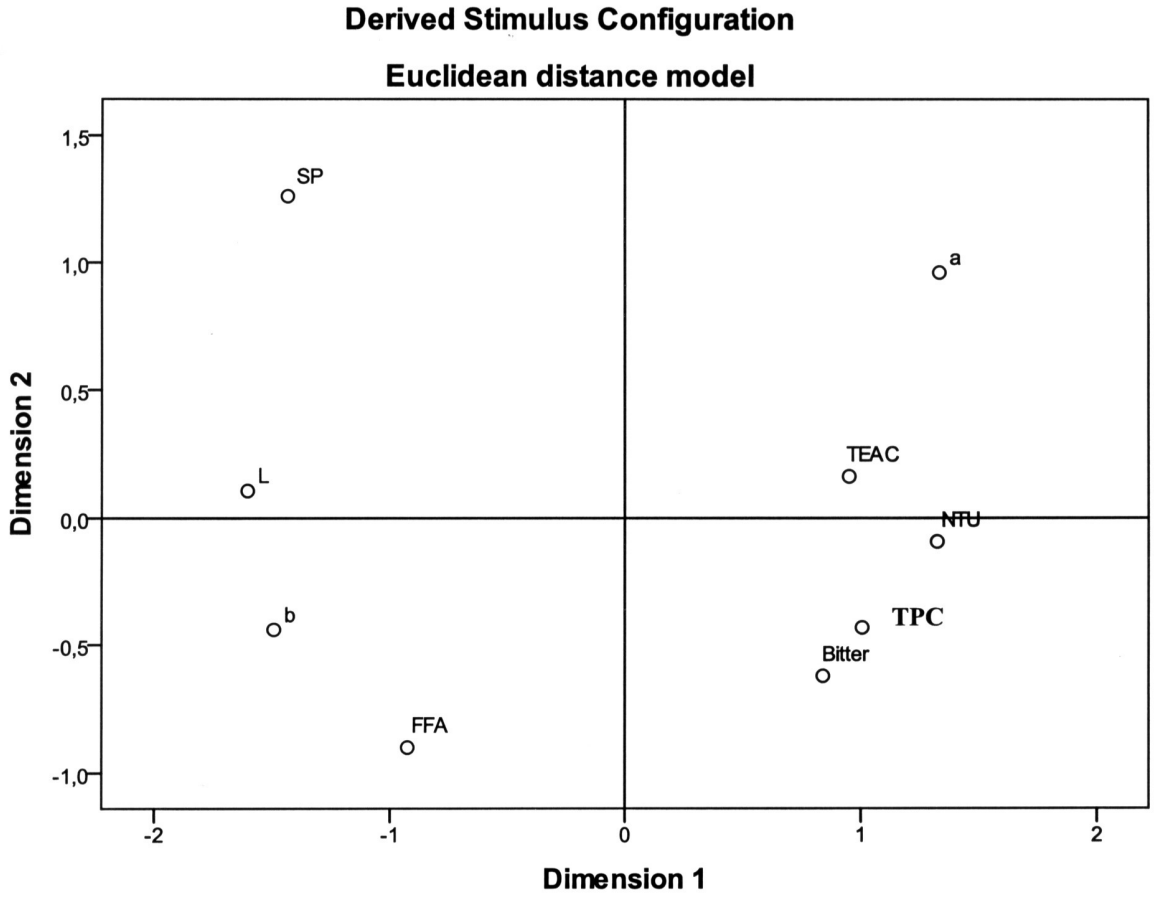

Fig. 2 MDS results of analytical parameters and bitterness value of all virgin olive oil samples (Stress:0.14; R^2:0.90). (SP: smoke point, FFA: free fatty acid, NTU: turbidity value, TPC; total phenolic contents, TEAC: antioxidant capacity, L: L value, b:b* value, a:a* value and Bitter: bitterness score).

CONCLUSION

Some physico-chemical differences exist between the VOO samples produced both in different systems and in different points of the same production system. Usually, turbidity and total phenolic values were higher in classical pressure system oils, while antioxidant capacity and bitterness values were higher in dual-phase centrifugation system oils. In general, VOO samples collected at the malaxer exit and decanter exit had higher levels of total phenolics, bitterness value and turbidity than centrifuge exit counterparts. In fact, this study has shown that due to higher level of phenolics and antioxidant capacity found in those samples, some health benefits through consumption of such VOO can be possible. Once again, it was shown that VOO bitterness, turbidity and total phenolics content are much related properties.

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