Characterization of almond oils and cakes, obtained from broken almonds discarded by sorting during shells' cracking process for almond kernels separation

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INTRODUCTION

In eastern Morocco, almond tree constitute an important socio-economic and ecologic role. The production of almond kernel has increased continually, from 136 000 T in 2012 to 183000 T in 2015. Farmers organize themselves into cooperatives, some of which are now equipped with almond cracking and shelling machine. Undamaged almond are separated from shell fragments. Partly damaged or broken almonds are sorted and collected to be used for almond oil's extraction in order to give them the best commercial added value. This work focuses on the chemical characterization of cakes and almond oils extracted from broken almonds (a co product of almonds sorting) of the main varieties (*Marcona (M), Fournat (FN), Ferragnes/Ferraduel (FF) and Beldi ecotype (B)*) cultivated in this region.

MATERIAL AND METHODS

- Samples of sweet Almonds (Crop years 2015/2016) of five varieties were collected from "Sidi Bouhria" region in eastern Morocco;
- Extraction of almond Oil (AO) was realized by screw press (Komet, model DD85G, Germany) at PRODIGIA Company, Casablanca;
- Almond oil yield was calculated from the difference between broken almonds gross weight and Almond oil weight extracted by the screw press (extruder);
- Total sugars content was determined according to Bertrand's Method. A deproteneization was done before determination of sugars by using Carrez I and II solutions. The Bertrand I and II solutions were used for the revelation and the titration was done by potassium permanganate;
- Total proteins was calculated from determination of total nitrogen by Kjeldahl method and using 6,25 as conversion factor;
- Total dietary fibers was estimated by enzymatic method witch amylase, protease and amyloglucosidase were used successively. The obtained solution was precipitated by ethanol and filtered;
- Ashes content , was determined by AFNOR method in a Furnace Muffle at 550°C for 16 hours;
- Almond oil analysis:
  - Fatty acid (FA) profile: FAs were analyzed by a GC System chromatograph (a HP 5880 A series), equipped with a capillary column (25m x 0.25mm x 0.26µm) and a FID detector;
  - Triglycerides was determined by HPLC system equipped with a C18 reversed- phase column (ODS C18: 250× 5mm, 5µm) and using a mobile phase consisted of acetone/acetonitile (60/40; V/V);
  - Minor component mainly tocopherols was analyzed by a HPLC system with fluorescence detector excitation at 298, emission at 325 nm and using a mixture of n-hexane / iso-propanol (99/1 : v / v) as mobile phase;
  - Almond oils' phenols content, was determined by the Folin method in the methanolic fraction, expressed as mg of Caffeic acid/kg of oil.

A: Almond

B: Almond oil extraction

C: Almond cake

RESULTS AND DISCUSSION

- Oleic acid was the mean fatty acid in almond oil followed by linoleic acid. The most dominant tocopherol in almond oil was α- tocopherol followed by γ and β- tocopherols;
- Quantitative importance of triglycerides in almond oil is as follows : OOO > OOL> LLO>POO > LLS+POL > POP > LLL > LPL > SOO;
- From the obtained results, wide variations between varieties was observed for the analyzed parameters such us oil content, oleic acid linoleic acid, OOO content and tocopherols. This variation is due to genetic characteristics of the varieties, the maturity stage of the fruit and the physiological factor;
- Defatted almond cake contain 35 to 39 % of dietary fibers and 44 to 48 % of proteins. The ashes are in minority and change from 4 to 6 of 100 g of defatted almond cake.

Table 1. Oil content of analyzed almond samples and their correspondent fatty acids profiles

Samples	Oil content %*	C16:0	C18:0	C18:1*	C18:2*	SFA	MUFA*	PUFA*	O/L ratio
M	39..55 ± 4.75	8.40 ± 0.99	3.23 ± 0.23	57.54 ± 0.13	29.81 ± 1.31	11.63	57.54	29.81	1.93
FN	45..22 ± 1.5	8.10 ± 0.02	3.20 ± 0.01	58.50 ± 0.04	29.10 ± 0.01	11.30	58.50	29.10	2.01
FF	49. 85 ± 3.88	7.23 ± 0.49	2.35 ± 0.12	70.33 ± 2.15	19.45 ± 0.1	9.60	70.33	19.45	3.62
B	49. .36 ± 2.56	8.24 ± 0.77	2.24 ± 0.202	62.09 ± 0.93	26.76 ± 1.3	10.50	62.10	26.80	2.32

C16:0: Palmitic acid; C18:0 Stearic acid; C18:1: Oleic acid; C18:2: Linoleic acid; SFA: Saturated fatty acids; MUFA: Mono Unsaturated Fatty Acids; PUFA: Poly Unsaturated Fatty Acids; O/L: Oleic acid / Linoleic acid ratio

Table 2. Triglyceride profile of the analyzed almond oil samples

Samples	LLL	LLO	LPL	OOL	LLS+POL	OOO*	POO	POP	SOO
M	3.62 ± 0.01	16.73 ± 0.30	3.35 ± 0.08	24.95 ± 0.03	11.4 ± 0.35	23.24 ± 0.13	11.53 ± 0.22	2.52 ± 0.091	1.05 ± 0.05
FN	1.98 ± 0.0	11.90 ± 0.01	2.14 ± 0.1	21.41 ± 0.50	8.52 ± 0.25	37.17 ± 1.25	11.80 ± 0.3c	3.25 ± 0.53	1.30 ± 0.5
FF	2.73 ± 0.13	13.84 ± 0.31	2.30 ± 0.1	24.27 ± 0.15	10.20 ± 0.6	31.85 ± 0.25	10.62 ± 0.55	2.31 ± 0.5	0.75 ± 0.08
B	1.88 ± 0.2	11.93 ± 0.1	2.04 ± 0.07	23.50 ± 0.21	9.10 ± 0.2	36.27 ± 0.40	10.93 ± 0.23	2.26 ± 0.23	0.97 ± 0.15

Table 3. Tocopherol profile and total phenols content of the analyzed almond oil samples

Samples	α- tocopherols* (mg/kg)	β- tocopherols (mg/kg)	γ – tocopherols (mg/kg)	δ- tocopherols (mg/kg)	Total tocopherols (mg/kg)	Total polyphenols (mg/kg)[a]
M	233.20 ± 3.3	3.66 ± 0.4	5.50 ± 0.1	ND	242.36	220.15 ± 30.41
FN	265.50 ± 5.32	1.36 ± 0.05	2.25 ± 0.1	ND	269.11	99.60 ± 12.97
FF	332.24 ± 0.92	2.96 ± 0.13	4.35 ± 0.1	ND	339.55	148.64 ± 20.51
B	231.24 ± 4.3	4.47 ± 0.02	1.63 ± 0.03	ND	237.34	180.29 ± 5.32

[a] Determined by the Folin method in the methanolic fraction, expressed as mg of Caffeic acid/kg of oil.

Table 4. Chemical composition of defatted almond cake

Samples	Dry mater %	Proteins %	Carbohydrates %	Dietary fibers %	Ashes %
M	93,55 ± 6,44	44,17 ± 1,05	15,02±1,836	35,27 ± 2,41	4,75 ± 0,01
FN	91,78 ± 8,22	44,09 ± 0,12	19,21±0,55	39,26 ± 0,19	7,25 ± 0,03
FF	90,74 ± 9,26	48,48 ± 1,13	15,29±0,63	34,50 ± 0,55	5,883 ± 0,05
B	91,85 ± 8,15	44,04 ± 0,26	17,48±0,97	35,05 ± 2,38	6,14 ± 0,12

* Significant variations

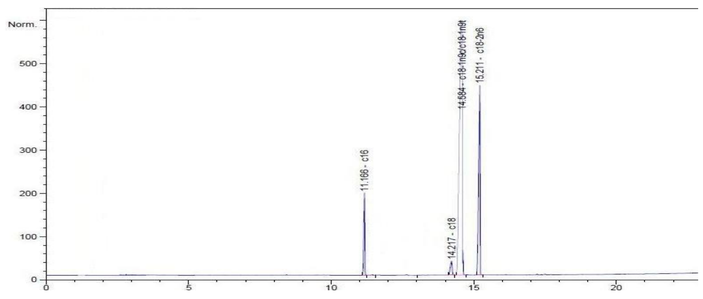

Figure 1. Example of Fatty acid profile of *Marcona's* almond oil

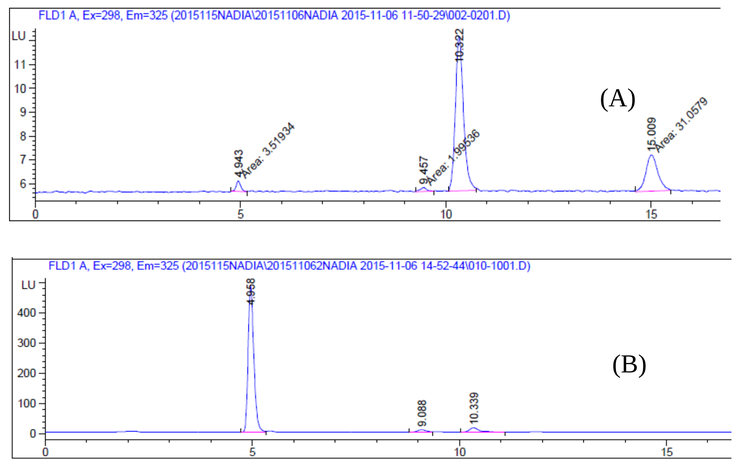

Figure 2. Tocopherols chromatograms
(A): Standard composed from four tocopherols (α, β, γ and δ);
(B): Example of tocopherol profile of *Marcona's* almond oil

CONCLUSION

This study was focused on evaluating the chemical composition of defatted almond cakes and almond oils produced in eastern Morocco.

Lipids are the main components of almond kernel , followed by proteins, fibers sugars and ashes . The lipid portion and the protein fraction are a major determinant of kernel flavor. Consumption of relatively small amounts of defatted almond cake can have positive effect on satiety because of the co-presence of dietary fiber and proteins.