



Almond Flavor Profiles: The Sensory Properties and Culinary Function of Almonds

Qualitative and Quantitative Research
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For the Almond Board

Prepared by
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Background and Objective

The Almond Board of California has previously developed an almond sensory lexicon which is used as a reference tool for detecting and describing flavor defects in heat pasteurized almonds. This descriptive analysis work has provided detailed descriptors of the sensory attributes of almonds. In addition, the Almond Board of California would like for sales and marketing personnel to be able to communicate the flavor profile of almonds, and the application/utilization of these flavor profiles with other ingredients and dishes, in a meaningful way to potential customers.

Objectives:

- Conduct a focus group with a panel of CIA chefs to gauge “top of mind reactions” to almonds
- Identify functional properties of almonds in culinary applications
- Evaluate the sensory properties of almonds
- Identify flavor profiles of 12 dishes containing almonds and correlate them to the existing lexicon

Methods

Product Handling

Almonds were shipped over night by representatives at Almond board and received by CIA on the day of evaluation, and held at room temperature.

Product Evaluation

A focus group consisting of 5 professionally trained CIA chefs (2 pastry chefs and 3 “hot-side” chefs), was organized and facilitated by a neutral moderator and assisted by a dedicated note taker. Sessions were recorded and relevant excerpts transcribed.

A combination of brain storming, ideation, product tasting, group discussion, product evaluation, and prototype development was used to evaluate the sensory and culinary functional properties of the almonds in culinary applications.

For product testing, chefs were asked to use the almonds in the kitchen and to try various flavor combinations and techniques that they felt would work well with the almonds.

A sensory evaluation ballot was used to collect hedonic scores (9-point) on the following attributes of the raw almonds: overall appearance, color, aroma, sweetness, bitter, overall taste, and texture.

Prototypes were documented using digital camera, and with basic recipes.

Findings

Brain storming and ideation on almond flavor profiles and culinary functions

Chefs commonly use almonds to add texture and lend depth of flavor to their culinary creations. Almonds are perceived to have a sophisticated and delicate flavor profile, but also contribute pronounced and contrasting textural components to a dish. Chefs toast almonds to augment the texture contrast, and to further develop complexity of flavor. Almonds can be used to build viscosity of a sauce, bind proteins, and as a substitute for flour. A variety of aroma (taste and flavor) and textural descriptors from the previously established lexicon, were identified during this session. Additional descriptors were identified during the evaluation.

Chefs identified a variety of flavor profiles/culinary functions for almonds that fell into 7 categories:

- 1) paired with fruit
- 2) paired with cheese
- 3) paired with fish
- 4) paired with other proteins
- 5) almonds as a base for a soup or sauce
- 6) almonds as a component of a confection, pastry or dessert
- 7) almonds on their own or as the primary component of a dish

1) Almonds paired with fruit

Almonds pair well with fruit for two primary reasons: the aromas and flavors of almonds (i.e. how they taste in the mouth) are comparable –the flavors pair, and almonds provide contrasting texture to the otherwise soft and juicy flesh of the fruit. Texture contrast theory, described by Hyde and Witherly (1993) is supported by our focus group discussion and observations working the almond flavor systems below. In the previously established lexicon (Beucler et al., 2005) dried fruits and cherries are aroma attribute descriptors. In addition to cherries, chefs found that stone fruit such as peaches, plums, and apricots work well with almonds, because their flavor (i.e. in the mouth) evokes these other fruits. Oranges are also commonly used with almonds, as the subtle floral “blossom” notes marry well on the plate. The existing lexicon describes fruity and floral aromas detected in almonds. The following flavor concepts were described:

- Orange supremes and almonds
- Nectarines, crème Anglaise, lemon zest and almonds
- Plum sorbet served with fried and salted almonds
- Sweet peaches, apricot, cherries, tamarind, and toasted almonds, to spread on toasted flat bread or crackers

2) Almonds paired with cheese

Chefs often pair almonds with soft and semi-soft cheeses. The almonds contribute a contrast in texture to the soft and homogenous mouthfeel of the cheese. Some of the flavors of the cheese are also perceived in the almonds. Chefs detected a milky note in almonds that is reminiscent of soft cheeses. Certain semi-soft and aged cheeses, such as

cheddar and Gouda have “nutty” notes that chefs pair with almonds. The roasted, woody, fermented dried tea, green bean, and clean (subtle -not pronounced) earthy aroma descriptors from the previously developed lexicon are the relevant descriptors that come together in this pairing category. The following flavor concepts were described:

- Brie, fresh peaches, and toasted almonds
- Mushroom brie, tamarind chutney, and toasted almonds
- Fromage blanc with chopped almonds and popped cumin, mustard seeds, nigelle, and mint
- Aged cheddar, honey, thyme, orange, and candied almonds
- Bean salad with goat cheese and almonds

3) Almonds with fish

Light delicately flavored fish (considered “sweet fish” by chefs) pair well with almonds. Two flavor principles underlying this pairing emerged: delicate fish require pairing with a delicately flavored nut with sweet aromas (i.e. brown sugar, maple syrup, honey, an vanilla from existing lexicon), and the flakey soft textures of white fish can benefit from texture contrast of the almonds. Peanuts or walnuts are too overpowering in flavor/taste and fat profile, and not appropriate for delicate (flavor and texture) white fish. For example, peanuts are considered too earthy and “mineral” and walnuts too bitter to work well with white fish. The flavor of these nuts will over power (“ride rough shot” as one chef articulated) over white fish such as sole, trout, and halibut that pair well with almonds. Scallops, shrimp, and lobster can work with almonds as well. Salmon can also work with almonds, especially when the preparation method is delicate, such as poach or bake. Bluefish, tuna, and mackerel do not work well with almonds because they are overpowering in overall flavor, fat, and texture.

- Halibut, roasted smoky red peppers, browned butter, with sliced almonds, and lemon (sweet fish is balanced with the acid, and paired with sweetness of the almonds)
- Halibut with almonds, capers, oranges, olive oil, and sherry vinegar salsa
- Halibut with curry and mint leaves; almonds crushed in the marinade to help it adhere
- California sea bass with sautéed peppers, raisins, and almonds
- Ono (snapper) coated with almond flour, sautéed, and served with romesco sauce
- Salmon encrusted with almonds and baked with scallions, white wine, lemon, dill and capers

4) Almonds with meats, and other proteins

Lamb and venison were considered “sweet” and gamey meats. The sweetness of almonds is perceived to pair with the sweetness of the meat. However, when game meat is ground, almonds mostly lend texture and help bind the meat. The brown fruit aromatics described in the previous lexicon (raisins, prunes, and figs) pair well with game meats. Almonds were also paired with eggs primarily as a textural component. The flavor of *raw* almonds would not complement the eggs, which is why almonds were incorporated into a coating for the egg, and fried.

- Poached and fried egg with almond crust

- Lamb and almond meatballs –onion, garlic mint, parsley, ground almonds, lemon juice, salt and pepper, gastric with dried cherries, bay leaves and port, can serve with a pita, as a kebab
- Chicken or duck with almonds, thyme or rosemary, and an orange (floral citrus) jus

5) Almonds as a base for soups, sauces, and beverages

Almond milk can be used as a base for warm and cold soups, dessert sauces, and to lend body or viscosity to sauces. The flavor of the almonds (whether toasted or raw) becomes the canvass on which a variety of ingredients can be layered. Almonds can also be used to “soften” the flavors of a sauce. The milky notes (associated with lactones in coconut milk as described in the existing lexicon) and opaque appearance of the almond milk, allows its use as a substitute for, or to supplement, milk.

- Cucumber gazpacho with cherries and almond milk, rose petals and toasted almond slices
- White grape gazpacho with almond milk
- Caramelized almond soup with fresh cream
- Romesco sauce (tomato and almond base; almonds provide body; often served with fish and seafood)
- Mexican style chocolate milk with almonds and cinnamon
- Frozen toasted almond milk

6) Almonds as a component of a confection, pastry or dessert

Almonds are utilized in desserts, pastries, and confections for a variety of reasons. Regular bread flour, and pastry flour, can be removed from recipes and replaced with almond flour (at approx. 20%) when a more delicate or softer texture is desired. The almond flour does not contain gluten and so will not develop a tight texture in the finished product. Almond flour is typically used for “creaming” method preparations: cookies, pound cakes, muffins, and Madelines, for example. The almond flavor in these preparations is subtle. The primary reason for using almond flour in this situation is for controlling the texture of the dough. Almonds are also added to desserts as the central flavor and textural component (raw or toasted). The sweet aromatics described in the lexicon (honey, brown sugar, maple syrup, vanilla), and floral blossom notes, provide flavor balance in sweet confections. In pastries and confections, chefs will leverage the appealing aesthetic of the almond: the red/brown/woody hue, the size of the almond and rounded shape. Consistency in size, ridges and overall appearance is desirable for pastry applications.

- Almond lavender financier
- Almond filled doughnuts with brandied cherry soda (very smoothly textured)
- Truffle with beurre noisette, almond flour, chili cinnamon
- Brioche with almond concha, served with coffee
- Almond nougats
- Almond brittle

- Almond macaroons
- Caramel custard with sliced toasted almonds
- Toasted almonds with gelato, fresh fruit, and crepes
- Almond blossom ice cream
- Browned butter almond streusel with fresh fruit.
- Almond butter and brioche
- Almond semi freddo
- Almond candy rocca

7) Almonds were also identified as the primary component of a dish. In these preparations, many of the flavor pairing principles mentioned above apply. Flavor profiles include fruity floral, sweet aromas, tannic, tea, fermented, and grassy.

- Sweet or dry sherry and almonds with olive oil and salt
- Honey and almonds (“= heaven”)
- Almonds, thyme, fennel, parsley, and mint
- Couscous with almonds three ways –raw, toasted, and caramelized
- Fresh ground almond butter
- Sweet and smoked almonds with buttered brioche
- Green tea with almonds (and white chocolate)

Product evaluation - hedonic ratings and comments on sensory profile

The following hedonic ratings and accompanying comments served to stimulate the creative process amongst chefs, and to confirm that the almonds received were of acceptable quality (not compromised during shipping).

The following questions were presented to the chef panel:

Respond to each questions about the almonds by marking an “X” in the box.

Feel free to put comments/observations in the extra space.

How do you feel about the overall appearance of the almonds?

How do you feel about the color of the almonds?

How do you feel about the overall aroma of the almonds?

How do you feel about the sweetness of the almonds?

How do you feel about the bitterness of the almonds?

How do you feel about the overall taste of the almonds?

How do you feel about the overall texture of the almonds?

Chefs were asked to respond using the following 9-point hedonic scale:

- Like extremely (9)
- Like very much
- Like moderately
- Like slightly
- Neither like nor dislike (5)
- Dislike slightly
- Dislike moderately
- Dislike very much
- Dislike extremely (1)

Results:

	Score						
Sensory attributes of almonds	Chef 1	Chef 2	Chef 3	Chef 4	Chef 5	Average	Stdev.
Overall appearance	8	9	8	9	7	8.2	0.8
Color	9	9	9	8	6	8.2	1.3
Overall aroma	7	7	7	6	5	6.4	0.9
Sweetness	8	9	9	7	7	8.0	1.0
Bitterness	6	5	9	5	7	6.4	1.7
Overall taste	8	9	9	7	7	8.0	1.0
Overall texture	8	7	8	9	9	8.2	0.8

Comments:

Chef 1

Very consistent color; crunchy bite texture; creamy mouthfeel; sweet inside

Chef 2

Large; shape is pleasing, intact; feminine; dense mouthfeel; pale milky interior; tawny skin; earthy delicate, grassy, milky aroma; a slight petrol smell; the sweetness is not cloying but rich like milk and honey (the "good life" nut); the bitterness is delicate and well integrated; not a "flavor bomb" -thoughtful flavor; asks more of the eater; regarding the texture: washed off the palate easily, sticks in the teeth, crunchy; chardonnay and almonds, sherry custard salted almonds; soup gazpacho; sherry brittle; sorbet creamcicle.

Chef 3

Fresh flavor, high quality; not tannic, lavender aroma

Chef 4

Regarding overall appearance: clean, even, firm, inviting; light and uniform color; overall aroma is raw, earthy, mild, dirty, mildly sweet, not bitter; mild flavor, nice finish; good crunch, slightly chewy; evokes flavors of peaches, nectarines, apples, salt and smoke

Chef 5

Healthful; perfect shape and size; golden honey color, soft tea color; subtle sweetness; creamy aftertaste; complex flavor release (the flavor evolves while eating it)

Almond Flavor profiles

The following are images and basic recipes for 12 of the prototypes developed in the kitchen.

White grape or cherry gazpacho with almond milk



Figure 1.



Figure 2.

Ingredients and preparation:

Rainier Cherries (or grapes)	2 lbs
English cucumbers	1 ea.
Scallions, green part only	1/2 bu.
Cream cheese	2 oz.
Almond milk	2 1/2 cup
White wine vinegar	1-2 oz. (to taste)
Plain yogurt	1 1/4 cup
Olive oil	1 oz.
Salt	1 tsp.
Ground white pepper	1/4 tsp.
Cayenne	to taste
Dill, chopped	1/2 bu.
Toasted almonds, chopped	3 Tbsp.
Chives, chopped	1 Tbsp.

Using a food processor, puree all ingredients except for the dill almonds and chives.

Taste and adjust seasoning as required

Blend in the dill and reserve refrigerated until ready to serve.

Serve well chilled and garnish with the toasted almonds and chives.

Fromage blanc with toasted almonds, and popped aromatic spices (mustard seeds, cumin, and nigella) and fresh mint.



Figure 3.

The nutty and milky notes from the toasted almonds, marries well with the cheese. The almonds also provide texture contrast, augmenting the overall flavor of the dish. This can be served as an accompaniment to crudité and crackers (as a type of dip).

Ingredients and preparation:

California Fromage Blanc	1 lbs.
Canola oil	¼ cup
Chopped, toasted almonds	3 Tbsp
Cumin seed	2 Tbsp.
Nigella seed	1 Tbsp.
Black mustard seed	1 Tbsp.
Mustard seed	1 Tbsp.

Mound the Fromage Blanc onto a serving plate.

Mix the oil with the almonds and spices in a sauté pan that has a tight fitting lid. Heat the pan over a moderate heat and swirl it gently so that the spices cook evenly. When the spices begin to pop, cover the pan and continue to cook and swirl for an additional 30 seconds. Remove the lid and spoon the spices, nut and the flavored oil over the cheese. Serve immediately with a fresh mint (and cilantro chutney and your favorite flatbread.)

Recipe adapted from Catherine Brandel

Spicy lamb meatballs with toasted almond and pomegranate syrup



Figure 4.



Figure 5.

Ingredients and preparation:

- 2# Ground lamb
- 1/4 Cup bread crumbs
- 1/2 Cup ground almonds
- 1 Tbsp. Harissa
- 1 Oz. Garlic
- 1 Ea. Lemon, Zest of
- 1/4 Bunch Mint
- 2 Ea. Eggs

Salt and pepper to taste Combine all, mix well, and sauté on medium to high heat until brown on the outside. Can be grilled on kebabs and served with pita.

Similar flavor profile to a Merguez (moroccan Lamb sausage). The almonds add a unique mouthfeel and visual texture. The ground almonds replace some of the bread as a binding agent.

Roasted honey-orange almonds with aged cheddar



Figure 6.

Ingredients and preparation:

Whole almonds, honey, brown sugar, thyme sprigs, orange peel, salt

The almonds, honey and orange peel are placed in a sauté pan and cook slowly to toast the almonds and candy the sugars

This is a slow cooking and slow roasting dish.

The flavor of this dish is sweet and bitter with floral notes from the thyme and orange.

Chilled almond soup with apricots and cherries



Figure 7.

Toasted almond and the almond milk contribute a sweet flavor, and provide body/viscosity for a smooth texture.

Ingredients and preparation:

2 cups toasted almonds

2 Cups almond milk

1/2 cup cane sugar

Place all in a blender and puree, pass through a fine meshed strainer and chill. Garnish with cherries and apricots.

Poached and fried egg with almond crust on crostini, with bacon lardon.



Figure 8.

Ingredients and preparation:

Breading

1/2 cup panko

1/2 cup ground almonds, raw

1/4 bunch parsley, chopped

1/2 bunch thyme

1/2 bunch marjoram

1 egg white, lightly frothed

1 tbsp. salt

1 tsp. black pepper

Poach eggs and place in ice water to stop the cooking. Dry the eggs and dip in lightly frothed egg whites. Roll in the bread crumb mixture and fry in 350 degree oil. The outside will be crunchy and the yolk still runny.

Serve on a crostini with lardons of bacon or on anything for that matter. Great as an accompaniment to a salad. Rich egg texture with an almond and herb crunch on the outside.

Summer Green Bean Salad with Almonds and Goat Cheese



Figure 9.



Figure 10.

Ingredients and preparation:

Blanched green beans, whole almonds with skin on roughly chopped, cherry tomatoes halved, pickled red onions and goat cheese. Champagne vinegar and tarragon vinaigrette.

The almonds provide texture contrast with the green beans and the goat cheese. The “soft” flavors of the other components allow the flavor of the almonds to come through. Use a slightly dry goat cheese so it breaks up evenly when the salad is tossed.

Bitter sweet almond meal truffles



Figure 11.

Ingredients and preparation:

Bittersweet chocolate (64% cocoa mass), cream, almond flour and liqueur made into a ganache, dipped in chocolate and rolled in cocoa powder.

Poach the almond flour in the cream to soften and elevate the almond flavor.

Toasted almond crusted halibut, with smoky roasted red peppers and browned butter



Figure 12.

Ingredients and preparation:

Whole roasted almonds sliced thin, fresh thyme, salt, olive oil.

Dry toast the almonds on low heat until toasted through; slice thin and add the flavorings.

Slow roast the almonds and fish.

The smoky dry toasted almonds and the sweetness of the halibut combine well. Red pepper salad with sherry vinegar and fresh shallot cuts the fat of the toasted almonds.

Almond frangipane stuffed nectarine



Figure 13.

Ingredients and preparation:

Ripe nectarines paired with toasted almonds, brown butter, vanilla, and a sauce made with un-toasted almonds; crème anglaise.

Fresh stone fruit paired with a cookie dough like batter with toasted almonds; baked to perfection and paired with a rich sauce

Brown the butter to give it toastier flavors; steep the raw almonds in milk and cream to infuse their flavor profile into the sauce.

Sweet and savory at the same time, and nice floral flavors from the infused sauce along with the orange zest and vanilla bean in the frangipane.

Pan-seared halibut with almond salsa



Figure 14.

Ingredients and methods:

Pan seared halibut, 4 oz.	6 ea.
Salt and Pepper	TT
Olive oil for searing	3 Tbsp.
Shallots, peeled and minced	2 ea.
Capers, rinsed and chopped	1 Tbsp.
Orange zest, chopped	1 tsp.
Orange supremes from	2 oranges
Italian parsley, chopped	2 Tbsp.
Toasted slivered almonds, chopped	3 Tbsp.
Extra virgin olive oil	6 Tbsp.
Sherry vinegar	2 Tbsp.
Salt	1 tsp.
Ground black pepper	1/4 tsp.

Blot the fish dry and season with salt and pepper

In a medium sauté pan over high heat sear the fish on both sides until golden before reducing the heat and cooking the fish gently until just translucent – about 145 F.

In a mixing bowl, combine the shallots, capers, orange zest, orange supremes, parsley and chopped almonds.

Whisk in the olive oil, sherry vinegar and season to taste with salt and pepper.

While still warm, arrange the fish on a serving platter and drizzle with the almond salsa.

Marzipan filled doughnuts with cherry soda chaser



Figure 15

Ingredients and preparation	
Bread Flour	2.5 lbs
Instant Dry Yeast	.5 oz
Eggs	1 lb
Whole Milk	8 oz
Sugar	4 oz
Salt	.75 oz
Butter	1.5 lb

Combine the flour and yeast, add the eggs, milk sugar and salt and mix on low for 4 minutes. Gradually add the butter while mixer is running. Mix for 15 minutes. Cover wrapped to chill over night.

Portion 1.5 oz balls, shape and place .5 oz ball of marzipan inside and seal over the seam. Proof for 20 minutes and fry in 360 degree oil until golden. Dust with powdered sugar and serve warm.

Marzipan

Ingredients and methods:

Sugar 1 lb
Water 5 oz
Glucose 2 oz
Almonds 9 oz
Amaretto 0.5 oz

Rough chop almonds, cook sugar, glucose, water to 257 degrees, add the almonds and pour onto an oiled marble slab to cool.

Grind in processor to a paste. Add Amaretto as needed.

Cherry soda:

Strain macerated cherries, and combine juice with soda water. Add simple syrup to sweeten if necessary.

Plum sorbet with candied salted almonds



Figure 16.

Ingredients and method:

Plums 2 lbs

Simple Syrup enough to bring sugar levels to 28 Brix

Poach plums, shock in ice to remove skins, remove the pit and puree. Add the simple syrup and spin in the ice cream machine to freeze. Serve with candied, salted almonds

Candied Salted Almonds

Blanched Almonds 1 lb

Simple Syrup as needed

Salt to taste

Toast almonds in a 300 degree oven until golden. Toss with simple syrup until just coated, sprinkle with maldon salt, return to the oven and set the coating of syrup. Cool

Mexican hot chocolate made with almond milk



Ingredients and methods:

Guittard Sur del Lago chocolate (65 % cacao content)	7 oz.
Almonds, lightly toasted, skins removed	¼ cup
Vanilla bean, plump, coarsely chopped	1 ea.
Almond milk	5 cup
Heavy cream	½ cup
Brown sugar,	¼ cup (or up to ½ cup to taste)
Salt	1 pn
Amaretto	¼ cup

With a sharp knife, chop the chocolate into small pieces. Set aside.

Place the almonds and vanilla in a mini-chopper, rotary blade spice mill, or small food processor, and grind to the consistency of breadcrumbs. Set aside.

In a heavy medium-sized saucepan, heat the almond milk and cream with the ground almond-vanilla mixture, sugar, and salt over medium heat. Bring to a gentle boil, stirring. Reduce the heat to low and simmer for about 10 minutes, stirring occasionally. Add the reserved chocolate and amaretto; whisk gently until the chocolate has melted. Don't worry if you see tiny specks of unmelted chocolate dotting the surface. They will disappear as you stir the chocolate.

Reduce the heat to the lowest possible setting and let the mixture cook for 10 minutes. Stir again and strain through a medium strainer if you want to keep the coarse texture of the ground almonds. For a smoother texture, force through a fine strainer with a wooden spoon. To achieve a thicker consistency, let the strained chocolate mixture rest off the

heat for 20-30 minutes, then reheat gently over medium heat. Serve immediately.
(adapted from Maricella Presilla, World of Flavors conference, 2002)

Almond Milk:

Ingredients and methods:

Sliced Almonds	2 C
Water	4 C
Sugar	1/2 tsp.

Mix the Almonds with the water in a medium sauce pot and bring to a boil. Remove from the heat and allow to steep for 2 hour. Place the entire mixture in a blender and blend on high for about 2 minutes or until smooth. Pass the resultant almond milk through a very fine strainer. Stir in the sugar and refrigerate until needed.

References:

Hyde, R.J., Witherly, S.A. (1993). Dynamic contrast: A sensory contribution to palatability. *Appetit*,21,1-16.