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Bioactive compounds, antioxidant activities, fatty acids, and sensorial characteristics of almond (*Prunus dulcis*) after roasting and blanching

THE QUESTION

Considering production area and consumer preference, almond is one of the major nuts worldwide, mainly due to the recognized health benefits provided by its ingestion. These benefits are related to fruit composition on bioactive compounds and fatty acids, which also impact sensorial characteristics. Almond is often eaten raw or after some processing procedures that can result in negative or positive changes in chemical and sensorial attributes. The present work was carried out to provide information on the effects of roasting and blanching on the contents of bioactive compounds, fatty acids in four neglected Portuguese almond cultivars (Casanova, Molar, Pegarinhos and Refêgo) in comparison with two foreign cultivars (Ferragnès and Glorieta), and their antioxidant activities.

THE STRATEGY

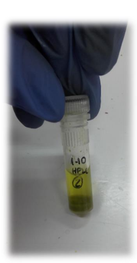
6 Samples

- Casanova
- Ferragnès
- Glorieta
- Molar
- Pegarinhos
- Refêgo

Raw samples with skin

Roasting conducted at 138 ◦C for 33 min

Kernels immersed in boiling water for 30,skins removed roasting at 138 ◦C



Panel of 12 tasters. Almond kernels were presented to the tasters in white pyrex dishes. Three tasting sessions were carried out; the first, second and third sessions were done using raw, roasted, and blanched almonds respectively. A Quantitative Descriptive Analysis (QDA) was performed using 20 descriptors and a structured scale from 1 (least intense) to 5 (most intense) for each descriptor.

An “antioxidant extract” was prepared by vortex-mixing 40 mg of the sample with 1 mL of 70 % methanol,heating for 30 min at 70 ◦C, and then centrifuged at 25,200 rcf for 15 min at 1 ◦C. The supernatant which constituted the “antioxidant extract” was filtered and used.

Preparation of methyl esters of the corresponding fatty acids (FAME).
Shimadzu GC-2010 Plus gas chromatograph (Shimadzu, Kyoto, Japan) flame ionization detector (FID-2010 Plus).
Peak separation on a DB-225MS capillary column (0.25 µm, 30 m×0.25mm i.d., Agilent Technologies,Wilmington, DE, U.S.A.)..

Room with controlled conditions

Sensorial Analysis

96-well microplate

Total phenolics and flavonoids
ABTS and DPPH

GC-FID

Fatty acid profile

Statistical analysis
Statistical Package for Social Sciences (SPSS) software, version 25.0 (IBM Corporation, New York, USA).
Comparison of averages performed using the Tukey test with a significance level of 5%.

THE OUTCOMES

Antioxidant activity and bioactive content

Raw extract show **highest ABTS** and **DPPH** activities for **Pegarinhos**, followed by **Casanova**.

Overall, the **lowest** antioxidant activities were recorded in **Refêgo**.

Positive correlations were found between the total **phenolic** content and **ABTS** (R^2=0.7057, y=50.67x + 1.7828) and between the total **phenolic** content and **DPPH** (R^2=0.7892, y=0.0298x – 0.0093).

The **total phenolic** content **ranged** from **0.048** in Glorieta to **0.189 mg** gallic acid equivalent (GAE)/g in Pegarinhos.

The **total flavonoid** content ranged from **0.35 in Pegarinhos to 1.86** mg catechin equivalents (CE)/g in Refêgo.

Table 1. Total phenolic and flavonoid content, and antioxidant activities of raw and processed almond kernels (mean f.w., n = 3). Different small letters in front of mean within a column indicate significant differences among cultivars for the same treatment. Different capital letters in front of mean within a row indicate significant differences among treatments for the same cultivar (p < 0.05, ANOVA Tukey’s test).

	Cultivar	Raw	Roasted	Blanched	*p* value
Phenolics (mg GAE/g FW)	Casanova	0.09B a,b	0.49A b	0.04B b	0.001
	Ferragnès	0.06B b	0.58A b	0.05B a,b	0.001
	Glorieta	0.05B b	1.33A a,b	0.01B c	0.000
	Molar	0.09B a,b	1.16A a,b	0.02C b,c	0.007
	Pegarinhos	0.19B a B	0.88A a,b	0.08C a	0.003
	Refêgo	0.02B b	2.66A a	0.01C c	0.013
	p value	0.002	0.019	0.023	
Flavonoids (mg CE/g FW)	Casanova	0.76A b,c	1.23A a	0.09B	0.002
	Ferragnès	0.59A c	0.85A a,b	0.16B	0.033
	Glorieta	0.77A b,c	0.62A a,b	0.08B	0.020
	Molar	1.38A a,b	0.58A b	0.06C	0.000
	Pegarinhos	0.35A c	0.44A b	0.14B	0.000
	Refêgo	1.86A a	0.53A b	0.11B	0.001
	p value	0.000	0.014	0.578	
DPPH (µg Trolox/g)	Casanova	4.02B b	9.48A b	0.48C a,b	0.000
	Ferragnès	2.82B c	12.96A a	0.42C b	0.001
	Glorieta	1.54B d	4.86A b	0.70C a	0.016
	Molar	3.37A b,c	4.51A b	0.49B a,b	0.016
	Pegarinhos	6.42A a	7.60A b	0.64B a	0.004
	Refêgo	1.01A d	0.33B c	0.01C c	0.000
	p value	0.000	0.000	0.014	
ABTS (µg Trolox/g)	Casanova	8.81B a,b	13.96A a	0.47C b	0.000
	Ferragnès	5.07B c,d	14.23A a	0.56C a,b	0.000
	Glorieta	2.51B d,e	8.92A b	0.44C b	0.000
	Molar	7.27A b,c	8.05A b	0.52B a,b	0.000
	Pegarinhos	11.59A a	11.14A a,b	0.68B a	0.000
	Refêgo	1.56A e	2.64A c	0.41B b	0.009
	p value	0.000	0.000	0.004	

Roasting increased antioxidant activities except for DPPH in Refêgo

Refêgo exhibited **lowest** antioxidant activities after **blanching and roasting**.

Blanching led to **large drops** in antioxidant activities.

Negative correlations in **roasted** samples for ABTS (R^2=0.708, y=−3.76362x + 14.27525) and DPPH (R^2=0.545, y=−2.48231x + 16.18607) with total phenolic content.

Higher levels of **phenolics** in **roasted** kernels relative to raw kernels

No effect of **roasting** on **flavonoid** content except for Molar and Refêgo.

In **blanched** almonds, the total **phenolic** and **flavonoid** content was generally **reduced.**

Fatty acid profile

Twenty three fatty acids were identified in the studied almond cultivars.

In **raw** kernels, **most abundant** fatty acids were **elaidic+oleic acids**, **linoleic+linolelaidic acids,** except for Refêgo, which had **α-linolenic acid** as the second abundant fatty acid.

Other major fatty acids were **α-linolenic** and **palmitic** acids.

Monounsaturated fatty acids (MUFA) values ranged from **65.58 % to 78.09** %. The content of **polyunsaturated fatty acids** (PUFA) ranged from **16.37 % in Molar to 23.81 %.**

Table 2. Contents of the main (most abundant and/or most affected) fatty acids in almond oil extracted from raw, roasted, and blanched kernels (%, mean, n = 3). Different small letters in front of mean within a row indicate significant differences among cultivars for the same treatment. Different capital letters in front of mean within a row indicate significant differences among treatments for the same cultivar (p < 0.05, ANOVA Tukey’s test). n.d.–not detected.

Cultivar	Casanova			Ferragnès			Glorieta			Molar			Pegarinhos			Refêgo		
	Raw	Roasted	Blanched	Raw	Roasted	Blanched	Raw	Roasted	Blanched	Raw	Roasted	Blanched	Raw	Roasted	Blanched	Raw	Roasted	Blanched
Palmitic	6.94A a	2.32B c	6.27A a	3.93A c	3.02AB c	2.71B c	2.92c	2.52c	2.96c	2.63B c	4.95A b	2.79B c	6.54A ab	2.14C c	3.57B bc	5.45B b	7.10A a	4.04C b
Stearic	0.132A a	n.d.	0.071B bc	n.d.	n.d.	0.36a	0.13a	n.d.	0.259ab	0.03B c	n.d.	0.33A a	0.11C b	0.17B a	0.23A ab	n.d.	0.09b	n.d.
Elaidic + Oleic	70.02A ab	34.05B d	68.26A a	61.51A c	48.28B b	45.97B c	77.03A a	40.86C c	54.11B b	65.08A bc	50.06B b	40.64C d	65.90A bc	26.87C e	42.67B cd	66.07B bc	82.19A a	52.17C b
Linoleic + Linolelaidic	13.54A ab	3.04B b	0.15C e	8.89A b	n.d.	1.05B a	10.34B ab	2.86C b	0.84A b	13.09A ab	0.36B c	0.54B cd	14.18A a	3.53B a	0.41C d	1.08A c	0.26C c	0.59B c
γ-Linolenic	0.17B	0.52A b	n.d.	0.104B	0.52B b	3.31A a	0.096C	0.75B a	2.31A b	0.08C	0.88B a	2.32A b	0.12C	0.48B b	1.66A c	n.d.	n.d.	0.943d
α-Linolenic	4.14C cd	33.89A b	18.89B b	4.99C bc	33.54A b	9.94B c	4.72B bc	32.73A b	6.18B cd	1.92B d	30.59A b	2.48B d	6.74C b	46.97A a	23.85B a	16.21A a	4.77B c	6.10B cd
Erucic	1.97B ab	5.64A a	2.25B d	2.72B a	3.62B b	7.34A b	0.98B cd	5.73A a	5.73A c	0.51C d	3.44B b	9.35A a	1.41C bc	4.29B ab	5.81C c	2.47B a	2.59B b	6.32A bc
Nervonic	0.71B d	5.58A a	0.73B c	4.26A a	4.77A ab	3.31C b	1.06C c	4.18B bc	6.22A a	0.47C d	3.36B c	5.52A a	1.20C c	3.70B bc	5.18A a	2.31B b	0.69C d	5.29A a

Stronger effect of **blanching** than of roasting.

After roasting, **major** fatty acid remained **elaidic + oleic acid**. The **second** most abundant was **α-linolenic acid**.

Elaidic + oleic and **α-linolenic** acid were also the **most abundant** fatty acids after **blanching** except for Molar.

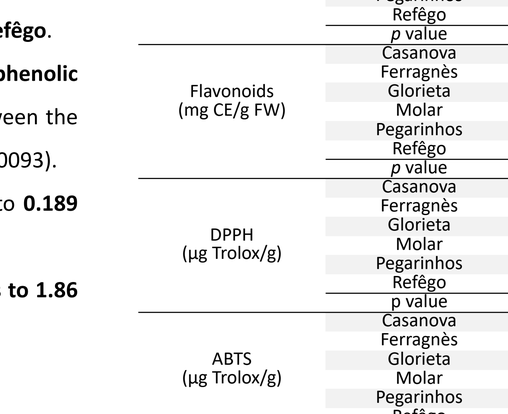
MUFA generally **decreased** after **roasting** and **blanching,** except Refêgo after roasting; the **inverse** was **true** for the **PUFA** content.

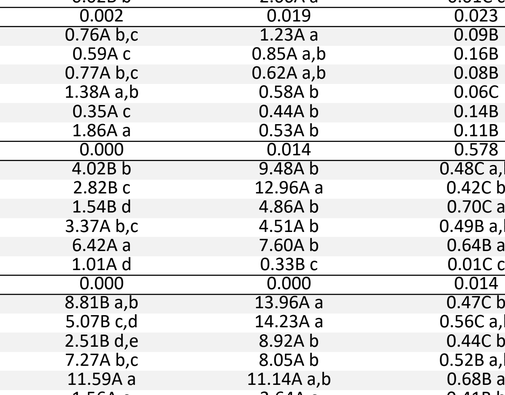
Sensorial Analysis

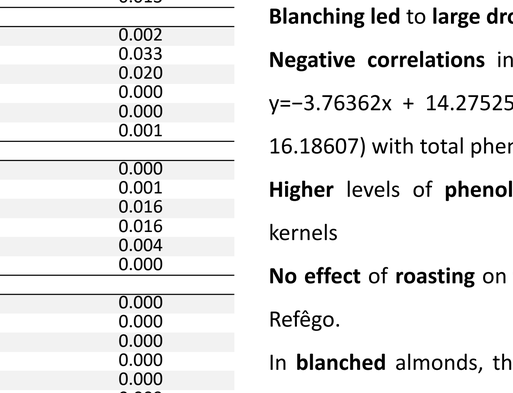
In raw samples (A) significant **differences** were observed relative to **skin color**, **bitter** almond **flavor** and bitter **taste**.

Skin **color** was found to be **darker** in the **foreign cultivars** (Glorieta and Ferragnès) than the Portuguese cultivars.

Bitter almond **flavor** and bitter **taste** were more associated with **Molar** and **Pegarinhos** than the rest of the cultivars.







After **roasting,** significant **differences** were observed in **skin color**, **bitter** almond **flavor**, **bitter taste**, **skin roughness**, and **sweet almond flavor** (B).

In **blanched** kernels (C), **differences** were only **recorded** for **textural** parameters, namely **first chew hardness** and **force to grind pieces**

CONCLUDING REMARKS

Antioxidant activities and bioactive compounds were generally enhanced following roasting but reduced after blanching. Both roasting and blanching led to significant changes in the fatty acid profiles of almonds. Very few significant differences in cultivars and treatments relative to sensorial characteristics were found. The findings of this study shed light on the nutritive and eating qualities of raw and processed kernels from neglected Portuguese almond cultivars, and highlight the potential use of these cultivars in various food industries.

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