HS-SPME GC/MS characterization of volatiles in raw and dry-roasted almond (*Prunus dulcis*)

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Xiao, L., J. Lee, G. Zhang, S.E. Ebeler, N. Wickramasinghe, J. Seiber, and A.E. Mitchell
University of California, Davis

Highlights

- Developed a method for ambient-temperature extraction and analysis of almond volatiles
- Volatile profiles of raw and dry-roasted (light, medium, dark roast) almonds were compared
- Most volatiles increased significantly upon roasting (at 138°C) and with roasting time
- Numerous volatiles not found in raw almonds were formed during roasting
- Benzaldehyde, the predominant raw-almond volatile, decreased significantly upon roasting

Summary

Volatile compounds are responsible for the flavor and aroma characteristics of foods. During roasting and other heat processes, additional volatiles are formed from reactions between food components. In roasted almonds a wide range of volatiles contribute to the typical and desirable roast flavor.

In this study, a method was developed to analyze the volatile profiles of raw and dry-roasted almonds. The method allowed for direct extraction and analysis of volatiles from finely ground almond samples at ambient temperature by headspace solid-phase microextraction (HS-SPME) and gas chromatography/mass spectrometry (GC/MS). The HS-SPME method is carried out at ambient temperature and is fast, simple, and does not require the use of solvents or a preliminary almond oil-extraction step.

Butte/Padre variety almonds were dry roasted at 138°C in a rotary roaster for specific times to achieve different degrees of roast: light (28 min), medium (33 min), and dark roast (33 min). Volatiles were analyzed immediately after roasting, and each volatile compound was quantified for almonds on a dry weight basis.

In raw almonds, a total of 41 volatiles were identified, including aldehydes, ketones, alcohols, a pyrazine, and other volatiles. Benzaldehyde was the predominant volatile present in the raw samples and is associated with a marzipan-like flavor. (Benzaldehyde is released from the enzymatic breakdown of amygdalin, the bitter compound that may be found in trace amounts in sweet almonds.) Roasting resulted in about a 90% decrease in benzaldehyde levels.

Roasting resulted in the formation of up to 17 new volatiles that were not found in the raw almonds. Many of these compounds are typically generated during the complex and well-known Maillard (non-enzymatic browning) reaction that occurs during roasting. Volatiles like pyrazines, furans, and pyrroles have been previously identified as key components of roasted almond aroma. Concentrations of many of these volatiles increased with roasting time.

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The following table (adapted from Xiao et al., Table 2) compares the concentrations of some of the major volatile compounds identified in the raw and roasted almonds samples.

Concentration of selected major volatiles in raw and roasted almonds

Volatile compounds	Volatile concentration (ng/g)[1]				% change[3]
	Raw almonds	Roasted almonds[2]			
		Light	Medium	Dark	
Aldehydes and ketones					
Benzaldehyde	2900	370	250	330	−89
Furfural	nd[4]	100	370	460	new
Hexanal	420	980	690	1100	122
3-hydroxybutanone	nd	2.2	3.0	3.8	new
2-methylbutanal	14	1500	5000	6600	30,216
3-methylbutanal	32	910	2900	4300	8,167
Alcohols					
Furfuryl alcohol	0.6	1.2	4.4	5.2	491
1-hexanol	47	53	42	70	17
3-pentanol	nd	0.8	2.4	2.7	new
Pyrazines					
2,5-dimethylpyrazine	11	16	53	67	298
2-methylpyrazine	nd	4.1	22	27	new
2-ethylpyrazine	nd	nd	2.6	3.2	new
Trimethylpyrazine	nd	nd	4.5	6.1	new
Others					
2-pentylfuran	2.4	17	25	30	905
Pyrrole	nd	0.6	2.7	2.1	new

[1] Table values represent rounded average concentrations without standard deviation.
[2] Almonds were roasted at 138°C for 28 min (light), 33 min (medium), or 38 min (dark).
[3] % change = (avg. conc. across roasting treatments – conc. in raw almonds)/(conc. in raw almonds) ×100.
[4] nd, not detected.