



Global Ingredients Division

Non-Dairy Yogurt

Perfecting Plant-Based Yogurts



bdingredients.com

TABLE OF CONTENTS

Objectives	3
Executive Summary	4
Introduction	5
Market Data.....	5
Product Category	6
Non-Dairy Yogurt	7
Almond Ingredients	8
Blanched Almond Ingredients.....	8
Almond Protein	9
Functional Benefits	10
Nutritional Properties.....	10
Functional Properties	11
Almond butter	11
Almond Protein	13
Synergies with Almond Butter and Almond Protein.....	14
Regulatory Considerations	15
Summary	15
References	16

OBJECTIVES AND OVERVIEW

The objective of the technical guide is to provide formulators and manufacturers a clear overview of the non-dairy yogurt landscape, a description of almond ingredients as a base in these products, and how almond ingredients can help formulators achieve success in this competitive product category. The following document will first review the growing opportunity of the non-dairy yogurt category in the United States and around the world, drivers that are increasing demand for non-dairy yogurt, and key technical challenges involved in the formulation of these products. The document will then introduce the reader to two almond-based ingredients, almond butter and almond protein, as solutions to meet these challenges.



Their advantages and weaknesses in terms of functional and nutritional properties are outlined in comparison to competitor ingredients for use in non-dairy yogurt, using data obtained through internal research projects on these ingredients. The document will go further in detail into how these properties make almond butter and almond protein especially suitable for the rapidly changing and demanding food manufacturing environment for non-dairy yogurt, followed by a review of the regulatory considerations associated with almond ingredients.

EXECUTIVE SUMMARY

Non-dairy yogurts are a growing product category fueled by consumer demand for sustainable, healthy, and clean-label options. Consumers are becoming more aware of the effect their purchase choices are having on the environment and on their health. However, they do not want to give up the enjoyment and health benefits of dairy yogurt. Non-dairy yogurt gives consumers the opportunity to retain their dietary routines without compromising on their desire to support their wellness and sustainability goals. Key to capturing the interest and loyalty of consumers are plant-based ingredients that can mimic the taste, aroma, mouthfeel, and appearance of regular dairy yogurt. However, many plant-based ingredient options fall short of these objectives due to the prevalence of off-flavors, off-odors, poor functionality, and unappealing colors. These formulation challenges often require the inclusion of sweeteners and other functional ingredients to non-dairy yogurt formulations, which can run counter against clean-label or other health-forward consumer trends.

Both almond butter and almond protein offer solutions to these challenges. These ingredients have a subtle flavor and light, near-white color that give formulators and manufacturers a clean slate to produce their non-dairy yogurts. Almond butter and almond protein are produced without the use of chemicals, solvents, or aggressive processing treatments, giving consumers the satisfaction of consuming natural, clean-label food ingredients. These almond ingredients also have the added benefit of having excellent nutritional properties and perceived healthiness. Almonds provide better-for-you fats, protein, and dietary fibers, along with essential minerals and vitamins that provide a nutritional boost without the need for additional ingredients. The combination of almond butter and almond protein in a non-dairy yogurt also allows formulators the option to modify their ratios to tune into the mouthfeel, taste, consistency, and nutritional profile desired by their target consumers.

Both almond butter and almond protein offer solutions to the challenges of inclusion of sweeteners or other functional ingredients in non-dairy yogurt formulations that would counter clean-label or health-forward consumer trends.

INTRODUCTION

MARKET DATA

Growing interest in non-dairy yogurt, as well as other plant-based food products such as meat analogues and non-dairy milk, is fueling the plant-based industry valued at \$5 billion.¹ In 2019, the global non-dairy yogurt market was estimated with a value of \$1.6 billion, while the United States market for non-dairy yogurt was valued at \$400 million for 2020. More recently, Vantage Market Research reported that the non-dairy market is currently valued at \$2.8 billion in 2022.²

Several drivers are increasing the demand for non-dairy yogurt. Consumer interest in alternative diets, concerns over dairy and lactose intolerance, and increasing awareness of the environmental impact of food production are all part of the equation for the growing demand for non-dairy yogurt.¹ The market is strongly influenced by veganism, vegetarianism, the clean-label movement, and other dietary and health trends. More than 5 percent of the United States population identifies as vegan, and there is evidence that the market group is growing. Millennials and Gen Z are driving the demand for the product category due to their influence in promoting veganism and vegetarianism for ethical, environmental, and health reasons.

Health-conscious consumers may see the consumption of dairy as impacting their health, with there being a higher risk for food-borne illness, increase risk of chronic illness, and the presence of residual antibiotics and hormones linked to animal products. Additionally, individuals who are struggling with dairy protein intolerance or lactose intolerance may opt for non-dairy yogurt, which does not contain milk proteins or lactose.

Of all the plant-based ingredient options available for yogurt formulation, almond is emerging as the most preferred variant of non-dairy yogurt due to its perceived health benefits, low cholesterol content, and relatively neutral taste.

European and Asian populations are particularly prone to lactose intolerance and the number of individuals who suffer from the condition is growing.¹

Consumers are also gaining more education regarding the impact of conventional agriculture on animal welfare and the greater environment. Many see the switch to non-dairy yogurt as a sustainable way to decrease their collective impact on the environment or reduce the number of cows that need to be raised and milked, while still being able to enjoy their daily yogurt.

Of all the plant-based ingredient options available for yogurt formulation, almond is emerging as the most preferred variant of non-dairy yogurt due to its perceived health benefits, low cholesterol content, and relatively neutral taste.



PRODUCT CATEGORY

Non-dairy yogurts are produced from several plant-based ingredients. Common bases used for producing non-dairy yogurt include almonds, cashews, chickpeas, coconut, oats, peas, soy, among others.³ Several strains of lactic acid bacteria cultures are used to ferment the base to produce the product. Non-dairy yogurts are either pasteurized to improve shelf-life stability or left untreated after fermentation to offer the probiotic benefits of the living bacteria cultures, much like in the dairy yogurt category.⁴ Depending on the species and strain included in the fermentation, specific gut health and immunity benefits can be outlined on the product. Here, non-dairy yogurt blurs the line between functional food product and healthy-for-you, non-dairy alternative categories.

Flavorings are added to improve the taste of the yogurt and provide a line of flavor options for consumers. Masking agents are sometimes necessary to include in the formulation to reduce consumer perception of off-flavors, as plant-based ingredients can contain aroma and flavor defects. Sweeteners can be included to amplify sweet and fruity flavors. Texturizers, emulsifiers, and gums are often added to improve the texture, mouthfeel, and creaminess of the product and reduce separation during storage. Inclusions, such as fruit puree, dried fruit, chopped nuts, granola, non-dairy chocolate, or non-dairy caramel, can be included to provide additional options for new tastes and textures. These inclusions can be used to target consumers who want a little indulgence in their healthy non-dairy snack.⁵

NON-DAIRY YOGURT OVERVIEW

Non-dairy yogurt is a fermented food product that uses plant-based ingredients to simulate the taste, texture, and color of conventional dairy yogurt. A base is mixed with water, vegan lactic acid bacteria cultures, and a source of sugar, if there is none present in the base, to initiate fermentation. The mixture is incubated at 38–46 degrees Celsius, which allows the lactic acid bacteria to proliferate.

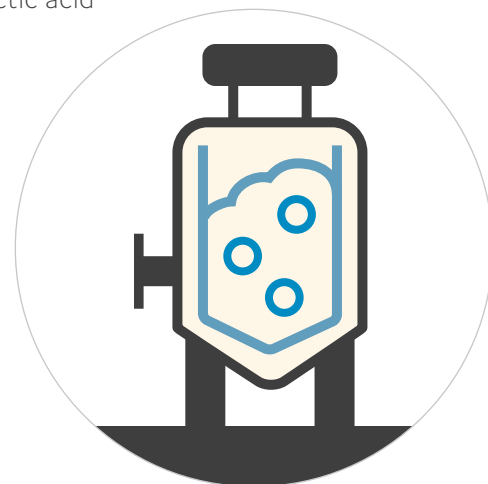
These microorganisms slowly convert the sugars into lactic acid, which drives down the pH of the fermentation. The increased acidity causes the proteins in the base to coagulate, increasing the gelling and thickness of the fermenting base. The bacteria will also produce flavor molecules, which is triggered by the composition of the base along with the types of bacteria included in the fermentation.

Depending on the culture selection and concentration, the non-dairy yogurt will achieve the desired level of acidity through fermentation after 4–12 hours. The pH of the yogurt will need to be below 4.6 to provide the balanced yogurt tartness and prevent undesirable bacterial growth.

However, fermenting non-dairy yogurt rarely achieves the desired thickness or consistency of a dairy yogurt. They typically have a thinner viscosity and require additional ingredients to improve the texture. These can include texturizers like starches, gums, fibers, and emulsifiers. Oils and fats may also need to be added to improve the creaminess and mouthfeel of the non-dairy yogurt.

Another challenge that arises from using plant-based ingredients to produce non-dairy yogurts is the flavor. Most plant-based materials have active enzymes that break down the lipids found in the legume, nut, or grain and produce off-flavors.⁶ Soy, pea, and other legumes produce several aldehydes that exhibit beany, grassy off-flavor. Oats and other grains can also contain compounds known as saponins, which can give an astringent and bitter aftertaste. Nuts such as cashews release volatile compounds that give their strong nutty flavors that are not typical to dairy yogurt flavors.

Additional flavors, sweeteners or masking agents are frequently required to eliminate these effects in non-dairy yogurts. Use of these ingredients can interfere with a formulator's goal of creating a clean label product. Regardless, the goal is to reach a more neutral flavor that better resembles that of conventional yogurt.



ALMOND INGREDIENTS OVERVIEW

BLANCHED ALMOND INGREDIENTS IN NON-DAIRY YOGURT APPLICATIONS



Almond butter and almond protein are produced by a multi-step process that does not involve chemicals, making them excellent clean-label ingredients for non-dairy formulations.

Almonds are first graded and sorted to ensure only high-quality almonds are used in the process. They can be either left in their raw natural state or roasted to varying levels depending on the end-product.

Blanched almonds are ground into a paste to reduce particles to a fine, smooth texture.

Our processes help develop the desired flavor, color and texture for non-dairy yogurt formulations.

Almond butter can be produced with blanched or unblanched almonds with various degrees of roasting. The blanching process involves scalding the almonds with hot water, after which the blanched almonds are grounded to a paste to reduce their size to a fine smooth texture. Roasting the almonds initiates a set of thermal reactions between the sugars and proteins, releasing flavor and aroma molecules. The result is the development of desirable flavors, colors, and texture. Roasting also helps disrupt the plant cell membranes, leading to greater oil release for efficient production of almond butter. The resulting almond butter retains much of the nutritional content of the original almonds.

ALMOND PROTEIN

Alternatively, Blue Diamond almond protein is produced from raw (unroasted) blanched almonds through a proprietary expeller press process, where no additives or solvents are used. Pasteurized blanched raw (unroasted) almonds are utilized. Throughout this process, the almonds do not reach temperatures that induce reactions between the sugars and amino acids found in the almonds, which normally cause the breakdown of nutrients and darkens the color of the almonds. The gentle processing greatly limits the degradation of the natural amino acids, oils, vitamins, and phytonutrients that give almonds their health benefits. Blanching also limits the physical changes in the protein and fibers, keeping them in their natural state for their texturizing properties. This gentle blanching process produces an almond ingredient with the advantageous texture, color, and nutritional content desirable for non-dairy applications.



The almond protein is a high protein, reduced fat material for use in formulations and improve product performance.

A large percentage of the almond oil is pressed out, resulting in a dense compact cake. The pressed cake is then milled into a fine powder that passes through a microbial load reduction treatment and other processes that results in a consistently fine powder. Vitamin E, which is an oil soluble vitamin, remains in the oils during the separation, while the powder increases in fiber and protein content compared to unprocessed almonds. This results in a higher protein and reduced fat material that has approximately 12 percent fat content and 45 percent protein, which can be used where lower fat is needed to improve product performance.

The Protein Digestibility Corrected Amino Acid Score (PDCAAS) is a method used to evaluate the quality of a protein based on how well humans can digest the protein and the protein's amino acid content. The PDCAAS of almond protein powder is 0.44. Lysine is the limiting amino acid in almond protein, which is also true for many plant-based proteins.

FUNCTIONAL BENEFITS

NUTRITIONAL PROPERTIES

Almonds are a whole food that contains protein, lipids, dietary fibers, minerals, and vitamins. California-grown almonds can contain anywhere between 45–54 percent fat depending on the cultivar, season, and region of production. The fats contain a balanced amount of polyunsaturated fatty acids that may help with blood sugar control, reduce blood pressure, and lower cholesterol levels. Almonds are also rich in tocopherols, a form of vitamin E, and these play a role as antioxidants and may reduce inflammation. Almonds are one of the foods highest in vitamin E.

Almonds are a source of plant-based protein. Protein accounts for approximately 20 percent of almond's mass. Almond protein contains all nine essential amino acids. However, some of the amino acids, most significantly lysine, are not present at levels required to be considered a complete protein. The protein fraction in almonds also contains arginine, one of the amino acids that is involved in cardiovascular function and insulin release and may support recovery after exercise.

Almonds contain essential minerals including calcium, potassium, iron and magnesium. And trace minerals such as zinc, copper and manganese can also be found in almonds, aiding in proper immune functions, metabolism, hormone production and regulation.

Several studies have shown that almonds possess potential cholesterol-lowering effects, although further research is needed to explore this possibility. For example, a 2003 study conducted by researchers at Stanford University found participants who consumed 100 g of almonds per day for four weeks had significantly lower low-density lipoprotein (LDL) cholesterol at the conclusion of the study.⁸

Phytonutrients found in almonds can potentially reduce the risk of chronic diseases. According to another study published 2002⁹, the relative risk of developing diabetes was reduced by 27 percent for individuals who consumed nuts five times per week compared to those who did not eat any nuts. Some evidence indicates that nut phytonutrients may be protective against certain types of cancers, including colon, prostate, and breast cancer.

In another recent study from 2023, researchers found that four weeks of consuming almonds improved recovery after exercise.¹⁰ Research participants were put on a 90-minute workout routine and biomarkers for inflammation, soreness, and muscle damage were analyzed post-workout. Almond consumption improved mood, retained strength, decreased muscle damage, and enhanced metabolism compared to a calorie-match placebo diet.

Furthermore, the inclusion of almonds as a major ingredient in a food may permit the use of the FDA's qualified health claim for nuts provided certain conditions are met. Formulators can include the following Heart Health Claim:

Scientific evidence suggests but does not prove that eating 1.5 ounces per day of most nuts, such as almonds, as part of a diet low in saturated fat and cholesterol may reduce the risk of heart disease. See nutrition information for fat content.



FUNCTIONAL PROPERTIES

ALMOND BUTTER

A conducted study indicated the following functional properties or attributes of almond butter benefit the production/manufacturing of non-dairy yogurt:

- Lower viscosity – ease of manufacturing
- Fine particle size – smooth texture
- High protein solubility
- High emulsion capacity

A desirable viscosity is the ability of an ingredient to flow and be pumped in a manufacturing environment. A consistent smaller particle size can affect consumer perceptions of smoothness or grittiness and may impact product flow. The protein solubility and emulsion capacity of the almond butter is an important functional property. The solubility of proteins is considered as the proportion of nitrogen in a protein product which is in the soluble state under specific conditions. Solubility is the amount of protein in a sample that dissolves into solution. Proteins can be partly or completely soluble or completely insoluble in water.



Emulsion capacity is the ability of an ingredient to create and stabilize an emulsion. An emulsion is a mixture of two or more liquids that are typically immiscible such as oil and water. The almond butters exhibited higher protein solubility when compared to competitor nut butters. Emulsion capacity is also an important functional property as it allows proteins to bind to both water and oil, creating a smoother consistency in a food product. The emulsion capacity of the various forms of Blue Diamond almond butters were comparable to each other but slightly higher than to the competitive nut butters.

ALMOND PROTEIN

Data provided more detail on the following functional properties or attributes of almond protein benefit the production/manufacturing of non-dairy yogurt:

- Uniform particle size – consistent results
- High wettability – quick dispersion in water
- High solubility in water – suitable pH
- High gelling concentration

Blue Diamond almond protein has a uniform and fine particle size which results in a consistent and smooth texture of the end product. The almond protein also showed some of the highest wettability compared to other plant-based proteins. Wettability corresponds to the time required for the sample to sink into the water when dropped at a water/air interface. In a manufacturing setting, this allows the ingredients to be quickly mixed without more aggressive processing equipment to break up surface clumps.

Almond protein exhibits high solubility at a pH of 7, while it also has low solubility at a pH level between 4–5. The solubility of proteins refers to the proportion of nitrogen in a protein product which is in the soluble state under specific conditions. Solubility is the amount of protein in a sample that dissolves into solution. For non-dairy yogurts, this allows the protein to be distributed throughout the ferment without forming clumps or settling to the bottom. At the same time, low solubility at low pH allows the protein to precipitate and gel as the bacteria cultures release acid over the course of the fermentation. These two opposing protein solubilities at different pH are critical for yogurt production.

For non-dairy yogurt, emulsifying ability is an important functional property (Emulsion capacity is the ability of an ingredient to create and stabilize an emulsion. An emulsion is a mixture of two or more liquids that are typically immiscible such as oil and water.) This property provides the smooth and creamy texture that is expected from a non-dairy yogurt. Poor emulsion stability over the lifetime of the product can result in separation between the oil and water, leading to product failure and poor presentation. The almond proteins produced emulsified oil droplets that were more stable over time.

Almond protein has excellent gelling properties compared to other plant-based proteins. Gelling is the ability to convert a fluid into a solid that is held together and contributes to desired texture, measured by the volume that is required to create the gel and must hold stability over time, temperature, and pH – which is desirable in non-dairy yogurt production.

High whiteness and low yellow color are ideal to ensure there are no off-colors in the final product. Blue Diamond blanched almond protein exhibited a high degree of whiteness and low yellow tint compared to other plant-based proteins. The aroma of almond protein is also perceived as more neutral, and the flavor was less bitter when compared to other plant-based proteins.

Data also confirms that the blanching process does not denature the almond proteins which confirms that Blue Diamond's manufacturing processes has no impact on the protein quality. Protein denaturation results in reduced functionality, decreasing desirable solubility, and emulsification properties.

SYNERGIES BETWEEN ALMOND BUTTER AND ALMOND PROTEIN IN NON-DAIRY YOGURT

Almonds as an ingredient exhibit several key advantages. In terms of color, almond butter and almond protein create a neutral near-white color that does not interfere with the desired appearance of the end product. This allows manufacturers to avoid the use of whitening agents that could impact the clean label.

Almond butter and protein together provide a neutral flavor and aroma, with a low degree of nuttiness and no aftertaste. These attributes or functional properties mimic the desirable taste of conventional yogurt and allow manufacturers to add flavors without concern for undesirable taste. Much like the neutral color of the ingredients, the clean flavor of almond-based yogurt eliminates the need to include masking agents.

Texture is an important characteristic that consumers come to expect in a non-dairy yogurt. Many plant-based ingredients may cause excess lumpiness or produce a non-dairy yogurt that has poor gelling properties, resulting in an undesirable texture. Almond butter and almond protein paired together provide a balanced level of gelling that best matches conventional yogurt. Almond-based yogurts yield a smooth and creamy texture for a desirable mouthfeel.

Combining almond butter and almond protein amplifies their functional properties when formulated into a non-dairy yogurt. Almond butter contributes a clean mouthfeel alongside balanced tart notes much like a conventional yogurt. Almond protein adds a white color, neutral flavor, and creamier mouthfeel. Specific ratios of almond butter and almond protein provide different results. This allows formulators to optimize viscosity and texture towards the most ideal for a non-dairy yogurt.



REGULATORY CONSIDERATIONS

The major consideration regarding almonds as ingredients is allergenicity. Food allergies affect nearly 3 percent of the population.¹¹ Food allergies occur when certain proteins found in ingredients are consumed and trigger the immune system of certain individuals to mistakenly overreact. The excessive immune response results in congestion, watery eyes, vomiting, and anaphylaxis. These symptoms appear nearly immediately or within minutes of ingestion, with rare cases manifesting several hours later.

Eight foods are identified as major food allergens — milk, eggs, fish, shellfish, tree nuts, peanuts, wheat, and soybeans. Almonds are tree nuts and so their inclusion in yogurt means the product must be labeled as containing this allergen and printed right next to the ingredient list. Almond butter and almond protein must be declared separately on the ingredient panel as almond protein has been partially defatted.

Food identified as major food allergens include:

- Milk
- Eggs
- Fish
- Shellfish
- Tree nuts
- Peanuts
- Wheat
- Soybeans

SUMMARY



Non-dairy yogurt is a growing category with demand driven by current wellness and sustainability trends. Formulating non-dairy yogurt can be challenging. Almond butter and almond protein offer advantages over other plant-based ingredients when used in non-dairy yogurt formulations. Both almond butter and almond protein provide excellent nutritional benefits along with desirable texture, color, and flavor in non-dairy applications. The combination of both produces a superior product overall.

The processes used to produce almond butter and almond protein are gentle and without the use of solvents or chemicals. These advantageous properties allow formulators to minimize the number of ingredients to achieve a clean label end product.

REFERENCES

1. Craig, W.J.; Brothers, C.J. Nutritional Content and Health Profile of Non-Dairy Plant-Based Yogurt Alternatives. *Nutrients* 2021, 13, 4069. <https://doi.org/10.3390/nu13114069>
2. Non-Dairy Yogurt Market. Available online: <https://www.vantagemarketresearch.com/nondairy-yogurt-market-2192/>
3. Montemurro, M.; Pontonio, E.; Coda, R.; Rizzello, C.G. Plant-Based Alternatives to Yogurt: State-of-the-Art and Perspectives of New Biotechnological Challenges. *Foods* 2021, 10, 316. <https://doi.org/10.3390/foods10020316>
4. Rasika, D.M.D.; Vidanarachchi, J.K.; Rocha, R.S.; Balthazar, C.F.; Cruz, A.G.; Sant'Ana, A.S.; Ranadheera, C.S. Plant-based milk substitutes as emerging probiotic carriers. *Curr. Opin. Food Sci.* 2021, 38, 8-20. <https://doi.org/10.1016/j.cofs.2020.10.025>
5. Inclusions are more than extras in dairy. Available online: <https://www.dairyfoods.com/articles/95467-inclusions-are-more-than-extras-in-dairy>
6. Mittermeier-Kleßinger, V.K.; Hofmann, T.; Dawid, C. Mitigating Off-Flavors of Plant-Based Proteins. *J. Agric. Food Chem.* 2021, 69, 9202-9207. <https://doi.org/10.1021/acs.jafc.1c03398>
7. Hughey, C.A.; Januszewicz, R.; Minardi, C.S.; Phung, J.; Huffman, B.A.; Reyes, L.; Wilcox, B.E.; Prakash, A. Distribution of almond polyphenols in blanch water and skins as a function of blanching time and temperature. *Food Chem.* 2012, 131, 1165-1173. <https://doi.org/10.1016/j.foodchem.2011.09.093>
8. Spiller, G.A.; Miller, A.; Olivera, K.; Reynolds, J.; Miller, B.; Morse, S.J.; Dewell, A.; Farquhar, J.W. Effects of plant-based diets high in raw or roasted almonds or roasted almond butter on serum lipoproteins in humans. *J. Am. Coll. Nutr.* 2003, 22, 195-200. <https://doi.org/10.1080/07315724.2003.10719293>
9. Cohen, A.E.; Johnston, C.S. Almond ingestion at mealtime reduces postprandial glycemia and chronic ingestion reduces hemoglobin A1c in individuals with well-controlled type 2 diabetes mellitus. *Metabolism* 2011, 60, 1312-1317. <https://doi.org/10.1016/j.metabol.2011.01.017>
10. Nieman, D.C.; Omar, A.M.; Kay, C.D.; Kasote, D.M.; Sakaguchi, C.A.; Lkhagva, A.; Weldemariam, M.M.; Zhang, Q. Almond intake alters the acute plasma dihydroxy-octadecenoic (DiHOME) response to eccentric exercise. *Front. Nutr.* 2023, 9, 1-14. <https://doi.org/10.3389/fnut.2022.1042719>
11. Valenta, R.; Hochwallner, H.; Linhart, B.; Pahr, S. Food Allergies: The Basics. *Gastroenterology* 2015, 148, 1120-1131. <https://doi.org/10.1053/j.gastro.2015.02.006>