Chemical changes in the composition of roasted kernels of Moroccan almonds

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Abstract. The present work aims at determining the changes in the chemical components of almond kernels after roasting in pan with sand at during 25 min, as done in Northern Morocco. After roasting, oil content varied between 56% and 58.8%, protein content between 18.24% and 23.27%, and sugar content between 5.47% and 6.84%. These results show that the kernels maintain their nutritional value after roasting. Fatty acid composition was affected, with significant decreases in the percentage of palmitoleic, oleic and linoleic acids. The ratio of oleic to linoleic acids, a good index of resistance to rancidity, also decreased after roasting, although it was still similar to that of raw kernels of some commercial cultivars. The amount of the different tocopherol homologues was altered after roasting: α-tocopherol decreased, mainly in 'Beldi', characterised by low values before roasting, whereas in 'Marcona', with higher tocopherol concentration, the decrease was not so drastic. On the other side, γ-tocopherol increased in all samples after roasting. These results clearly show that the fatty acid profile and the tocopherol concentration are affected, but not drastically, by this roasting method. As a consequence, the quality of these roasted kernels is not significantly altered as compared to the raw kernels.

Keywords. *Prunus amygdalus* Batsch – Almond – Roasting – Fatty acids – Tocopherol.

Changement de la composition chimique des amandons grillés d'amandier au Maroc

Résumé. *L'objective de ce travail est la détermination des changements dans la composition chimique des amandons après grillage dans des poêles avec sable à une température de 80°C pendant 25 min, technique adoptée au Nord du Maroc. Après le grillage, le content en huile a varié entre 56% et 58,8%, le contenu en protéine entre 18,24% et 23,27%, et le taux de sucre entre 5,47% et 6,84%. Ces résultats montrent que les amandons maintiennent leur valeur nutritionnelle après le grillage. La composition en acides gras a été affectée, avec une diminution significative dans les pourcentages des acides palmitoléïque, oléïque et linoléïque. La relation entre les acides oléïque et linoléïque, un indice utilisé pour évaluer la résistance de l'amandon à la rancidité, a aussi diminué après le grillage, même si il reste comparable à l'indice trouvé dans les amandons de quelques cultivars commerciaux. Le grillage a aussi altéré la quantité des différents homologues de tocophérol: l'α-tocophérol a été diminué, surtout pour le type 'Beldi', caractérisé par des valeurs faibles avant le grillage, tandis que pour 'Marcona', avec des concentrations de tocophérol plus élevées, la diminution n'a pas été si drastique. En outre,le γ-tocophérol a augmenté dans tous les échantillons après le grillage. Ces résultats montrent clairement que le profile des acides gras et la concentration des tocophérols est affecté par l'opération du grillage utilisée au Nord du Maroc, mais pas drastiquement. Par conséquent, la qualité de ces amandons grillés n'est pas significativement affectée en comparaison aux amandons non grillés*

Mots-clés. Prunus amygdalus *Batsch – Amandier – Grillage – Acides gras – Tocophérol.*

I – Introduction

In Morocco, almond is grown in several regions from north to south, under different environmental conditions, mostly on non-irrigated areas of poor soils and receiving little attention from farmers. Almost all almond production in Morocco is provided by a traditional production sector, characterized by a dominance of almond trees propagated by seed, located primarily in the north and the south. Almost all production is commercialized directly by farmers in local markets at low prices. Kernels produced by almond seedling in the North of Morocco is characterized by high protein content, ranging from 21 to 27% of kernel DM, and oil content from 55 to 58% of kernel DM (Kodad *et al*., 2011). Almonds are marketed in different commercial forms: in-shell almonds, shelled kernels, blanched, roasted or not. In Northern Morocco, the local farmers roast almond in a pan with sand. This method could alter the flavor and cause product rancidity. Roasting promotes different changes in the kernels, mainly for the volatile compounds (Gou *et al*., 2000). Consequently, our aim was to study the chemical composition of raw and roasted almond kernels as done in Northern Morocco in order to evaluate the potential changes during the roasting process.

II – Materials and methods

This study was carried out in the Rif Mountains (North of Morocco). The samples were collected from local genotypes named 'Beldi' and from cultivars 'Marcona' and 'Ferragnès'. The nuts were collected in summer of 2012. Before processing, the mesocarp was removed and the nuts were dried and stored at ambient temperature during three weeks. A sample of 30 kernels was collected and the remaining kernels were roasted traditionally, without any additives, in pan with sand at 80°C during 25 min. After roasting, two independent samples, two replicates for each sample, were randomly taken for analysis. Kernels were ground in an electrical grinder.

For kernel composition, protein, oil and total sugar content, as well as fatty acid and tocopherol composition were determined as already described (Kodad *et al*., 2011).

III – Results and discussion

The oil, protein and sugar contents of roasted kernel varied significantly among samples (Table 1). Oil content varied from 59.8% DM in 'Marcona'" to 56.2% DM in 'Beldi', whereas protein content was higher in 'Beldi' (23.7% DM) and lower in 'Ferragnès'. Sugar content was higher in 'Ferragnès' and lower in 'Beldi'. These results do not differ from those reported for 'Marcona' and 'Ferragnès' raw kernel (Kodad *et al*., 2011), clearly showing that roasted kernels maintain their nutritional quality after roasting.

Table 1. Chemical components of roasted almond kernels

Sample	Sugar content (% Glucose)	Protein content (% DM)	Oil content (% DM)
'Beldi'	5.47 b	23.27 a	56.2 b
'Marcona'	5.99 b	21.31 a	59.39 a
'Ferragnès'	6.84 a	18.24 b	58.84 a

Mean values of each component followed by different letters are significantly different between samples at $P < 0.05$.

Almost all studied variables showed significant differences among samples, probably due to their different genetic origin. Since unsaturated fatty acids are prone to oxidation during heat processing, the study of the fatty acid composition and their changes during roasting is relevant. The treatment effect was significant for all fatty acids with the exception of palmitoleic acid (Table 2). Oleic acid percentage decreased significantly after roasting whereas palmitic, stearic and linoleic acids increased (Table 3).

Table 2. Mean value of oleic and linoleic fatty acids of raw and roasted almond kernels

	Raw kernels		Roasted kernels	
Sample	**Oleic ac.**	**Linoleic ac.**	**Oleic ac.**	**Linoleic ac.**
'Beldi'	74.22 a	15,89 a	73.3 a	16.14 a
'Ferragnès'	73.97 a	16.40 b	68.01 b	22.2 a
'Marcona'	73.05 a	17.01 b	69.86 b	20.48 a

Mean values of each component followed by different letters are significantly different between treatments at $P < 0.05$.

Table 3. Mean values of fatty acids and tocopherol homologues of raw and roasted kernels

	Treatment	
Component	**Raw kernel**	**Roasted kernel**
Palmitic acid (% of total oil)	6.30 a	6.74 b
Palmitoleic acid (% of total oil)	0.65 a	0.62a
Stearic acid (% of total oil)	1.54 a	2.03 b
Oleic acid (% of total oil)	73.7 a	70.39 b
Linoleic acid (% of total oil)	16.43 a	19.60 b
Oleic acid/Linoleic acid ratio	4.49 a	3.59 b
Linolenic acid (% of total oil)	0.019 a	0.03 a
α-tocopherol (mg/kg oil)	398.8 a	277.78 b
γ-tocopherol (mg/kg oil)	9.64 b	17.41 a
δ-tocopherol (mg/kg oil)	0.52 b	3.17 a

Mean values of each component followed by different letters are significantly different between treatments at $P < 0.05$.

The ratio of oleic to linoleic acid (O/L) is used as an index of resistance to oil rancidity (Kester *et al*., 1993), with high ratios being preferable (Socias i Company *et al*., 2008). This ratio decreased after roasting (Table 3), although its value is still similar to some commercial cultivars (Kodad *et al*., 2011). The percentage of linolenic acid is considered low, even if it increased slightly after roasting. Linoleic acid, an essential fatty acid, is reported to be useful for reducing the risk of diabetes and cardiovascular disease (Venkatchalam *et al*., 2004).

The percentage of oleic acid decreased significantly after roasting in 'Ferragnès' and 'Marcona' (Table 2), whereas in 'Beldi' the differences between raw and roasted kernels were not significant, not detecting changes in the flavour of the kernels before and after roasting. Therefore, the roasting method used in this traditional processing does not drastically affect the fatty acid composition and quality of the almond kernels.

Table 4. Means values of tocopherol homologues in raw and roasted kernels

	δ-tocopherol (mg/kg oil)		γ-tocopherol (mg/kg oil)		α-tocopherol (mg/kg oil)	
	Raw kernel	**Roasted kernel**	**Raw kernel**	**Roasted kernel**	**Raw kernel**	**Roasted kernel**
'Beldi'	0.74 b	3.60 a	10.58 b	13.23 a	358.42 a	161.33 b
'Ferragnès'	0.41 b	1.65 a	6.08 b	17.74 a	413.11 a	302.01 b
'Marcona'	0.44 b	3.76 a	8.28 b	21.22 a	485.02 a	363.88 b

Mean values of each component followed by different letters are significantly different between treatment at $P < 0.05$.

The tocopherol concentration was significantly affected by the roasting process, with a significant decrease for α-tocopherol (Table 3). Garcia-Pascual *et al.* (2003) studied the effect of storage time of raw and roasted kernels of four almond cultivars reporting that α-tocopherol decreased significantly in roasted kernels and with storage time. On the contrary, γ-tocopherol increased after roasting (Table 4). Lane *et al*. (1997) suggested that a significant amount of the vitamin E homologues are bound to proteins or linked to phosphate or phospholipids. Heat breaks these bonds, resulting in an increase of extractable tocopherols. This phenomenon could explain the increase of this homologue in the roasted almond kernels.

The analysis of variance showed that the sample effect was significant for all tocopherol homologues (Table 3). 'Marcona' showed the highest concentration of α-tocopherol and 'Beldi' the lowest values (Table 4). Moreover, the decrease of α-tocopherol was drastic in 'Beldi', as opposite to 'Marcona'. It has been reported that α-tocopherol has ten times higher biological activity than γ-tocopherol in almond (Zacheo *et al*., 2000). Thus, the presence of a high concentration of α-tocopherol in almond oil is of primary importance because its levels declined slightly two years after harvest, to approx. 90% of the initial concentration (Zacheo *et al*., 2000). Our results confirm that α-tocopherol plays an important role in the protection of almond kernels against oxidation. A high level of this isomer is suitable not only to prolong the storage period without quality losses (Senesi *et al*., 1996), but also to maintain high nutritional value and to maintain the quality of the kernel after roasting.

As a conclusion, the roasting treatment affected the fatty acid composition and the tocopherol concentration of almond kernels. However, since the decrease of α-tocopherol was lower in 'Marcona', this cultivar is mostly suitable to roasting with this traditional method because it maintains relatively high levels of tocopherol homologues, which protect almond kernel against oxidation.

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References

Garcıa-Pascual P., Mateos M., Carbonell V. and Salazar D.M., 2003. Influence of storage conditions on the quality of shelled and roasted almonds. In: *Biosystems Engineering*, 84, p. 201-209.

Gou P., Dıaz I., Guerrero L., Valero A., Arnau J. and Romero A., 2000. Physico-chemical and sensory property changes in almonds of Desmayo Largueta variety during roasting. In: *Food Science and Technology International*, 6, p. 1-7.

Kester D.E., Cunningham S. and Kader A.A., 1993. Almonds. In: *Encyclopedia of food science, food technology and nutrition*. Academic Press, London, p. 121-126.

Kodad O., Alonso J.M., Espiau M.T, Estopañán G., Juan T. and Socias i Company R., 2011. Chemometric characterization of almond germplasm: compositional aspects involved in quality and breeding. In: *Journal of the American Society for Horticultural Science*, 136, p. 273-281.

Lane R.H., Quereshi A.A. and Salser W.A., 1997. Tocotrienols and tocotrienol-like compounds and methods for their use, U.S. Patent 5, 591, 772.

Senesi E., Rizzolo A., Colombo C. and Testoni A., 1996. Influence of pre-processing storage conditions on peeled almond quality. In: *Italian Jorunal of Food Science*, 8, p. 115-125.

Socias i Company R., Kodad O., Alonso J.M. and Gradziel T.M., 2008. Almond quality: a breeding perspective. In: *Horticultural Reviews*, 34, p. 197-238.

Venkatchalam S.R., Deokattey S.C. and Fulzele D.P., 2004. Soya: prophylactic and other health related benefits from its chemical components. *Indian Journal of Nutrition and Dietetics*, 41, p. 394-404.

Zacheo G., Cappello M.S., Gallo A., Santino A. and Cappello A.R., 2000. Changes associated with postharvest ageing in almond seeds In:. *Lebensmittel-Wissenschaft und Technologie*, 33, p. 415-423.