Acrylamide in Roasted Almonds

Introduction

Acrylamide is a chemical that forms in some carbohydrate-rich foods (e.g., potatoes, bakery products, cereals) during frying, roasting, and baking. In foods, most acrylamide is formed through a reaction between the free amino acid *asparagine* and the reducing sugars glucose and fructose. This reaction occurs mainly during the heating of food above 250°F (~120°C) in low moisture conditions and is part of the Maillard reaction (also known as non-enzymatic browning). Almonds contain free asparagine and reducing sugars, the precursors for acrylamide formation. Acrylamide can form in roasted almonds. Research has shown that acrylamide formation can be mitigated through optimization of roasting.[i,ii,iii]

Highlights

- *Acrylamide can form in roasted almonds, but is not found in raw almonds.*
- *Roasting temperature has much greater impact on acrylamide formation than roasting time. Roasting at a temperature below 265°F (130°C) will minimize acrylamide formation in roasted almonds.*
- *It is advisable to roast almonds at a lowest temperature possible for a light or medium-roasted product to minimize acrylamide formation.*
- *Estimated dietary exposures of acrylamide from roasted almonds are very low.*

ABC Research Findings on Acrylamide

Since 2003, the Almond Board of California (ABC) has funded several research projects investigating acrylamide levels in almonds. These projects have ranged from commercial product surveys, analyses of acrylamide precursors in almond varieties, and studies on how roasting temperature and time may influence acrylamide levels.

Research on acrylamide formation in almonds has focused on the effects of the dry (hot air) roasting process. The acrylamide content of roasted almonds is highly dependent on the process temperature. Several studies have clearly demonstrated that control of the roasting temperature is the critical factor in limiting acrylamide formation in roasted almonds. Roasting at a temperature of 310°F (154°C) or above will lead to an exponential increase in acrylamide. Dark roasted almonds have strong roasting flavor notes that are considered desirable for some applications, but depending on the roasting temperature used, the acrylamide content may be very high (>1000 ppb). Acrylamide contents increased as roasting time increased at a certain roasting temperature, but the rate of increase is considerably greater at the higher roasting

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temperatures. Roasting almonds at or below 265°F (129°C) to achieve light- or medium-roasted product will result in minimum acrylamide formation.

ABC also funded a project at the University of California, Davis, to survey acrylamide levels in commercially available roasted almonds.[iv] From a total of 132 samples of both dry and oil roasted almonds, the researchers reported a mean value of 178 ppb acrylamide. Out of 89 dry roasted samples (ten flavored or seasoned products from nine brands), an average acrylamide level of 169 ppb (range from 4 to 726 ppb) was detected. Three brands of light roasted and salted almonds from China had the lowest level of acrylamide, less than 30 ppb. A mean value of 194 ppb (range from 28 to 544 ppb) was found in 41 oil roasted samples.

Estimation of Acrylamide Exposure from Roasted Almonds

Based on a survey of over 43,000 food samples analyzed since 2010, the European Food Safety Authority (EFSA) estimated that the average dietary exposure to acrylamide is 0.3–1.9 micrograms per kilogram body weight per day (µg/kg bw per day) across various age groups.[v] (Nuts were not surveyed as a separate food category)

Commercial roasted almonds surveyed by various groups have found acrylamide levels of 4–749 ppb with a mean value of 178ppb [FDA, 2006; Health Canada, 2012; Mitchell & Zhang, 2012]. To obtain an estimate of dietary exposure to acrylamide from roasted almonds, the mean value (~180 µg/kg) and highest survey value obtained (~750 µg/kg) are used in calculations as follows for various scenarios:

Scenario I for the highest per capita almond consumption country: Per capita U.S. almond consumption is 1.81 lb/person/year = 2.25 g/day/person or 0.00225 kg/day/person[vi]. For an average American with a body weight of 65 kg (143lb), the daily acrylamide exposure from almond consumption would be: (1) at mean value: (0.00225 kg × 180 µg/kg)/(65 kg b.w.) = **0.006 µg/kg b.w.;** (2) at the highest level: (0.00225 kg × 750 µg/kg)/(65 kg b.w.) = **0.026 µg/kg b.w.** The exposure would be lower if roasted almonds made up only a part of the daily almond consumption.

Scenario II for habitual almond consumers: Based on NHANES (2001–2010), daily almond consumption for a habitual American consumer is 29.5 g or 0.0295 kg[vii]. For a consumer with a body weight of 65 kg (143lb), the daily acrylamide exposure from almonds would be: (1) at mean value level: (0.0295 kg × 180 µg/kg)/(65 kg b.w.) = **0.08 µg/kg b.w.;** (2) at highest level: (0.0295 kg × 750 µg/kg)/(65 kg b.w.) = **0.34 µg/kg b.w**. As habitual American consumers tend to eat mostly unroasted almonds, the actual acrylamide exposure from almonds would be lower.

Regulatory Status

Acrylamide at concentrations found in some foods is a concern because the chemical is known to cause cancer in laboratory animals and also may be a human carcinogen. Acrylamide is considered by food safety authorities to be an undesirable but inevitable consequence of

baking, frying or roasting starchy foods. International research is ongoing to better understand acrylamide formation in foods and to develop strategies to reduce the levels [EFSA, 2013]. These efforts aim to reduce the potential health risks associated with exposure to this chemical. The U.S. Food and Drug Administration (FDA) issued a draft guidance document on acrylamide in foods [FDA, 2013][viii]. This document states:

> "FDA is not suggesting maximum recommended levels for acrylamide at this time. We recommend that manufacturers be aware of acrylamide levels in their products, because knowledge of acrylamide levels is essential for determining the effectiveness of acrylamide reduction techniques."

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[i] Zhang, G., G. Huang, L. Xiao, J. Seiber, and A.E. Mitchell. 2011. Acrylamide formation in almonds (*Prunus dulcis*): Influences of roasting time and temperature, precursors, varietal selection, and storage. *J. Agricultural and Food Chemistry* 59:8225–8232.

[ii] Amrein, T.M., H. Lukac, L. Andres, R. Perren, F. Escher, and R. Amadò. 2005. Acrylamide in roasted almonds and hazelnuts. *J. Agricultural and Food Chemistry* 53:7819–7825.

[iii] Amrein, T.M., L. Andres, B. Schönbächler, B. Conde-Petit, F. Escher, and R. Amadò. 2005. Acrylamide in almond products. *European Food Research and Technology* 221:14–18.

[iv] Mitchell, A. and Zhang, G., 2012, Commercial roasted almond acrylamide survey results presentation.

[v] (EFSA) European Food Safety Authority. 2013. Acrylamide. Available at: http://www.efsa.europa.eu/en/consultations/call/140701.pdf

[vi] Almond Board of California, Almanac 2013, 2011/12 USA per capita almond consumption USDA ERS.

[vii] Papanikolaou, Y., O'Neil, C.E., Nicklas, T.A., Fulgoni, V.L, Consumption of almonds is associated with increased nutrient intake, better diet quality, and better physiological status in adult participants (19+ y) from the NHANES (2001-2010).

[viii] (FDA) U.S. Food and Drug Administration. 2006. Survey data on acrylamide in food: Individual food products, 2002–2006. Available at: http://www.fda.gov/Food/FoodborneIllnessContaminants/ChemicalContaminants/ucm053549.htm