ISBN: 978-628-96613-3-0. ISSN: 2414-6390. Digital Object Identifier: https://dx.doi.org/10.18687/LACCEI2026.1.1.1701

Comparative Evaluation of Proximate Composition, Fatty Acids, and Color Attributes of Conventional Cheeses and Plant-Based Cheese Analogues

Ramón Astul Pineda Rodas[1]; Valerie Ivonne Rodas Carranza[1]; Anna Anggela Papadatos-Beis Lobos[1]; Monserrat Abigail Galvez Rodas[1]; Lurvin Israel Ventura Caballero[1]; Ramón Ariel Romero Ochoa[1];
[1]Food Science and Technology Department, Zamorano University, Honduras, ramonpineda1998@gmail.com, valerie.rodas@est.zamorano.edu, anna.papadatos@est.zamorano.edu, monserrat.galvez@est.zamorano.edu, lurvin.ventura@est.zamorano.edu, ramon.romero@est.zamorano.edu

Abstract*– This study conducted a comparative physicochemical analysis of traditional dairy cheeses (Cheddar, Mozzarella, and Parmesan) and their plant-based analogues. Compositional analysis included moisture, ash, organic matter, protein content and fatty acid profiling. Physical analysis included color (CIE L*a*b*). Results revealed significant differences; dairy cheeses exhibited higher protein (19.36–29.35% vs. 1.93–2.24%), lower moisture (31.02–48.70% vs. 46.30–48.61%), and distinct fatty acid profiles dominated by palmitic acid (35.93–37.49%). Plant-based analogues showed uniform moisture and high lauric acid content (24.76–25.03%). Compositional disparities highlight that plant-based alternatives, while visually similar, lack protein and exhibit higher sodium content. These findings inform consumer choices and product development for sustainable cheese analogues.

***Keywords*-- Cheese alternative, dairy cheese, intolerance, protein quality, Vegetarian.**

I. Introduction

Physicochemical analyses are essential for understanding food product composition, quality, processing behavior, storage stability, and regulatory compliance. Traditional cheese, a highly consumed and nutritionally relevant dairy product, possesses a matrix primarily composed of proteins, fats, minerals, and compounds governing its sensory properties and consumer's acceptance. Driven by trends in veganism, food intolerances, and sustainability, plant-based cheese analogues have emerged. These are produced by emulsifying plant-based oils and proteins under heat and shear to mimic traditional cheese [1]. However, they exhibit significant differences in chemical composition and structure compared to their dairy counterparts.

Furthermore, plant-based cheeses demonstrate considerable variability in nutritional profiles and physicochemical properties due to the diverse range of raw materials used (e.g., starches, legumes, nuts, plant oils like coconut), which critically impact their composition, structure, behavior, and texture [2]. This variability complicates comparisons with traditional cheese regarding health benefits and functional performance. Consequently, detailed physicochemical comparison is crucial for consumers, producers, and researchers to evaluate quality, ensure consistency, and guide improvements in plant-based cheese formulations.

II. Objectives

To compare the proximate composition and fatty acid profile of Cheddar, Mozzarella, and Parmesan cheeses and their plant-based analogues.

To evaluate the color characteristics of Cheddar, Mozzarella, and Parmesan cheeses and their plant-based analogues.

III. Methods and Materials

Commercial Mozzarella, Parmesan (Kraft Heinz, Chicago, IL, USA), and Cheddar dairy cheeses (Crystal Farms Dairy Co., Edina/Minnetonka, MN, USA) were purchased from local grocery stores. In addition, commercial plant-based cheeses (Daiya Foods Inc., Burnaby, BC, Canada) were also purchased from a local grocery store.

A proximal analysis was performed on traditional cheeses (Cheddar, Mozzarella, Parmesan) and their plant-based analogues to characterize key physicochemical properties. The analyses were conducted at the Food Analysis Laboratory of Zamorano University (Valle de Yeguare, Honduras). These included: crude protein (AOAC 2001.11), moisture (AOAC 950.46B), total minerals (ash and indirect organic matter, AOAC 923.03), fatty acid profile (ISO 5509, AOCS Ce 2b 11 and AOCS Ce 1j-07) and color (CIE L*a*b*). All procedures were performed in triplicates.

This characterization is essential given the significant compositional and structural differences between traditional dairy cheese and plant-based analogues, the latter exhibiting high variability due to diverse ingredient bases (e.g., starches, legumes, nuts, plant oils).

Color analysis was performed using a HunterLab ColorFlex® Model 45/0 spectrophotometer calibrated with standard black and white tiles, and using the coordinates L*, a* and b*. Following standardized protocols, triplicate measurements of L* (lightness), a* (green-red), and b* (blue-yellow) values were obtained for all cheese samples (traditional and plant-based analogues) in clean glass cuvettes. For this analysis, the samples were previously homogenized.

Moisture and ash content were determined by gravimetric methods following AOAC (1975) official procedures. Moisture analysis involved drying samples at 100–102°C for 18 hours in a hot-air oven until constant weight was achieved, using pre-dried crucibles cooled in a desiccator. The weight difference before and after drying represented moisture content.

Ash content was quantified via dry ashing in a muffle furnace at 550°C for 6 hours until light gray residues (indicating complete organic matter removal) were obtained. Crucibles were similarly cooled in a desiccator before weighing to calculate total mineral content. These established methods provide reliable determination of essential quality parameters in cheese analysis [3], organic matter was determined using a differential method.

Crude protein content was determined using the Kjeldahl method [3]. Homogenized samples were weighed into parafilm: 0.5000 ± 0.0050 g for traditional cheeses (3–25% fat range) and 1.000 ± 0.0050 g for plant-based analogues. Samples in digestion tubes received two Kjeltabs® catalysts and 12.0 mL concentrated H_2SO_4. Digestion proceeded at 420°C for 60 minutes until clear-green solutions formed, with tubes cooled under aluminum foil to prevent nitrogen loss. Distillation used an automated unit, with liberated ammonia captured in 30.0 mL of 4% H_3BO_3 and titrated with standardized hydrochloric acid. Total nitrogen was converted to crude protein using dairy-specific (6.38) and general food (6.25) conversion factors for traditional and plant-based samples, respectively.

Crude fat quantification was not performed experimentally in the laboratory; to interpret the results, only the information provided by each product on its nutritional label was used. The fatty acid content of each sample was evaluated. For this purpose, the methyl esters of fatty acids were prepared using the official methods ISO 5509 and AOCS Ce 2b-11. Each preparation was performed in triplicate for each sample. The AOCS Ce 1j-07 method and an Agilent Technologies 7890A gas chromatograph (Santa Clara, California, USA) were used for the determination and quantification of fatty acids.

A completely randomized design (CRD) was used to evaluate the six treatments (3 conventional and 3 analog cheeses). Three replicates were performed for each treatment, for a total of 18 experimental units. The experimental data were analyzed using SAS® Statistical Analysis System version 9.4, through analysis of variance (ANOVA) and Duncan's multiple range test, at a significance level of ≤ 0.05 to observe significant differences between treatments for all variables evaluated.

IV. Results and discussion

Table 1 shows the color characteristics of traditional cheeses (Cheddar, Mozzarella and Parmesan) and their plant-based analogues, quantified in the CIE L*a*b* color space. Values for lightness (L*), green-red coordinate (a*), and blue-yellow coordinate (b*) are reported as mean ± standard deviation. This data provides an objective, quantitative comparison of visual appearance differences between dairy and plant-based samples.

Significant color differences ($p<0.05$) were observed between all traditional cheeses and their plant-based analogues through CIE L*a*b* analysis (Table 1). Compared to cheddar cheese, its analogue exhibited lower lightness (darker), higher a* (redder), and higher b* (yellower) values, yielding a perceptible difference ($\Delta E \approx 7.70$). Mozzarella's analogue showed reduced lightness, increased a* (redder), and decreased b* (less yellow) versus traditional mozzarella ($\Delta E \approx 5.89$), indicating moderate visual distinction. Parmesan's analogue demonstrated markedly reduced lightness and increased a* (redder) despite similar b* values, resulting in a clearly perceptible $\Delta E \approx 7.70$.

These deviations likely stem from plant-based formulations where:

(i) Vegetable oils and modified starches alter light scattering properties [4].
(ii) Colorants or flavorings mimic maturation notes [5].
(iii) Ingredient interactions affect surface gloss and chromatic balance.

TABLE I
COLOR MEASUREMENT OF DAIRY CHESSES AND THEIR PLANT-BASED ANALOGUES.

Sample	Color value		
	L* Mean ± S.D.	a* Mean ± S.D.	b* Mean ± S.D.
Cheddar	70.23±0.06^{E}	24.32±0.06^{B}	48.92±0.18^{B}
Cheddar Analogue	64.33±0.25^{F}	25.56±0.20^{A}	53.71±0.40^{A}
Mozzarella	84.65±0.11^{B}	0.62±0.11^{F}	26.17±0.26^{C}
Mozzarella Analogue	80.29±0.06^{C}	2.90±0.06^{C}	22.93±0.13^{E}
Parmesan	86.52±0.09^{A}	0.91±0.08^{E}	22.59±0.16^{E}
Parmesan Analogue	78.81±0.09^{D}	2.37±0.06^{D}	23.43±0.16^{D}
CV%	0.17%	1.15%	0.71%

$^{A-F}$: Different letters in each column indicate a significant difference between values ($p<0.05$). S.D.: standard deviation. L*: lightness (0 = black, 100 = white). a*: green-red chromaticity (approx. -60 = green, +60 = red). b*: blue-yellow chromaticity (approx. -60 = blue, +60 = yellow).

Table 2 presents the moisture and organic matter content of traditional cheeses (Cheddar, Mozzarella and Parmesan) and their corresponding plant-based analogues; a critical parameter influencing texture, microbial stability, and shelf life. Results are expressed as mean percentage ± standard deviation, providing quantitative comparison of hydration differences between dairy and alternative formulations.

TABLE 2.
MOISTURE AND ORGANIC MATTER CONTENT OF DAIRY CHESSES AND THEIR PLANT-BASED ANALOGUES.

Sample	Moisture% Mean ± S.D.	Organic matter% Mean ± S.D.
Cheddar	$34.79{\pm}0.06^{C}$	$61.62{\pm}0.03^{A}$
Cheddar Analogue	$46.30{\pm}0.04^{B}$	$50.58{\pm}0.11^{B}$
Mozzarella	$48.70{\pm}0.23^{A}$	$47.98{\pm}0.24^{C}$
Mozzarella Analogue	$48.61{\pm}0.03^{A}$	$46.65{\pm}0.16^{D}$
Parmesan	$31.02{\pm}1.20^{D}$	$62.56{\pm}1.04^{A}$
Parmesan Analogue	$48.36{\pm}0.01^{A}$	$46.33{\pm}0.11^{D}$

$^{A\text{-}D}$: Different letters in each column indicate a significant difference between treatments ($p<0.05$). S.D.: standard deviation.

Moisture analysis revealed distinct patterns between cheese types (Table 2). Traditional cheeses exhibited expected variation: Parmesan (31.02%) and Cheddar (34.79%) showed significantly lower moisture ($p<0.05$), consistent with their aged, firm textures, while fresh Mozzarella (48.70%) demonstrated higher hydration. In contrast, plant-based analogues displayed uniform moisture levels (46–48%), reflecting standardized industrial formulation practices [6]. Notably, this analogues range exceeded moisture content in aged dairy cheeses but was comparable to fresh Mozzarella. Wider literature comparisons reveal certain plant-based substitutes can reach 52–56% moisture [7], exceeding even high moisture dairy variants like buffalo Mozzarella (55.15 ± 0.88% [8]. These variations underscore how moisture content depends on both product category (aged vs. fresh) and specific production parameters, including milk origin and processing methods.

The organic matter represents the non-mineral fraction of composition calculated indirectly from ash content. This parameter reflects key nutritional components including proteins, lipids, and carbohydrates that influence functional and sensory properties. A confirmed inverse relationship existed between moisture and organic matter content (Table 2). Traditional cheeses exhibited characteristic compositional patterns: lower moisture Parmesan (62.56% organic matter) and Cheddar (61.62%) contained higher organic solids, while higher moisture Mozzarella (47.98%) showed reduced organic content. Plant-based analogues on the other side displayed consistently lower organic matter (46.33–50.58%) than all dairy counterparts. This reduction stems from formulation strategies where starch based bulking agents and hydrocolloids dilute protein and lipid fractions, primary organic constituents in dairy matrices. Lower protein levels (0.1–1.7 g/100 g) in plant-based substitutes versus dairy cheeses, directly contributing to diminished organic solids. Collectively, these compositional divergences demonstrate how analogues achieve textural mimicry through carbohydrate rich systems rather than replicating the protein lipid nutritional profile of traditional cheese [9].

TABLE 3.
CRUDE PROTEIN, ASHES AND FAT CONTENT OF DAIRY CHESSES AND THEIR PLANT-BASED ANALOGUES.

Sample	Crude Protein% Mean ± S.D.	Ashes% Mean ± S.D.	Fat%*
Cheddar	$19.36{\pm}0.10^{C}$	$3.59{\pm}0.03^{D}$	24.5
Cheddar Analogue	$2.24{\pm}0.10^{D}$	$3.13{\pm}0.15^{E}$	22
Mozzarella	$21.19{\pm}0.52^{B}$	$3.32{\pm}0.02^{DE}$	14.5
Mozzarella Analogue	$1.93{\pm}0.05^{D}$	$4.74{\pm}0.13^{C}$	20
Parmesan	$29.35{\pm}0.33^{A}$	$6.43{\pm}0.16^{A}$	26
Parmesan Analogue	$2.06{\pm}0.05^{D}$	$5.32{\pm}0.09^{B}$	19.5

$^{A\text{-}E}$: Different letters in each column indicate a significant difference between treatments ($p<0.05$). S.D.: standard deviation. *: these results were obtained from the nutritional facts of the products and not by laboratory analyses.

The results in table 3 reveal clear compositional differences between the dairy cheeses and their analogues. Among the dairy samples, ash contents were consistent with those reported in literature: Cheddar (3.59 ± 0.03 %), Mozzarella (3.32 ± 0.02 %), and Parmesan (6.43 ± 0.16 %), aligning with the typical range of 3–6% for semi hard cheeses, with Parmesan showing higher ash content due to its longer maturation period [10]. High ash levels in traditional cheeses are associated with desirable characteristics such as rind formation and flavor development.

In contrast, plant-based cheese analogues exhibited greater variability. The Cheddar analogue showed a slightly lower ash value (3.13 ± 0.15 %) than its dairy equivalent, while the Mozzarella analogue (4.74 ± 0.13 %) was higher, and the Parmesan analogue (5.32 ± 0.09 %) was notably lower. These results differ from previous studies reporting higher ash content in plant-based cheeses due to mineral fortification [11]. Such discrepancies may arise from differences in formulation, ingredient selection, or regional product availability [12], as observed in Honduran markets. Similar findings in Spain reported that plant-based cheese alternatives tend to have lower calcium and protein, but higher salt content compared to dairy counterparts [13].

Nutritional facts information of the plant-based samples confirmed this trend, showing elevated sodium (240–330 mg per serving) and low protein content (1-2 g), with variable calcium levels (122–311 mg). Although fortified, these products displayed imbalanced nutrient profiles, indicating that while ash content provides insights into mineral presence, its interpretation must be integrated with the overall nutritional composition to accurately assess product quality and equivalence.

The protein analysis revealed a significant contrast between dairy and plant-based cheeses across all samples, the dairy cheeses contained substantially higher protein levels: Cheddar (19.36 ± 0.1%), Mozzarella (21.19 ± 0.52%), and Parmesan (29.35 ± 0.33%). In contrast, the plant-based alternatives showed markedly lower contents: Analogue Cheddar (2.24 ± 0.1%), Analogue Mozzarella (1.93 ± 0.05%), and Analogue Parmesan (2.06 ± 0.05%).

These findings align with existing research confirming that plant-based cheeses typically contain around 2% protein, while dairy cheeses range from 20% to over 30%, depending on the processing method [14]. For instance, one comparative study found that dairy-based cheeses averaged 20.7% protein, while their vegan counterparts contained only 13.3% [15], further supporting the results of these analyses.

Beyond the quantity, the quality of the protein is a critical factor to consider. Dairy proteins, namely casein and whey, are renowned for their high biological value, offering benefits such as excellent digestibility and a complete profile of all essential amino acids. This is reflected in their ideal Protein Digestibility-Corrected Amino Acid Score (PDCAAS) of 1.0, indicating full amino acid availability. Conversely, plant-based proteins like pea protein used in the analyzed plant-based cheeses typically score between 0.6 and 0.9 on the PDCAAS due to limiting amino acids [16]. Therefore, even when present, the protein in plant-based cheeses may not provide the same nutritional quality or health benefits.

The unrivaled PDCAAS of dairy proteins is not only due to their complete amino acid profile but also their enhanced digestibility, which is improved through the cheese ripening process. During maturation, enzymes progressively break down long casein molecules into smaller peptides and free amino acids via proteolysis. This breakdown makes the nutrients significantly easier for the human digestive system to absorb.

The results presented in table 3 show a noticeable variation in fat content between dairy cheeses and their plant-based analogues. Among the dairy samples, Parmesan had the highest fat percentage (26%), followed by Cheddar (24.5%) and Mozzarella (14.5%). In contrast, the plant-based analogues displayed different trends: the Cheddar and Parmesan analogues contained slightly lower fat levels (22% and 19.5%, respectively), whereas the Mozzarella analogue exhibited a higher fat content (20%) compared to its dairy counterpart. These variations may be attributed to the types of oils and emulsifiers used in plant-based formulations, which can alter the overall lipid composition and texture of the final product.

As shown in table 4, the comparative analysis of the fatty acid profiles reveals fundamental and statistically significant differences between traditional dairy cheeses and their cheese analogue counterparts. These distinctions are a direct consequence of their fat sources: milk fat for traditional cheeses and, most likely, a blend of vegetable oils such as coconut and palm for the analogues.

TABLE 4.
FATTY ACID PROFILE OF DAIRY CHESSES AND THEIR PLANT-BASED ANALOGUES.

Main fatty acids	Cheddar (g/100 g)* Mean ± S.D.	Cheddar Analogue (g/100 g)* Mean ± S.D.
C12:0	3.40±0.09^{B}	24.90±0.20^{A}
C14:0	11.35±0.15^{C}	12.51±0.08^{AB}
C16:0	37.49±0.12^{A}	9.41±0.14^{B}
C18:0	11.62±0.09^{B}	3.30±0.05^{D}
C18:1, N9 (ω- 9)	21.22±0.48^{C}	36.38±0.64^{AB}
C18:2, n9, 12,(ω-6)	2.44±0.06^{D}	7.32±0.09^{A}
	Mozzarella (g/100 g)* Mean ± S.D.	Mozzarella Analogue (g/100 g)* Mean ± S.D.
C12:0	3.72±0.03^{B}	25.03±0.58^{A}
C14:0	11.43±0.07^{C}	12.78±0.05^{A}
C16:0	36.99±0.25^{A}	9.55±0.13^{B}
C18:0	11.27±0.03^{C}	3.20±0.12^{D}
C18:1, N9 (ω- 9)	19.10±0.16^{D}	37.57±0.51^{A}
C18:2, n9, 12,(ω-6)	2.58±0.04^{D}	6.45±0.02^{B}
Main fatty acids	Parmesan (g/100 g)* Mean ± S.D.	Parmesan Analogue (g/100 g)* Mean ± S.D.
C12:0	3.52±0.12^{B}	24.76±0.49^{A}
C14:0	11.20±0.61^{C}	12.15±0.07^{B}
C16:0	35.93±2.27^{A}	9.02±0.10^{B}
C18:0	14.32±0.40A	3.12±0.06^{D}
C18:1, N9 (ω- 9)	19.93±1.39^{D}	35.28±0.47^{B}
C18:2, n9, 12,(ω-6)	2.83±0.27^{C}	7.10±0.13^{A}

$^{A-D}$: Different letters in each row indicate a significant difference between each fatty acid when comparing dairy cheese with its analogue ($p<0.05$). S.D.: standard deviation. *: these results are presented as grams of each fatty acid per 100 g of fat in the product.

The most notable differences were observed in Lauric acid (C12:0) and Palmitic acid (C16:0) in the 3 types of cheeses evaluated. The concentration of C12:0 in the analogue cheeses is remarkably high, approximately 25%, which is over seven times greater than the 3.5-3.7% found in the traditional cheeses. This extreme difference is a clear chemical fingerprint of coconut or palm kernel oil, which are rich in this specific medium chain saturated fatty acid [17]. While the analogues have a vastly higher C12:0 content, the levels of Palmitic acid (C16:0) show the opposite trend. Traditional cheeses contain a very high percentage of C16:0 (around 36-37.5%), a characteristic of milk fat, whereas the analogues contain only about 9-9.5%. This represents a reduction of nearly 75% in the analogue products for this saturated fat [18].

The profile of unsaturated fats further delineates the two product categories. Oleic acid (C18:1, ω-9) and Linoleic acid (C18:2, ω-6) are significantly more abundant in the analogue cheeses [19]. The Oleic acid content is about 1.7 times higher, and the Linoleic acid content is approximately 2.5 to 3 times higher in the analogues compared to the traditional cheeses. This pattern is characteristic of vegetable oils like sunflower or canola, which are commonly used to provide a soft texture and are rich in unsaturated fats. For the other saturated fats, Myristic acid (C14:0) is slightly but consistently higher in the analogues, while Stearic acid (C18:0) is substantially lower in all analogues compared to the traditional cheeses, with Parmesan cheese having a notably higher Stearic acid content than Cheddar or Mozzarella.

From a nutritional perspective, these findings present a complex picture. The analogue cheeses have a significantly lower content of the long chain saturated fatty acid C16:0, which is often the target of dietary guidelines [20]. Furthermore, they offer a more favorable ratio of unsaturated to saturated fats due to their high levels of C18:1 and C18:2. However, this potential benefit is counterbalanced by an exceptionally high level of the medium-chain saturated fat C12:0, whose impact on blood lipid profiles can be similarly negative [21]. Therefore, the switch from a traditional cheese to an analogue does not simply represent a reduction in saturated fat, but rather a complete shift in the types of fatty acids consumed, trading one form of saturated fat for another while increasing unsaturated fat intake. The fatty acid profile serves as a definitive marker for distinguishing the origin of fat in cheese products, with analogue cheeses exhibiting a signature profile dominated by C12:0 and C18:1, pronouncedly different from the C16:0-rich profile characteristic of traditional dairy cheeses.

V. NUTRITIONAL INITIATIVE

This study opens the opportunity to improve the way food products are verified during their commercialization in Latin America. Perishable products are distributed across several locations around the world on a daily basis. Many countries implement national regulatory frameworks to evaluate food products; however, ensuring product transparency should not rely solely on the regulatory scope or enforcement capacity of individual markets, highlighting the need for harmonized approaches to labeling and food control systems [22]. Instead, a regional approach would help ensure that countries across Latin America speak the same technical language regarding labeling, composition, quality, and consumer protection.

The creation of a regional program, linked with already existing regulatory organizations like the RTCA (Reglamento Técnico Centroamericano), would allow for random checkups of products that are available in the market. By considering its implementation, there is a way to guarantee that all Latin American countries are evaluated by the same criteria and quality standards. At the same time, it may serve as some sort of certification for companies. This will help gain trust from consumers and will elevate the public perception of the product.

In the case of cheese analogues, their composition is vastly different from traditional cheeses in the market; however, customers may perceive them as equivalent to each other. A common shopper may assume that the only difference between these products is the dietary lifestyle they are intended to serve. However, recent research on plant-based product trends [23] indicates that consumer perception is consistently disconnected from the actual nutritional profile of these substitutes. Providing a service that is tasked with verifying nutritional information and communicating the reality of a product to a consumer is beneficial and educational for both parties.

This initiative can create campaigns aimed at consumers to allow them to understand the composition of foods. This idea may translate better by utilizing products like traditional cheeses and their analogue counterparts. Although it may sound that this information can cause discouragement in the consumption of analogue products, it is merely a way to provide consumers with the tools to make informed decisions. A great product will always sell, it is just necessary for consumers to be more conscious of what they are consuming. This research goes far beyond a mere evaluation of physicochemical differences between commercial products; it is the foundation for a system that wants equivalent nutrition standards and superior education for consumers.

VI. PROMOTING CONSUMER AWARENESS

The nutritional discrepancy observed in this study reflects a critical public health challenge known as hidden malnutrition. This phenomenon occurs when caloric intake is sufficient, yet a severe deficiency of essential nutrients is present. Furthermore, this problem is accompanied by challenges in nutrition education. For example, a study conducted in Chile shows that most nutrition education programs target students in state schools and focus on diet, nutrition, and physical activity to help prevent obesity, which is highly prevalent in the country [24]. These programs often omit critical content regarding the bioavailability and quality of nutrients, creating vulnerability among consumers, especially those with lactose intolerance and vegans who choose plant-based alternatives assuming nutritional similarity.

Regarding the need for transparent regulatory frameworks for producers to protect consumers from this confusion, it is necessary to move towards independent verification models. A comparable model exists in Europe, where the European Food Safety Authority (EFSA) complements EU regulation and enforcement, including Regulation (EC) No 178/2002 (establishing EFSA), Regulation (EC) No 852/2004 (on the hygiene of foodstuffs), and Regulation (EC) No 853/2004 (specific hygiene rules for food of animal origin) [25]. Without similar initiatives in other countries to validate nutritional similarity, consumers are vulnerable to purchasing decisions based on trends or visual appearance, unintentionally sacrificing their biological health.

VII. Conclusion

This detailed compositional comparison between traditional dairy cheeses (Cheddar, Mozzarella, Parmesan) and their plant-based analogues reveals profound and significant differences that extend beyond their ingredient origins. The analysis demonstrates that while plant-based analogues achieve a degree of visual resemblance, as evidenced by the CIE L*a*b* color space data, their core nutritional composition is fundamentally distinct.

Nutritionally, the disparity is most pronounced in protein content and its quality. Dairy cheeses provided a high-quality protein source with superior protein digestibility, whereas plant-based analogues were markedly deficient in both protein quantity and quality. Furthermore, the fatty acid profiles were completely opposed: dairy cheeses were characterized by high levels of palmitic acid (C16:0), a characteristic of milk fat, while the analogues exhibited a signature profile dominated by lauric acid (C12:0) from coconut oil, alongside elevated levels of unsaturated oleic (C18:1) and linoleic (C18:2) acids. This represents not merely a reduction in saturated fat, but a complete substitution with a different saturated fat profile and a higher proportion of unsaturated fats.

Compositionally, plant-based analogues displayed uniform, high moisture content and lower organic matter, reflecting their reliance on starches, and water to replicate texture, rather than the protein and lipid matrix of dairy cheese. The ash content and associated mineral profile were variable, with some analogues showing higher sodium levels, underscoring potential nutritional concerns.

In summary, plant-based cheese analogues are not nutritional equivalent to traditional dairy cheeses. They represent a distinct category of food products designed primarily for visual and textural imitation. These findings are critical for informing consumers, health professionals, and food technologists. For the food industry, these results underscore the necessity for continued research and development to enhance the nutritional profile, particularly the protein quality and mineral balance, of plant-based cheese analogues to better align with consumer health expectations and nutritional requirements.

VIII. RECOMMENDATIONS

Taking into consideration that this initiative is quite ambitious, it is recommended that this project begins on a small scale. Starting in a single country may help institutions like the RTCA evaluate the feasibility and success rate of the program. It will be an opportunity to identify points of concern, measure the response of both the industry and the consumers, and gradually implement those ideas in other countries in Latin America. This way there's a risk reduction and encouragement of adaptation.

Another important recommendation is the fact that knowledge is already available for the masses. Consumers need a direct incentive to spark their need to learn. Companies that are willing to participate in the educational aspect of the program may offer coupons and online discounts for participants. This way, buyers are motivated to attend these events, allowing them to bond with the brand in the process. By linking education with practical benefits, the initiative could increase public interest and help consumers make more informed purchasing decisions based on nutritional value, composition, and product transparency.

Finally, it is recommended that the program promotes its affiliation with existing regulatory authorities. This gives credibility to the initiative, making them a trustworthy source for people in the industry. The key to success is trust from the consumer. The only way to achieve that is by publicly establishing partnerships that validate the verification and education process. This collaborative model could contribute to the development of stronger regional standards, greater consumer trust, and a more responsible food industry in Latin America.

References

[1] F. Masotti, S. Cattaneo, M. Stuknyte, I. De Noni. " Status and developments in analogue cheese formulations and functionalities," Trends Food Sci. Technol., vol. 74, pp. 158–169, 2018.

[2] L. Grossmann and D. J. McClements, "The science of plant-based foods: Approaches to create nutritious and sustainable plant-based cheese analogs," Trends in Food Science & Technology, vol. 118, pp. 207–229, 2021.

[3] AOAC International, Official Methods of Analysis, 20th ed. Rockville, MD: AOAC International, 2016.

[4] C. E. Narváez-Cuenca and A. Rodríguez de Stouvenel, "Efecto de la adición de dos tipos de almidones en las propiedades de análogos de queso," Revista de la Facultad de Ciencias Agropecuarias, vol. 15, pp. 15–25, 2015.

[5] M.P. Ntakatsane, X.M. Liu, P. Zhou, "Short communication: Rapid detection of milk fat adulteration with vegetable oil by fluorescence spectroscopy," Journal of Dairy Science, vol. 96, Issue 4, Pages 2130-2136, 2013. doi:https://doi.org/10.3168/jds.2012-6417. [accessed 2025 Aug 11].

[6] N. Grasso, Y.H. Roos, S.V. Crowley, E.K. Arendt, J.A. O'Mahony, "Composition and physicochemical properties of commercial plant-based block-style products as alternatives to cheese, " Future Foods. 4:100048–

100048. 2021. doi:https://doi.org/10.1016/j.fufo.2021.100048. [accessed 2025 Aug 11].
[7] F. Ali, J.A. O'Mahony, M.G. O'Sullivan J.P. Kerry, " Comparative Analysis of Composition, Texture, and Sensory Attributes of Commercial Forms of Plant-Based Cheese Analogue Products Available on the Irish Market," Foods, vol. 14, no. 15, p. 2701, 2025.
[8] G.M. Mari, M. Khaskheli, A.S. Jatoi, I.H. Qazi, M. Samina, A. Talpur, S. Majeed, A.H. Soomro, L. Rukhsana and A. Samad, "Compositional and Rheological Properties of Mozzarella Cheese Prepared from Buffalo Milk," Pakistan Journal of Nutrition. 13(9):533–536. 2014. doi:https://doi.org/10.3923/pjn.2014.533.536. [accessed 2025 Aug 11]. https://www.researchgate.net/publication/281019531_Compositional_and_Rheological_Properties_of_Mozzarella_Cheese_Prepared_from_Buffalo_Milk.
[9] M.F. Arief, A. Manab, "The effect of various spices on functional properties of plant-based cheese analogue". IOP Conference Series Earth and Environmental Science. 1292(1):012023–012023. 2024. doi:https://doi.org/10.1088/1755-1315/1292/1/012023. [accessed 2025 Aug 12]. https://www.researchgate.net/publication/377525199_The_effect_of_various_spices_on_functional_properties_of_plant-based_cheese_analogue.
[10]U. Fresán, H. Rippin, "Nutritional Quality of Plant-Based Cheese Available in Spanish Supermarkets: How Do They Compare to Dairy Cheese? Nutrients", Nutrients. 13(9):3291–3291. 2021. doi:https://doi.org/10.3390/nu13093291. [accessed 2025 Aug 12]. https://www.mdpi.com/2072-6643/13/9/3291.
[11]N. Grasso, Y.H. Roos, S.V. Crowley, E.K. Arendt, J.A. O'Mahony, "Composition and physicochemical properties of commercial plant-based block-style products as alternatives to cheese". Future Foods. 4:100048. 2021. doi:https://doi.org/10.1016/j.fufo.2021.100048. [accessed 2025 Oct 13]. https://www.sciencedirect.com/science/article/pii/S2666833521000381?via%3Dihub.
[12]A.Č. Majhenič, A. Levart, J. Salobir, T. Prevc, T. Pajk Žontar. "Can Plant-Based Cheese Substitutes Nutritionally and Sensorially Replace Cheese in Our Diet?", Foods. 14(5):771. doi:https://doi.org/10.3390/foods14050771. 2025.[accessed 2025 Oct 15]. https://www.mdpi.com/2304-8158/14/5/771.
[13]S. Durak, A.N. Demirci, A. Çavdar, Y. Yılmazer, S. Andaç, İ.H. Tekiner, "Vegan Cheese versus Regular Cheese: A Nutritional and Cytotoxic Assessment," Turkish Journal of Agriculture - Food Science and Technology. 13(4):1034–1041. 2025. doi:https://doi.org/10.24925/turjaf.v13i4.1034-1041.7436. [accessed 2025 Oct 15]. https://agrifoodscience.com/index.php/TURJAF/article/view/7436.
[14]D. Lu, D. Roy, A. Acevedo-Fani, H. Singh, A. Ye, "Investigation of various plant protein ingredients for processed cheese analogues: physical properties and microstructure compared with milk proteins," International Journal of Food Science and Technology, Volume 60, Issue 1, vvae018, 2025. https://doi.org/10.1093/ijfood/vvae018.
[15]F.M. Dayrit. "The Properties of Lauric Acid and Their Significance in Coconut Oil," Journal of the American Oil Chemists Society. 92(1):1–15. 2015. doi:https://doi.org/10.1007/s11746-014-2562-7. [accessed 2025 Oct 15]. https://aocs.onlinelibrary.wiley.com/doi/10.1007/s11746-014-2562-7.
[16] R.L.S. Viriato, M de S. Queirós, G.A. Macedo, A.P.B. Ribeiro, M.L. Gigante. "Design of new lipids from bovine milk fat for baby nutrition," Critical Reviews in Food Science and Nutrition. 62(1):145–159. 2020. doi:https://doi.org/10.1080/10408398.2020.1813073.
[17]L. Xue, R. Yang, X. Wang, F. Ma, L. Yu, L. Zhang, P. Li. "Comparative advantages of chemical compositions of specific edible vegetable oils," Oil Crop Science. 8(1):1–6. 2023. doi:https://doi.org/10.1016/j.ocsci.2023.02.005. [accessed 2025 Oct 15]. https://www.sciencedirect.com/science/article/pii/S209624282300012X?via%3Dihub.
[18]S. Kotopoulou, G. Marakis, D. Papanastasiou, S. Skoulika, A. Papaioannou, G. Boukouvalas, Z. Mousia, F. Tzoumanika, A. Karpouza, A. Zampelas, E. Magriplis. "Palmitic acid content in savoury baked goods and modelled trend intake prior and post EU trans-fat regulation,". European Journal of Nutrition. 64(4). 2025. doi:https://doi.org/10.1007/s00394-025-03659-0. [accessed 2025 Oct 15]. https://link.springer.com/article/10.1007/s00394-025-03659-0.
[19]M.F. McCarty, J.J. DiNicolantonio. "Lauric acid-rich medium-chain triglycerides can substitute for other oils in cooking applications and may have limited pathogenicity," Open Heart. 3(2):e000467. 2016. doi:https://doi.org/10.1136/openhrt-2016-000467. [accessed 2025 Oct 15]. https://openheart.bmj.com/content/openhrt/3/2/e000467.full.pdf?utm_source=consensus.
[20]S. Kotopoulou, G. Marakis, D. Papanastasiou, S. Skoulika, A. Papaioannou, G. Boukouvalas, Z. Mousia, F. Tzoumanika, A. Karpouza, A. Zampelas, E. Magriplis. "Palmitic acid content in savoury baked goods and modelled trend intake prior and post EU trans-fat regulation," European Journal of Nutrition. 64(4). 2025. doi:https://doi.org/10.1007/s00394-025-03659-0. [accessed 2025 Oct 15]. https://link.springer.com/article/10.1007/s00394-025-03659-0
[21]M.F. McCarty, J.J. DiNicolantonio. "Lauric acid-rich medium-chain triglycerides can substitute for other oils in cooking applications and may have limited pathogenicity," Open Heart. 3(2):e000467. 2016. doi:https://doi.org/10.1136/openhrt-2016-000467. [accessed 2025 Oct 15]. https://openheart.bmj.com/content/openhrt/3/2/e000467.full.pdf?utm_source=consensus
[22]FAO & WO. *"Food control systems: Guidelines for strengthening national food control systems,"* FAO Food and Nutrition Paper. Rome: FAO, 2003. Available: https://www.fao.org/3/y8705e/y8705e00.htm. [accessed 2025 Oct 15].
[23]Castro Carvalho G, Carneiro JDDS, Rocha RAR, Pereira E (2025), "Plant-based trends: consumer's perception and factors that influence the purchase of plant-based products". British Food Journal, Vol. 127 No. 9 pp. 3396–3426, doi: https://doi.org/10.1108/BFJ-08-2024-0830Añadir
[24]Olivares, Las buenas prácticas en programas de información, comunicación y educación en alimentación y nutrición (ICEAN). [City, Country]: Food and Agriculture Organization of the United Nations (FAO), YEAR. [Online]. Available: https://www.fao.org/ag/humannutrition/30022-0842b81aad1e03d40773c2aa9f4f85d5.pdf. [Accessed: 27-Apr-2026].
[25]European Food Safety Authority (EFSA), "Minutes: Advisory Group on Risk Communications (AGRC) of EFSA, 1st Plenary Meeting, 7 March 2005, EFSA, DUS Building, Parma, Italy," 2005. [Online]. Available: https://efsa.europa.eu/sites/default/files/event/agrc050307-m.pdf. [Accessed: 27-Apr-2026]