

**UCDAVIS**  
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GRADUATE SCHOOL  
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# THE EVOLVING MARKET FOR PLANT-BASED MILK: ALFALFA AND OTHER POTENTIAL SOURCES

MARKET DISCOVERY PAPER  
APRIL 2022



## EXECUTIVE SUMMARY

The transformative food category of plant-based milks has seen rapid development and expansion and accounts for 16% of all milk sales.<sup>1b</sup> This growth coincides with a convergence between consumer's increasing interest in how food affects the long-term health of both themselves and the planet. In this white paper, we explore the current state of the market as well as the investment potential for a hypothetical new type of plant-based milk, alfalfa. Key features that we discuss are consumer purchase behavior, economics, nutrition, and sustainability. We conclude our analysis with frameworks on what features may be needed to be competitive, the current investment landscape, and an overall summary on the alternative-milk market landscape.

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# STATE OF THE MARKET

While plant-based milk products have seemingly taken over every grocery store and coffee shop within the past few years, they are not as novel as most consider them to be. Many cultures have in fact been consuming and creating plant milks since ancient times.<sup>2</sup> The main varieties we know now, such as almond, oat, and soy, are only a few of the many different potential sources shown below.



## Grains

barley, fonio, maize, millet, oat, rice, rye, sorghum, teff, triticale, spelt, wheat



## Pseudo Cereals

amaranth, buckwheat, quinoa



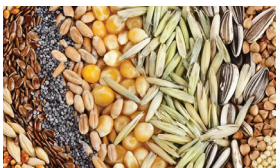
## Legumes

lupin, pea, peanut, soy



## Nuts

almond, brazil, cashew, hazelnut, macadamia, pecan, pistachio, walnut



## Seeds

chia seed, flax seed, hemp seed, pumpkin seed, sesame seed, sunflower seed



## Other

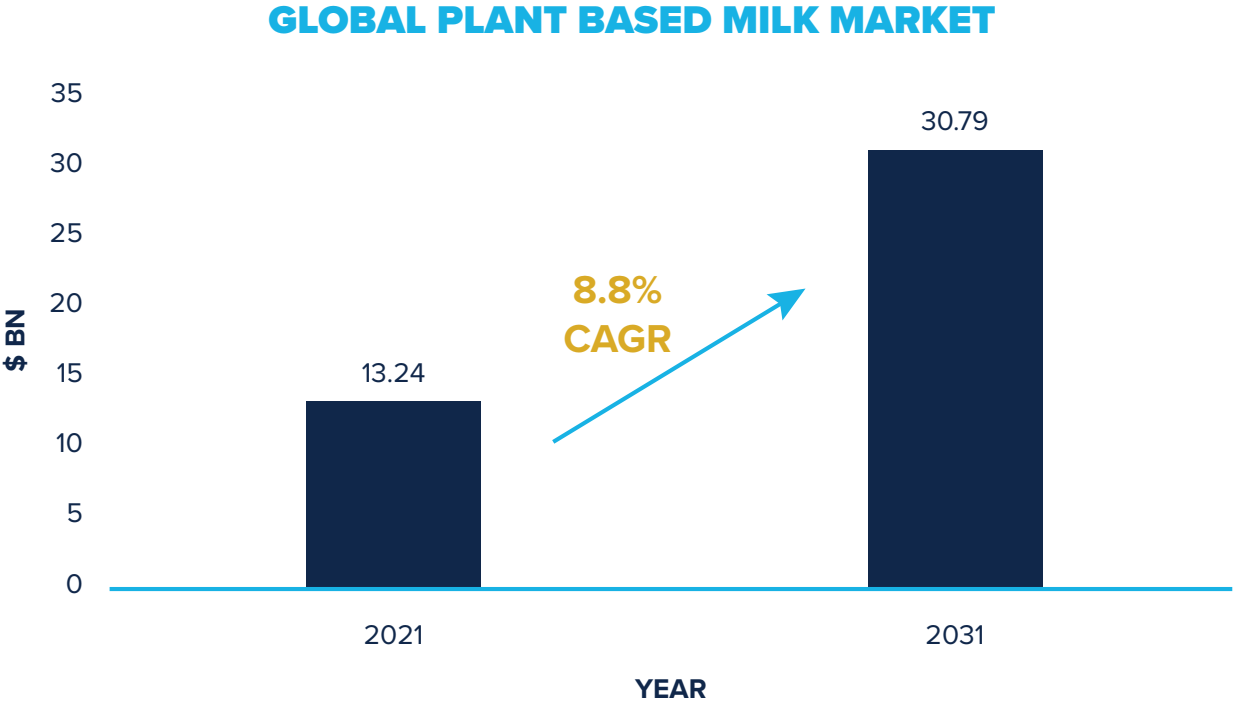
coconut (fruit; drupe), potato (tuber), tiger nut (tuber)



## Other Traditional Milk

Kunu, a Nigerian beverage made from sprouted millet, sorghum, or maize  
Sikhye, a traditional sweet Korean rice  
Amazake, a Japanese rice milk

Today, the global market size for plant-based milks is \$13.24B with a CAGR of 8.8%. By 2031, the market size is estimated to reach \$30.79B.<sup>3</sup>



Factors contributing to this growth are: an increased prevalence of veganism (9% global CAGR)<sup>4</sup>, rising self-diagnosis of lactose intolerance (doubled from 2014 to 2016 in US & Europe, 8.7% CAGR)<sup>5,5b</sup> and a desire for sustainable products (6% global CAGR).<sup>6</sup> Soy milk products remain the most popular, accounting for 29.5% of global revenue in 2019.<sup>7</sup> Across all types of plant-milks, plain flavors dominate sales, accounting for 71.1% of the total value.<sup>7</sup>

In the United States, the plant-based milk category was worth \$2.6 billion in 2021 and dollar sales have grown with a 33% CAGR over the past three years.<sup>1b</sup>



Of all U.S. households, 42% purchase plant-based milk, which equates to more than 50 million homes, up from 37.2% in 2019.<sup>1b</sup>

Of households purchasing refrigerated plant-based milk, 76% are repeat purchasers, up from 73.6% in 2019.<sup>1b</sup>

These positive trends indicate that plant-based milks are increasingly becoming a staple as opposed to a once-off purchase.

Almond milk is the category leader in the USA and generated \$1.5 billion worth of sales in 2019-20.<sup>8</sup> Oat milk has grown at a rapid rate of 350% to become the second major player in the market in the same period.<sup>8</sup>

TYPE OF MILK	TOTAL VALUE	MARKET SHARE	GROWTH RATE
Almond	\$1.50B	59%	Refrig: 13.4% Shelf Stable: +10%
Oat	\$424M	17%	<b>Refrig: 350.8%</b> <b>Shelf Stable: +106.4%</b>
Soy	\$200M	8%	Refrig: -4.8% Shelf Stable: -2.1%
Coconut	\$125M	5%	Refrig: 3.1% Shelf Stable: 50.5%
Rice	\$50M	2%	Refrig: -7.8% Shelf Stable: 4.1%
Pea	\$50M	2%	Refrig: 11.9% Shelf Stable: +18.6%

*\*Data adapted from SPINS natural enhanced and multi outlet (USA), 52 weeks to Sept 6, 2020) <sup>8</sup> and SPINS 2021 plant-based milk report. <sup>1b</sup>*

Oat milk's quick market capture may be a reassuring sign for other emerging varieties as it could be indicative of consumers' willingness to try new products<sup>8(b)</sup> and reward quality when they find it.

# COMPETITOR ANALYSIS

Below we showcase the top five plant-based milk brands by revenues<sup>1</sup> as well as one of the most successful newcomers to the market, Ripple Foods.

COMPANY	ESTIMATED REVENUE (US)	LOGO	CLAIMS USED (ON AT LEAST ONE PRODUCT PACKAGE)		VARIETIES	SIZES	PRICE	COMPLIMENTARY PRODUCTS
Blue Diamond Breeze (HP Hood LLC)	\$618M		<ul style="list-style-type: none"> <li>Excellent source of calcium and vit. E</li> <li>Free from: lactose, dairy, casein, cholesterol, carrageenan, MSG, Gluten, artificial flavors &amp; colors, added sugars</li> <li>Non-GMO project verified</li> <li>50% more calcium than cow's milk</li> <li>46% less calories than cow's milk</li> <li>Vegan</li> <li>Kosher</li> <li>Reduced sugar</li> </ul>	<ul style="list-style-type: none"> <li>Almond, Coconut, Banana, Blends</li> <li>Flavors: Sweetened &amp; Unsweetened, Vanilla &amp; Chocolate, Hint of Honey</li> <li>Extra Creamy</li> </ul>	<ul style="list-style-type: none"> <li>96 oz</li> <li>64 oz</li> <li>59 oz</li> <li>32 oz</li> <li>8 oz</li> </ul>	<ul style="list-style-type: none"> <li>\$4.12</li> <li>\$2.97</li> <li>\$3.59</li> <li>\$1.99</li> <li>\$1.99</li> </ul>	<ul style="list-style-type: none"> <li>Creamers</li> <li>Yogurt</li> <li>Alternatives</li> <li>Almondmilk</li> <li>Nog</li> </ul>	
Califia Farms	\$62.1M		<ul style="list-style-type: none"> <li>Excellent source of calcium &amp; vit. A &amp; D</li> <li>Free from: gluten dairy, soy, &amp; carrageenan</li> <li>Non-GMO project verified</li> <li>50% less calories than average oat milk</li> <li>Vegan</li> <li>Kosher</li> <li>BPA free packaging</li> </ul>	<ul style="list-style-type: none"> <li>Almond, Oat, Coconut, Blends</li> <li>Unsweetened</li> <li>Zero Sugar</li> <li>Extra Creamy</li> <li>Vanilla</li> <li>Barista Blends</li> </ul>	<ul style="list-style-type: none"> <li>48 oz</li> <li>32 oz</li> </ul>	<ul style="list-style-type: none"> <li>\$3.67</li> <li>\$3.58</li> </ul>	<ul style="list-style-type: none"> <li>Half and Half</li> <li>Cold Brew</li> <li>Coffee</li> <li>RTD Latte's</li> <li>Creamer</li> <li>Juices</li> </ul>	
Oatly	\$170M		<ul style="list-style-type: none"> <li>Gluten Free</li> <li>Glyphosate Free</li> <li>Nut &amp; Dairy Free</li> <li>100% Vegan</li> </ul>	<ul style="list-style-type: none"> <li>Oat</li> <li>Low Fat, Original, Full Fat</li> <li>Barista Edition</li> <li>Chocolate</li> </ul>	<ul style="list-style-type: none"> <li>64 oz</li> <li>32 oz</li> <li>11 oz</li> </ul>	<ul style="list-style-type: none"> <li>\$4.38</li> <li>\$4.18</li> <li>\$3.52</li> </ul>	<ul style="list-style-type: none"> <li>Frozen Desserts</li> <li>Yogurt</li> <li>Alternatives</li> </ul>	
Planet Oat (HP Hood LLC)	\$80M		<ul style="list-style-type: none"> <li>Excellent source of calcium, vit. A &amp; D</li> <li>Free from: dairy, soy, peanuts, lactose, tree nuts, gluten and artificial flavors, colors &amp; preservatives</li> <li>Non-GMO project verified</li> <li>Low calorie</li> <li>Reduced sugar</li> <li>Kosher</li> </ul>	<ul style="list-style-type: none"> <li>Oat</li> <li>Extra Creamy</li> <li>Flavors: Sweetened &amp; Unsweetened, Vanilla &amp; Dark Chocolate</li> </ul>	<ul style="list-style-type: none"> <li>86oz</li> <li>52 oz</li> <li>32 oz</li> </ul>	<ul style="list-style-type: none"> <li>\$5.99</li> <li>\$4.29</li> <li>\$2.99</li> </ul>	<ul style="list-style-type: none"> <li>Creamers</li> <li>Frozen Desserts</li> </ul>	
Ripple	\$21.3M		<ul style="list-style-type: none"> <li>Excellent source of vit. D</li> <li>32 mg of DHA Omega-3's</li> <li>Half the sugar of cow's milk</li> <li>50% more calcium than cow's milk</li> </ul>	<ul style="list-style-type: none"> <li>Pea</li> <li>Sweetened &amp; Unsweetened Original and Vanilla</li> <li>Chocolate</li> <li>Kids variety</li> </ul>	<ul style="list-style-type: none"> <li>48 oz</li> <li>32 oz</li> </ul>	<ul style="list-style-type: none"> <li>\$3.99</li> <li>\$4.16</li> </ul>	<ul style="list-style-type: none"> <li>Half &amp; Half</li> <li>Protein Shakes</li> </ul>	
Silk (Danone)	>\$800M		<ul style="list-style-type: none"> <li>Excellent source of calcium and vit. E</li> <li>Free from dairy, gluten, carrageenan, cholesterol, and artificial colors &amp; flavors</li> <li>Non-GMO project verified</li> <li>Reduced sugar</li> <li>Low in saturated fat, low calorie</li> <li>Certified organic</li> <li>Health healthy</li> <li>Certified B Corp</li> </ul>	<ul style="list-style-type: none"> <li>Soy, Almond, Oat, Cashew, Coconut, Blends</li> <li>Flavors: Sweetened &amp; Unsweetened, Vanilla &amp; Chocolate</li> <li>Extra Creamy</li> <li>High Protein (7g/8g/10g/20g)</li> </ul>	<ul style="list-style-type: none"> <li>96 oz</li> <li>64 oz</li> <li>59 oz</li> <li>32 oz</li> <li>10 oz</li> <li>8 oz</li> </ul>	<ul style="list-style-type: none"> <li>\$4.00</li> <li>\$3.99</li> <li>\$4.69</li> <li>\$2.19</li> <li>\$2.75</li> <li>\$1.38</li> </ul>	<ul style="list-style-type: none"> <li>Creamers</li> <li>Yogurt</li> <li>Alternatives</li> </ul>	

\*References 9/10,11,12,13,14,15,16,17,18,19\*

Plant-based milks retail at prices nearly twice that of traditional dairy (\$3.36/gallon), and average \$0.08/ fl oz (California market, February 2022). Whether target consumers perceive this price increase at all or allocate it to other product benefits is unknown, however, Oatly appears to be able to charge a slight premium over its competitors. This in part may be due to the newness of the category (though Planet Oat is offered at a lower price), brand strength from an undeniably strong marketing group, or their claimed superior quality.

The majority of products are in flavors most similar to traditional milk offerings such as plain and chocolate. Most manufacturers also offer sweetened and unsweetened varieties. Several manufacturers have introduced other flavored varieties and blends to satisfy the demand for innovative products in the market and drive growth. An example is Blue Diamond Breeze's Almond and Banana blended beverage.

A column is included in the analysis to showcase the claims made by each company. Nutrient claims are prominent as well as "free from" claims. Less prevalent claims include vegan, kosher, Non-GMO project verified, and organic.

Carton packaging accounted for ~ 69% of the plant-based milk products in 2019 and are most often in half gallon (64oz) or smaller sizes.<sup>20</sup>

Manufacturers have also launched a variety of complimentary products in the plant-based space to gain market size such as yogurt alternatives and frozen desserts. These products are expected to become more important as consumers seek out comfort foods as the world recovers from COVID-19 uncertainty.<sup>21</sup>



## CONSUMER PURCHASE BEHAVIOR

With the proper positioning and marketing, we see potential for alfalfa milk to drive customer adoption by focusing on three primary pain points. These pain points are: 1) Consumers want products that make them feel healthier, 2) Consumers want products that have superior sensory properties to the competition, and 3) Consumers want products that are sustainable.

In terms of health, one of the primary drivers of adoption of plant-based dairy replacements is uneasiness with hormones in antibiotics and dairy products.<sup>22</sup> In addition, intolerance and other health concerns have led 51% of Americans to adopt restrictive diets that lead to increased consumption of plant-based products.<sup>22</sup> Consumers see plant-based milks as important sources of nutrition – it's worth noting that this is only true once one accounts for fortification. A LEK Consulting analysis demonstrated that the most desired claims for plant-based milks were locally sourced, all natural, protein rich, no artificial ingredients/preservatives, and low calorie.<sup>23</sup> Low calorie is of particular interest in the aftermath of the COVID-19 pandemic, since as of the publication of the LEK report in August 2021, 35% of Americans reported weight gain.<sup>23</sup> This statistic suggests that a lower-calorie plant milk that delivers on the desired sensory attributes relative to the market leaders oat and almond milk could drive a competitive advantage.

This observation leads us to the second potential pain point: sensory properties. A survey of the literature shows frequent references to sweetness, creaminess, and neutral taste as the top desired sensory attributes.<sup>22,24</sup> It's worth noting that these attributes come from a customer desire for plant-based milk to replicate the experience of drinking bovine milk as closely as possible.<sup>25</sup> In the converse, sensory

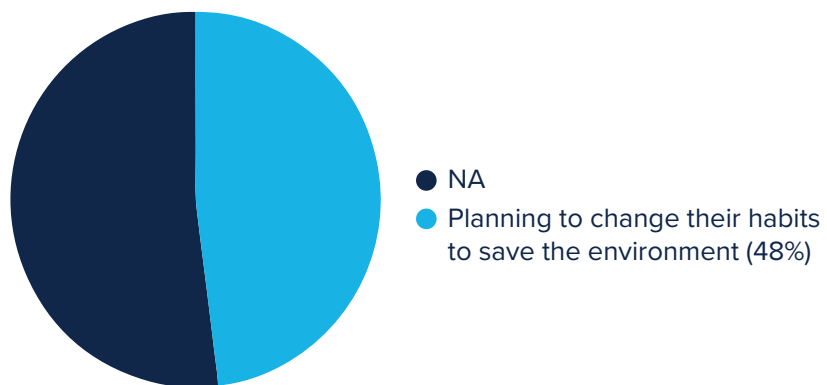
penalties are associated with grittiness, and off-flavors (unexpected flavors that consumers find unappealing) and aftertastes. Overall, the plant-based milk industry has made great strides in improving the sensory properties of their products and avoiding these penalties to a great extent. Unfortunately, these properties have required additional processing of the milks, and with consumers increasingly seeking out products that are more natural and less processed, this “fix” is in fact creating its own consumer penalty.<sup>26</sup>

While health and sensory qualities will likely continue to dominate consumer choice in this space, and would be the top two priorities for a formulator of a novel plant-based milk such as alfalfa, sustainability is a third area in which alfalfa could produce points of differentiation. Consumers are increasingly eager to better understand their foods’ supply chains and where the products they eat come from.<sup>22</sup>

Millennials, at 75%, are more likely than baby boomers, at 34%, to say they are definitely or probably changing their habits to reduce impact on the environment.<sup>27</sup>

### PERCENTAGE OF US CONSUMERS

Reference #27 (Gelski 2019)



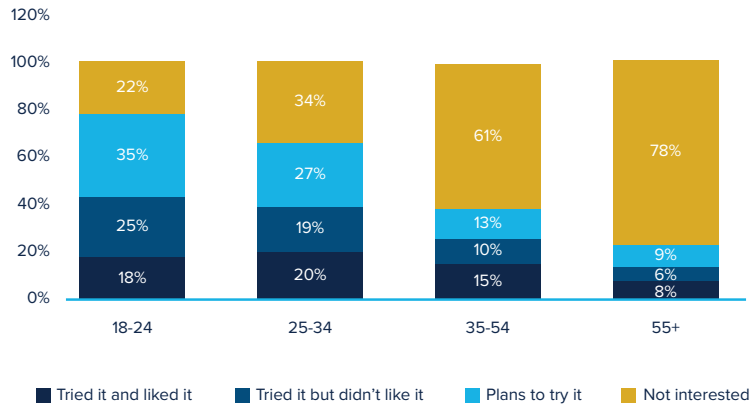
Therefore, driving transparency in any

sustainability claims that the products make would be vital to gaining customer loyalty. Despite this desire, the paradox is that consumers don’t seem to fully understand what makes products sustainable. In a conjoint analysis ranking features related to sustainability, cold chain distribution received one of the lowest scores, even though in fact refrigerated transport has perhaps one of the great carbon impacts.<sup>28</sup> The same study found that packaging is a major driver of purchase for sustainability-conscious consumers. They tend to favor glass over

cans over plastic. While this is technically the order of recyclability for these materials, this ranking assumes that the products are disposed of properly and in a municipality that actually recycles them. If not, it could be argued that glass is actually the least sustainable material, since its higher density makes it heavier to transport and thus requires more fuel. In addition, consumers tend to associate sustainability with “clean” ingredient lines, meaning that the ingredients are recognizable and perceived to be healthy. However, this is likely a spurious correlation, since there is no clear connection between these “clean” ingredients and their carbon footprint. Consumers’ confusion over sustainability metrics fortifies the argument that water is a strong messaging tool. Consumers can readily understand water requirements for different crops, and they can also see the effect of water shortages on their daily life, especially in California, a likely test market for this product. In California in recent years, droughts and land subsidence due to drawing down the water tables have interrupted consumers’ lives and damaged infrastructure.<sup>29</sup>

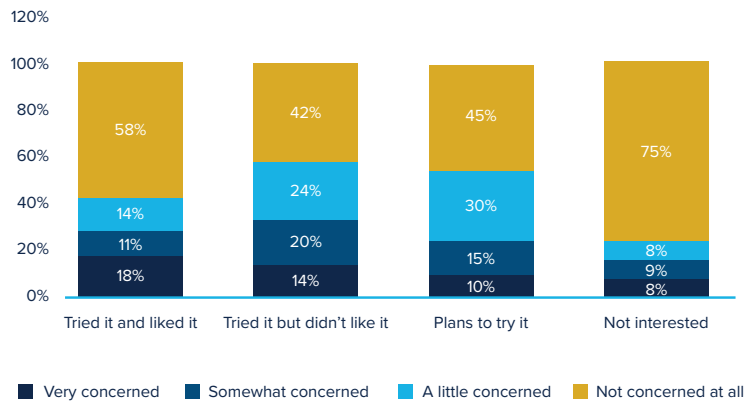
In a survey by (Aklin, 2021)<sup>30</sup>, consumers were polled on their experience with oat milk and how strongly they are concerned about the environment. It was found that the younger generations of consumers were the most likely to either have tried or have plans to try oat milk (78% for 18-24 yr. old’s). This data further emphasizes the increased prevalence of consumers wanting to try new products and implies a growing market size as Gen-Z enters the workforce and begins to have greater spending power. Interestingly, 25% of respondents reported having tried but not enjoying the beverage. This indicates that some white space still remains for other competitors to fill.

### EXPERIENCE WITH OAT MILK BY AGE



We also note that a greater proportion of respondents who have plans to try or have tried oat milk are in general more concerned about the environment than people who have no interest.

### HOW CONCERNED ARE YOU RIGHT NOW ABOUT CLIMATE CHANGE AND THE ENVIRONMENT? COMPARED WITH OAT MILK



If we apply these findings to the category, we can infer that younger generations and people who are more concerned about the environment are most likely to try a new plant-based milk. By targeting these demographics, an alfalfa milk may be best poised for success.

Overall, a combination of driving differentiation on health, taste, and sustainability could position alfalfa strongly to compete against existing plant milks in the market.

## ECONOMICS

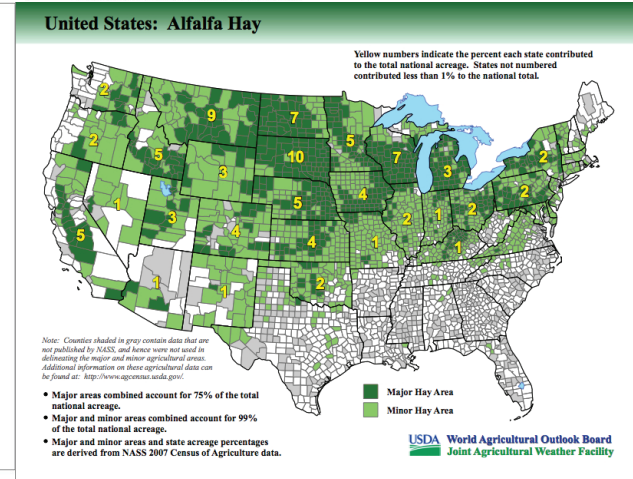
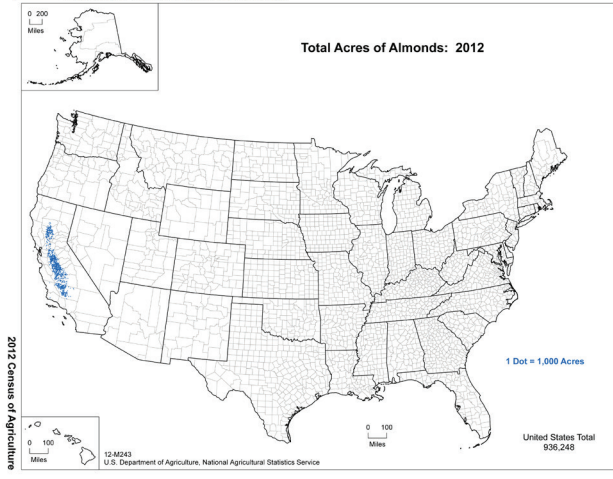
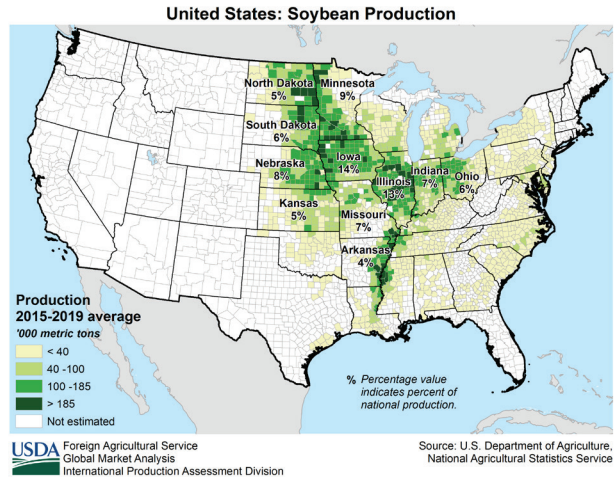
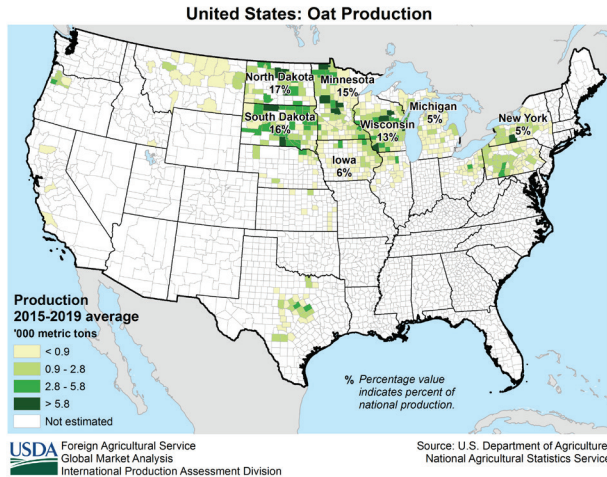
Several factors are important to consider when analyzing the economic viability of plant-based beverages: crop availability, competing purchasers, distance to production facilities, process costs, channels to market, and overall margin.

Alfalfa is the 4th largest crop in the U.S. by acreage and production value behind corn, soy, and wheat.<sup>31</sup> Thus, it is widely available and likely less subjected to the supply chain issues encountered by almond and oat. Yearly production of alfalfa averages 52,395 megatons per year (2019-2021), and the typical price received by farmers is ~\$200/ton.<sup>32,33</sup> This is significantly cheaper than soy (~\$400/ton), oat (~\$1000/ton) and almonds (\$2/lb).<sup>33,34</sup>

In addition, alfalfa has few competing purchasers, as it predominately used as animal feed. Almonds, oats, and soy, however, are typically in high demand from many manufacturers to create multiple types of food products and food ingredients.

Alfalfa can also be grown in a broader range of the contiguous United States than other plant-based milk crops. Therefore, distance to a production facility should be relatively short, less costly, and less geographically constrained than for oat, soy, or almond (of which 80% of the global supply is grown in California).<sup>36</sup>





Multiple processing methods may exist for the conversion of an alfalfa into a milk beverage. The traditional approach encompasses eight key steps: soaking, grinding, separation, enzyme or chemical hydrolysis, blanching, thermal processing, homogenization, and formulation.<sup>25</sup> What this process lacks in simplicity it makes up for in flexibility. Given the right conditions, processors can hypothetically break down any plant matter into its base components and formulate in any emulsifiers, texturizers, or flavors they may need. This flexibility in final beverage design is a competitive advantage over all traditional dairy products, as bovine milk is strictly defined by regulatory bodies such as the FDA.<sup>37</sup>

Another emerging technology is the utilization of microbial and cellular fermentation (commonly referred to as cellular agriculture) to create the macronutrients found in bovine milk.<sup>25</sup> Pending commercial feasibility,

alfalfa could be an attractive substrate candidate. However, it is still too early to accurately predict how consumers will respond to cellular agriculture's products, methods, or how much of a price premium they are willing to pay for such technology.

Several channels to market are being utilized by players in the industry. Originally, shelf-stable retail offerings were the primary form for plant-based milks, but now refrigerated varieties make up the majority of the plant-based milks category sales. A significant portion of sales are also achieved through food service partnerships, such as between Oatly and Starbucks. Oatly reports that 36% of its revenues can be attributed to the foodservice channel.<sup>11</sup> Furthermore, the e-commerce channel is expected to see the fastest growth with a CAGR of 14.10% for online oat milk sales.<sup>38</sup>

In terms of margins, Oatly reports healthy targets of 40% GP margin and a 20% adjusted EBITDA margin.<sup>11</sup> Danone reports a consolidated recurring operating margin of 13.1%.<sup>39</sup> Given alfalfa's superior availability, lower crop cost, and assuming comparable processing methods, an alfalfa-based milk may be able to achieve similar or better margins.

## NUTRITION

Another important topic in the plant-based milk sector is the validity of products' nutrition claims and related comparability to traditional cow milk. Many consumers perceive these products to be innately healthier due to their plant-based origin, yet large variation exists within the category. Extensive research is available on the topics of soy and almond milk as they have been in the market for the greatest amount of time. The comparatively newer offerings such as oat and pea milk have less readily available data. Below, the top 6 alternative milk types by revenue have been compared to each other and to traditional dairy. Hypothetical values have been included in the alfalfa column to showcase the minimum nutrient content required to compete nutritionally with the other offerings. These values fulfill the “good” source of each nutrient claim as defined by 21-CFR-101.54(c) per 240 mL serving, which is approximately equal to 1 cup of liquid milk.<sup>40</sup>

# NUTRITION COMPARABLE MATRIX

Nutritional Comparison per 240mL of product

Components	Recommended Dietary Allowance (RDA) *Average for M&F ages 19-50*	Recommended Dietary Allowance (RDA) *Average for M&F ages 19-50*									
		Animal Milk (Cow)			Almond	Oat	Alfalfa★	Soy	Rice	Pea	Coconut
		Whole	2%	NF	Milk	Milk	Hypothetical	Milk	Milk	Milk	Milk
Carbohydrates (g)	130	12	12	5.1	1.3	16	-	5.0	25	6.0	1.2
Sugars	-	12	12	5.1	0.1	9.8	-	3.4	13	6.0	0.6
Fibers	30	0.0	0.0	0.0	0.6	1.9	3.0	1.0	0.0	-	0.3
Fats (g)		8.0	4.7	0.1	2.7	3.6	-	4.4	2.3	4.5	4.4
Saturated	<23	4.6	2.7	0.0	0.0	-	-	0.6	0.2	0.5	4.1
MUFA & PUFA	16	2.0	1.1	0.0	2.3	-	1.6	3.2	2.0	4.0	0.0
Proteins (g)	51	8.1	8.2	3.4	1.7	2.4	5.1	8.7	0.9	8.0	0.0
Minerals (mg)		-	-	-	-	-	-	-	-	-	-
Calcium	1000	306	309	132	325	288	100	206	246	360	245
Iron	13	0.0	0.0	0.0	0.2	-	1.3	0.8	0.1	-	0.1
Magnesium	362	30	29	13	21	-	36	49	35	-	35
Phosphorus	700	251	252	107	48	-	70	108	63	-	0
Potassium	3000	374	390	167	65	-	300	364	50	-	47
Sodium	2300	95	96	41	146	-	-	65	72	130	64
Zinc	9.5	1.1	1.1	0.5	0.6	-	1.0	0.8	0.8	-	0.7
Vitamins		-	-	-	-	-	-	-	-	-	-
Vitamin C (mg)	83	-	-	-	0.0	-	-	0.0	0.0	-	0.0
Thiamine (B1) (mg)	1.2	0.1	0.1	0.1	-	-	0.1	0.1	-	-	-
Riboflavin (B2) (mg)	1.2	0.3	0.3	0.1	0.2	0.5	0.1	0.2	0.3	-	-
Niacin (B3) (mg)	15	0.3	0.3	0.1	-	-	1.5	0.3	-	-	-
Pyrodoxamine (B6) (mg)	1.3	0.9	1.0	0.4	-	-	-	0.1	-	-	-
Folate (B9) (µg DFE)	400	0.0	4.9	2.0	19	-	40	34	-	-	19
Cobalamine (B12) (µg)	2.4	1.3	1.4	0.6	1.0	0.9	0.2	0.7	1.0	-	0.8
Vitamin A (µg)	800	80	203	64	77	-	80	33	68	80	60
Vitamin E (mg)	15	0.1	0.1	0.0	3.8	-	1.5	4.0	3.0	-	-
Vitamin D (µg)	15	2.4	2.8	1.1	2.3	3.6	1.5	1.9	2.1	1.5	2.9
Vitamin K (µg)	102	-	-	-	-	-	10.5	-	-	-	-
Total Energy (kcal)	2100	152	122	34	36	110	-	95	133	100	49
Major Allergen?		Yes	Yes	Yes	Yes	Potentially	No	Yes	No	No	Yes
Reference ID	41	42	42	42	43	44	41	43	43	44	43

\*indicates that product may be a "good" or better source of specified nutrient (10-19% of RDA)

Based on this data, plant-based milks appear to be successful in reducing the proportion of saturated fatty acids to unsaturated, offering a lower sugar option than traditional milk, and reducing calories per serving. Calorie reduction may seem paradoxical since the historical role of food has been to provide as many bioavailable calories to the body as possible. However, we are seeing an ever-changing food landscape where consumers are shifting their focus from calorie dense foods to ones that are nutritionally dense, satiating, or impact driven.

Plant based milks are generally superior in magnesium, folate, and vitamin E, while lacking vitamin B6. Interestingly, soy milk is relatively high in iron, potassium, and protein, making it the strongest plant-based competitor nutritionally. It appears that the common nutrients prevalent in traditional milk such as calcium, and vitamin's A, D, and B12, have been adequately addressed by the plant-based milk industry through the use of fortification and enrichment. Alfalfa and pea both have a natural presence of vitamin A which may alleviate some of these costs. Alfalfa also naturally has a significant level of vitamin C and K which could potentially be a source of differentiation. In addition to the macro and micronutrient differences, each of these milk products contain functional nutrient benefits and antinutrient risks. A summary of the current plant-based milks functional benefits can be found in Sethi, Swati's 2016 Review.<sup>45</sup>

**Alfalfa Functional Components:** In animal studies, alfalfa has been shown to lower LDL cholesterol while promoting HDL cholesterol due to its high content of saponins, a type of glycoside naturally occurring in plants.<sup>47,48,49</sup> This makes it a potential agent for people suffering from hyperlipidemia. Alfalfa extract has also been shown to potentially treat hyperglycemia, heart disease, stroke, cancer, atherosclerosis, osteoporosis, menopausal symptoms in women (due to phytoestrogen content), and reduce blood triglyceride levels.<sup>47</sup> These effects are mostly attributed to alfalfa's high content of antioxidants and other phenolic compounds.<sup>48</sup>



**Anti-Nutrients Risks:** Two major nutritional risks may be associated with Alfalfa consumption. These include the risk of induced systemic lupus erythematosus (SLE) and the risk of induced pancytopenia. SLE is believed to have been induced by the compound canavanine naturally found within the seed in concentrations of 8.33mg/kg. Ingestion of 80-160 g/day of ground alfalfa seeds was shown to cause pancytopenia in humans and thought to be attributed to seed saponins. Alfalfa top saponins however, have shown no evidence of toxicity.<sup>49,50</sup> While the hazard may be significant, the risk is low and comparable to frivolous concerns made about cyanide in apple seeds. In addition, anti-nutritional and functional challenges are not unique in the plant-based sector and have been overcome in the current leading varieties as well.<sup>45</sup>

**Regulatory:** Overall, alfalfa is considered a safe food ingredient. In the U.S., alfalfa is listed as GRAS (generally recognized as safe) according to the FDA 21CFR182.10.<sup>51</sup> It is also listed by the Council of Europe as a source of natural food flavor (category N2 and N3).<sup>47</sup>

## SUSTAINABILITY

How purchase decisions affect global health has become an ever-increasing topic of importance to consumers.<sup>27</sup> However, customers have difficulty judging the relative difference in impact between products or even entire food categories.<sup>28</sup> The four most widely used metrics for measuring a product's sustainability are: land use, water use, greenhouse gas (GHG) emissions, and eutrophication & acidification. Several comprehensive studies exist to compare these metrics within the milk category.<sup>52,53,54,55,56</sup> The insights derived from these studies however are highly dependent on the basis in which we value food production. The basis is essentially what we gain per unit of environmental cost. Basis used by researchers have been kg of protein, calories, and liters of product. While protein is an important macronutrient, making it the sole basis for a milk-product sustainability claim has little validity; foods are innately complex systems with varying proportions of macro and micronutrients that themselves have varying degrees of importance to the final consumer's health. In addition, milk's sole purpose in the diet is not to supply the average person's protein requirement, since protein can be accessed in other sources such as meat, protein powders, and legumes. Calories produced per environmental unit makes scientific sense as a basis of comparison, since creating bioavailable calories is the sole purpose of food production. That said, in a world where 50% of malnutrition is attributed to the overconsumption of calories and obesity,<sup>57</sup> we must acknowledge that communicating sustainability claims based on calories is hardly in alignment with global need or consumer's goals. Therefore, liters of product produced per environmental unit is the best basis for milk sustainability messaging. It is easily understood, communicated, and aligned consumer's milk purchase behavior. Milk consumers typically choose products based on net weight of product (fl. oz.) rather than by grams of protein/serving or maximum calories provided.

In Poore and Nemecek’s 2018 global review<sup>52</sup>, soy milk outcompetes almond and oat milk in three of the four sustainability metrics. In Wenzel, Paula, and Niels Jungbluth 2017 study in Switzerland, soy milk was again the top performer – it had the least amount of environmental impact compared to other plant-based milks.<sup>53</sup> For this reason we will compare alfalfa milk to soy as well as the most recent newcomer to the plant-based milk scene, pea-milk. In addition, agricultural methods account for most of the environmental impact attributed to each of the plant-based milks. Therefore, it is key to understand the **agriculture practices** employed for the raw commodity of any future plant-based milk. Growing locations will undoubtedly make significant contributions to a product’s GHG emissions/L of milk score.

By using FAO and USDA crop database information <sup>58,59</sup>, inferences can be made on the

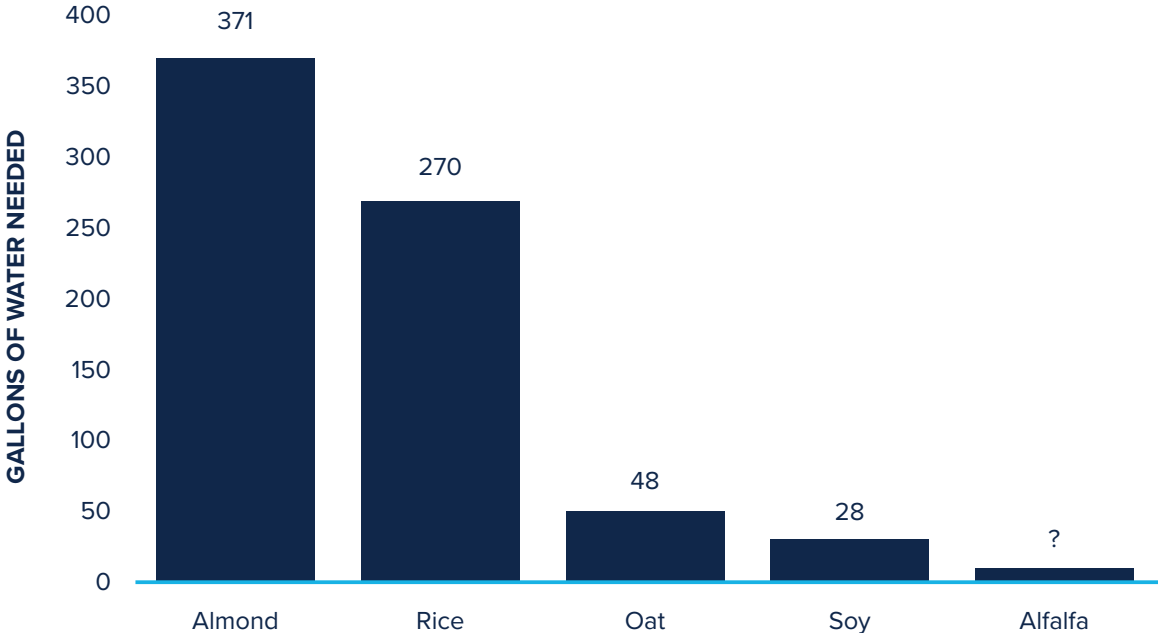
land use, water use, and eutrophication & acidification impact of alfalfa in comparison to soy and pea. We can see that alfalfa has the potential to outcompete soy, (the current plant-based milk sustainability leader) as well as pea in both land and water usage. However,

<b>Metrics</b>	<b>Alfalfa (hay)</b>	<b>Soy</b>	<b>Pea (dry)</b>	<b>Pea (fresh)</b>
Yield (ton/ha)	2.0 to 28.0	1.5 to 3.5	0.6 to 0.8	2.0 to 3.0
Water Utilization Efficiency (Ey)	1.5 to 2.0	0.4 to 0.7	0.15 to 0.20	0.5 to 0.70
Ey M.C. %	10 to 15	6 to 10	12	70 to 80
<b>Fertilizer Requirements (kg/ha)</b>				
	<b>Alfalfa</b>	<b>Soy</b>	<b>Pea</b>	
N	NA*	NA*	20 to 40	
P	55 to 65	15 to 30	40 to 70	
K	75 to 100	25 to 60	80 to 160	
<b>Fertilizer Requirements (kg/ha)</b>	<b>Alfalfa (hay)</b>	<b>Soy</b>	<b>Pea (dry)</b>	<b>Pea (fresh)</b>
N	NA*	NA*	25 to 67	6.7 to 20
P	2.0 to 32.5	4.3 to 20	50 to 117	13.3 to 35
K	2.7 to 50	7.1 to 40	100 to 267	26.7 to 80

the range of fertilizer requirements may pose a risk for alfalfa to be a greater contributor of eutrophication and acidification effects on the environment in comparison to soy milk, while still vastly beneath dry

pea or traditional cow’s milk. We believe that of the four environmental impact metrics, water usage is the easiest for consumers to relate to. Therefore, making a product claim on this portion of sustainability will

**WATER USE PER GALLON OF ALT-MILK**



likely be met with the most success.

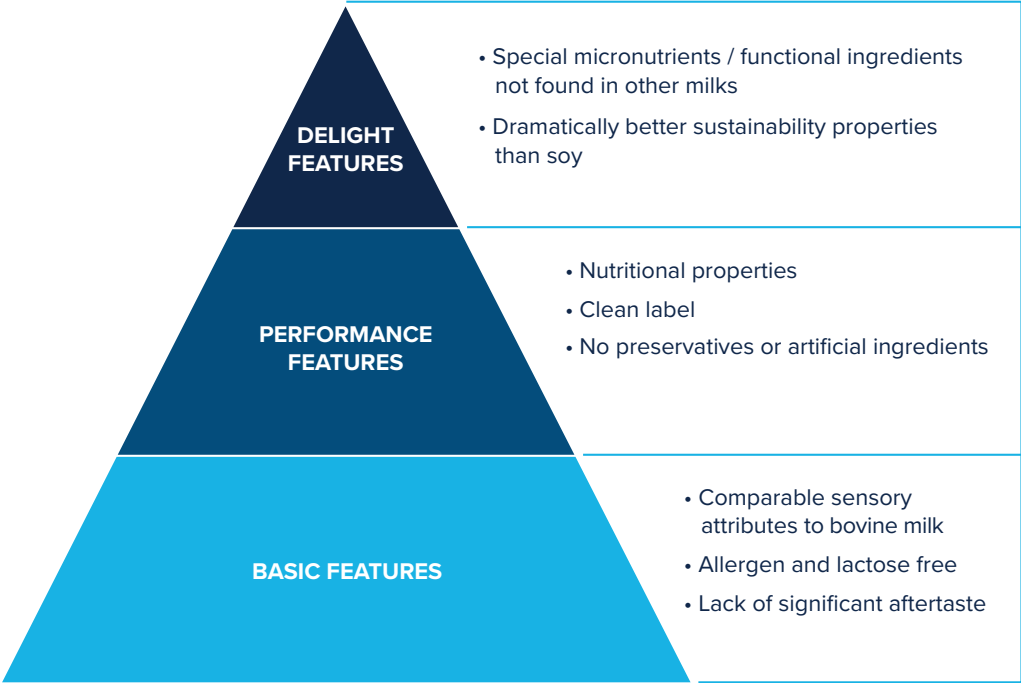
44

Since alfalfa’s water utilization efficiency is superior to soy milk, an opportunity might exist for it to have a superior water use claim if created by similar processing methods.

# FEATURE FRAMEWORKS

Overall, we propose the following frameworks to evaluate a new plant-based milk. In the Kano model, plant-based milk features are divided into basic, performance, and delighters.

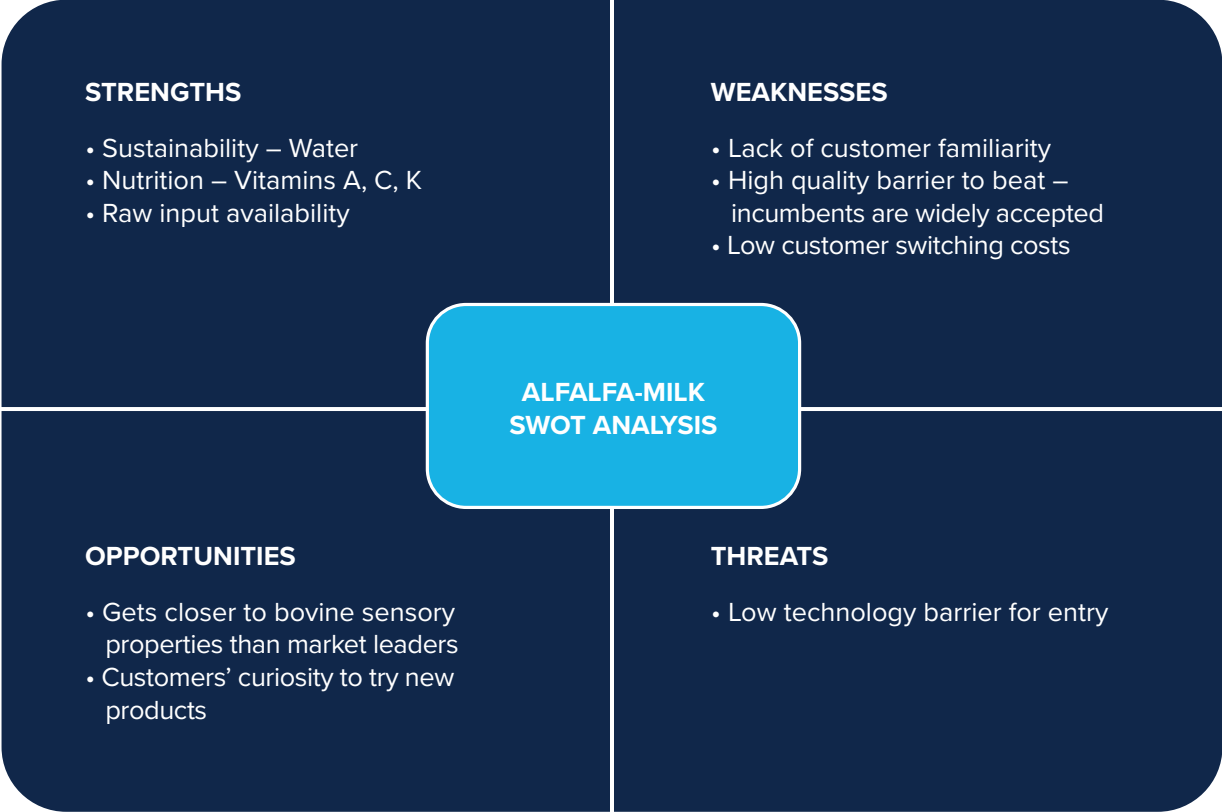
## KANO MODEL – IDEAL PLANT-BASED MILK



Basic features are the ones required at a minimum by the customer. Performance features will allow a new product to compete adequately in the market, while delighters would truly distinguish a new product from what is currently available and give a company’s product a competitive advantage.



The below SWOT model details identified Strengths, Weaknesses, Opportunities, and Threats for Alfalfa milk or an analogous ideal plant-based milk.



## INVESTMENT LANDSCAPE

During a time of an immense amount of VC funding, alternative milk companies have been no exception. Recent investment activity highlights the optimistic outlook of the market on the future of the category.

In the past year (2021), we have seen Oatly have a \$1.4B IPO (NASDAQ: OTLY), NotCo reach a valuation of \$1.5B, Perfect Day raise a massive \$350M Series D, ReMilk raise \$120M Series B, Ripple Foods raise \$60M Series E, and several smaller fundraising rounds such as: Turtle Tree (\$30M), Biomilq (\$21M), Urban Remedy (\$18M), The Planting Hope Company (\$10.35M via IPO - TSXV: MYLK), Goodmylk (>\$5.5M), Sproud (€4.8M), VidaVeg (R\$18M), MOA Foodtech (€1.5M), and Maya Milk (\$200K).<sup>1,60,61,61(b)</sup>

Major players such as Danone, Blue Diamond, and Califia Farms continue to invest in the category and launch new products as well. These developments put the total amount of capital invested in 2021 >\$1.8B. This certainly dwarfs the once record year of plant-based milk investments in 2020 of \$450M. Key investors in alternative milk have been Big Idea Ventures, KBW Ventures, Novo Holdings, Siddhi Capital, Stray Dog Capital, Temasek Holdings, Unovis Asset Management, VegInvest, VGC Partners, and Verso Capital.<sup>1,61</sup> We believe this space will continue to receive well-deserved attention, especially as ESG and impact investing continue to climb.<sup>62</sup>

## CONCLUSION

Based on our analysis, the plant-based milk sector will continue to see growth. The impressive CAGR of plant-based beverages, combined with the younger generation's interest in sustainable, healthy eating focused on new flavors and varieties presents overall favorable conditions. A new plant-based milk concept, such as alfalfa, would need to maximize several differentiating factors such as water-use and functional components. While consumers have a desire to find new and unique products, a strong brand and exceptional quality from the start may also be needed to drive repeat purchases beyond consumer's initial curiosity. With these combinations of factors, we believe that there is ample opportunity for a new plant-based milk company to succeed and capture a significant portion of the growing market size.

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