Dairy Milk vs Plant-Based Milk Alternatives Exploring Fat Nutritional Indices in Retail Products

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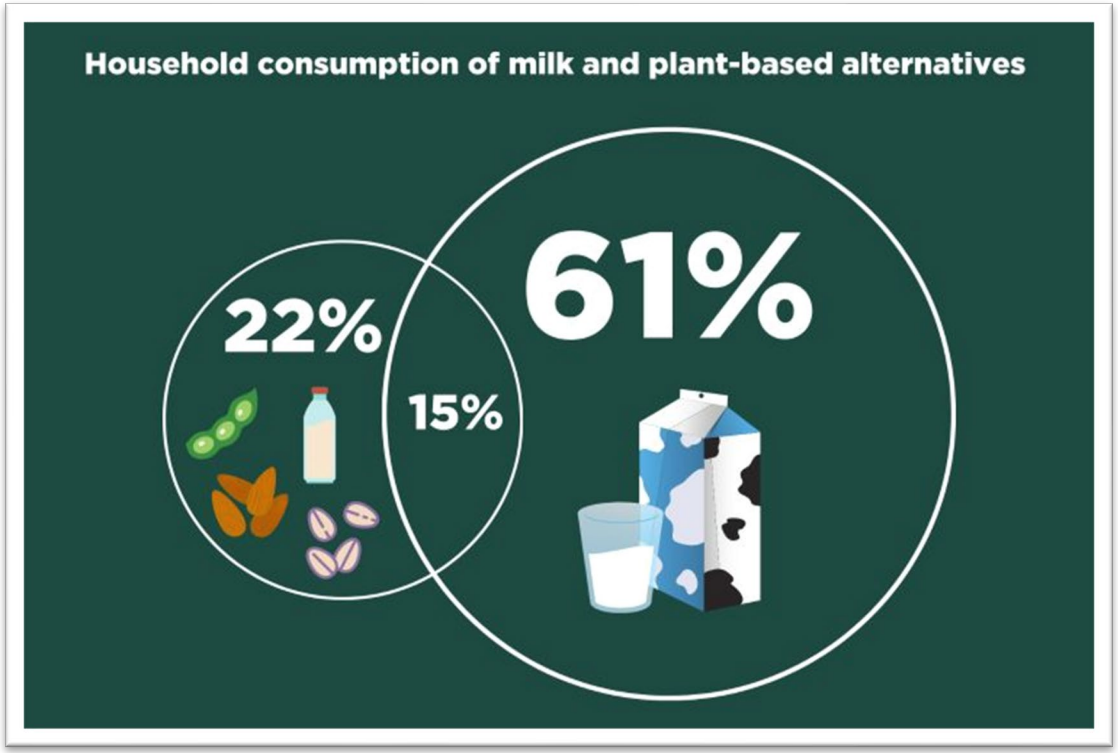
The Changing Landscape of Milk Consumption

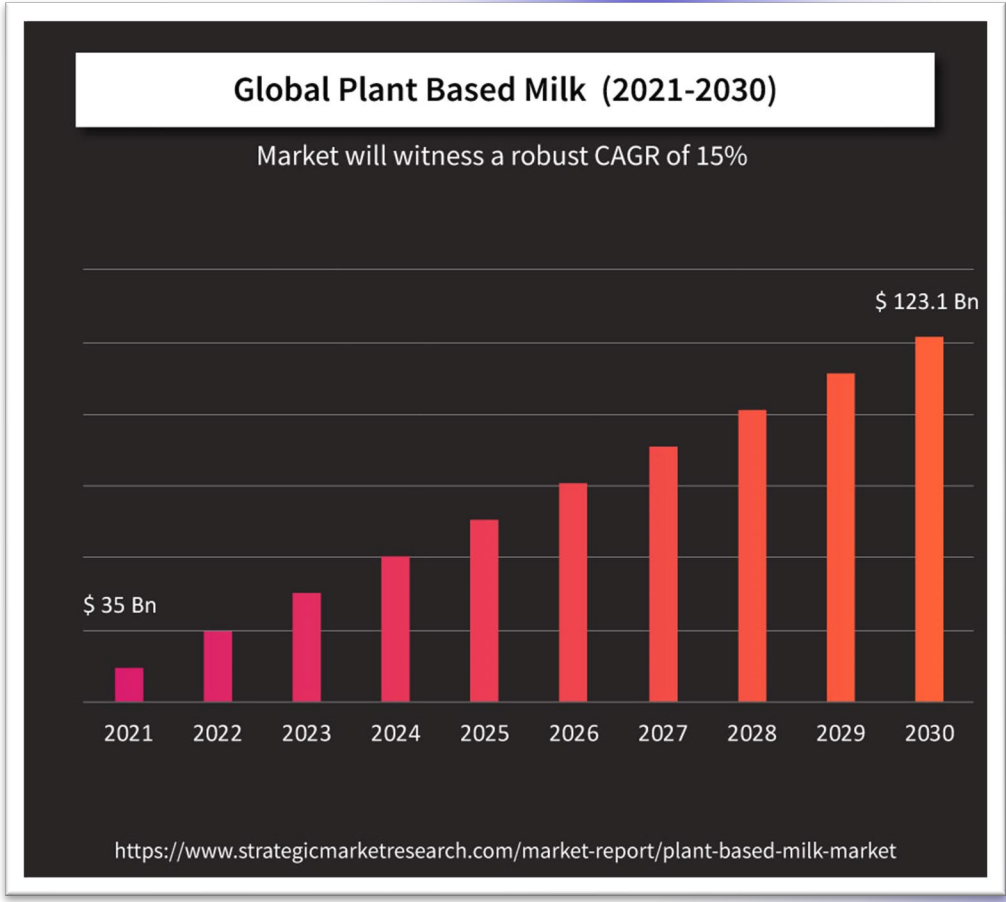
- Milk has been a fundamental part of human diet for centuries, providing essential nutrients such as calcium, protein, and vitamins.
- In recent years, there has been a significant shift in consumer preferences towards plant-based milk alternatives (PBMAs).
- Factors driving this shift include dietary restrictions, lactose intolerance, environmental concerns, and ethical considerations.
- Examples of PBMAs include almond milk, soy milk, oat milk, and rice milk.

Increasing Consumption of Goat Milk

- Growing popularity of goat milk globally.
- Goat milk offers better digestibility due to smaller fat globules that aid digestion.
- Better tolerated by individuals with sensitivities to cow milk, contributing to its rising demand.

Plant Based Milk Consumption





Why Compare Nutritional Profiles?

- Despite the growing popularity of PBMAs, there is limited data on their nutrient profiles compared to traditional dairy milk at retail level.

- Comparative analysis can highlight the benefits and drawbacks of each type, guiding consumers and health professionals.

Comparison of nutritional components between dairy milk and plant based alternatives

Ultimate Milk Comparison Chart

avg. qnt. per 100ml

Dairy Milk	Energy (kj)	Calories (kcal)	Sugar (g)	Protein (g)	Calcium (mg)	Sodium (mg)	Lactose Free?
Full Cream	259	61.9	4.8	3.4	118	44	✗
Skim Milk	147	35.13	4.6	3.5	132	45	✗
Light Milk	190	45.41	4.6	3.5	118	44	✗
A2 Milk Full Cream	275	65.73	4.7	3.3	109	33	✗
Organic Full Cream	300	71.7	4.9	3.5	114	37	✗
Alternatives	**Energy (kj)**	**Calories (kcal)**	**Sugar (g)**	**Protein (g)**	**Calcium (mg)**	**Sodium (mg)**	**Lactose Free?**
Soy	257	61.42	2.6	3.3	120	60	✓
Almond	123	29.4	3.4	0.6	120	32	✓
Oat	193	46.13	4.1	1	120	40	✓
Rice	185	44.23	5.8	0.2	120	65	✓
Coconut	187	44.69	2.6	0.6	16	15	✓
Powdered Milk	**Energy (kj)**	**Calories (kcal)**	**Sugar (g)**	**Protein (g)**	**Calcium (mg)**	**Sodium (mg)**	**Lactose Free?**
A2+ Probiotic Milk Powder	2084	49.71	38.2	23.9	1635	235	✗
Full Cream Milk Powder	303	72.42	5.6	3.5	117	47	✗
Skim Milk Powder	153	36.57	5.3	3.5	115	45	✗
Other	**Energy (kj)**	**Calories (kcal)**	**Sugar (g)**	**Protein (g)**	**Calcium (mg)**	**Sodium (mg)**	**Lactose Free?**
Goats	253	60.47	4.4	3.2	138.3	79	✗
Hemp	108	25.81	0.2	0.1	26	50	✓
Plant-Based Milk	251	59.99	2.4	2	120	89	✓

https://www.naturedaydairy.com/post/the-ultimate-milk-comparison-chart

Aim of Study

- To determine the nutritional indices of dairy milk (cow and goat) and plant-based milk alternatives available at retail.
- To compare the nutritional indices between the three types of milk i.e. cow, goat and plant-based milk alternatives in relation to current guidelines for healthy fat consumption.

Materials and Methods

Sampling Criteria

- To be conventionally produced.
- To be widely available in food stores (super markets).
- To bare the “Greek Produce” Mark, which certifies the origin of good and services produced in Greece.
- The “Greek Produce“ Mark is an official Trademark of the Greek State and it is optional.

Sampling

- 7 samples of cow milk
- 8 samples of goat milk
- 14 samples of “white” plant based milk alternatives
- 7 almond
- 4 oat with seeds/nuts
- 1 rice with coconut
- 1 pistachio

Fatty Acid Analysis

- Lipids were extracted according to the Bligh & Dyer method and converted to FAMEs using base-catalyzed methanolysis with KOH in methanol

- GC Analysis Parameters
  - Agilent 6890N GC equipped with a flame ionization detector (FID)
  - Column: 60 m × 0.25 mm i.d., 0.25 µm film thickness DB-23 capillary column

- Standards used for identification
  - 37 component FAME mix (Supelco, 47885-U)
  - PUFA-2, Animal source (Supelco, 47015-U)
  - Mixture of cis- and trans-9,11- and 10,12-octadecadienoic acid methyl esters (Sigma, O5632-250MG)

- Fatty acids quantified by peak area measurement.

Lipid Quality Nutritional Indices

- PUFA/SFA = $\frac{\Sigma PUFA}{\Sigma SFA}$

- Atherogenicity Index

$$AI = \frac{[C12:0 + (4 \times C14:0) + C16:0]}{\Sigma MUFA + \Sigma PUFA}$$

- Thrombogenicity Index

$$TI = \frac{(C14:0 + C16:0 + C18:0)/}{(0.5 \times \Sigma MUFA) + (0.5 \times \Sigma n{-}6PUFA) + (3 \times \Sigma n{-}3PUFA) + (n{-}3/n{-}6)]}$$

- Hypocholesterolaemic: hypercholesterolaemic fatty acid ratio (h/H)

$$h/H = \frac{(C18:1\ n{-}9\ cis + \Sigma PUFA)}{(C12:0 + C14:0 + C16:0)}$$

Statistical Analysis

- One-way analysis of variance (ANOVA) was conducted to assess the statistically significant differences in lipid quality nutritional indices among cow, goat, and plant-based milk alternatives.
- SPSS software (version 29.0, SPSS Inc., Chicago, IL, USA) was used for data analysis.
- The results were considered to be significant when the P-values were <0.05.

Results and Discussion

Product Characteristics - Animal Milk

- Cow milk samples
  - Full fat - homogenized
  - Pasteurized under either high-temperature - short-time (HTST) or ultra-high-temperature (UHT) conditions
  - For extended shelf-life samples, a combination of pasteurization and microfiltration was applied

- Goat milk samples
  - Full fat or non-characterized as low fat – homogenized
  - Pasteurized under either high-temperature - short-time (HTST) or ultra-high-temperature (UHT) conditions

Cow milk - Declared composition (g/100 ml)

Sample No	Fat	SFA	Protein	Carbohydrates	Sugars
1	3.5	2.4	3.2	4.7	4.7
2	3.5	2.3	3.2	4.6	4.6
3	3.5	2.0	3.2	4.7	4.7
4	3.5	2.4	3.2	4.7	4.7
5	3.5	2.35	3.2	4.7	4.7
6	3.9	2.6	3.4	4.7	4.7
7	3.7	2.2	3.3	4.7	4.7

Goat milk – Declared composition (g/100 ml)

Sample No	Fat	SFA	Protein	Carbohydrates	Sugars
1	4.1	3.2	3.8	4.1	4.1
2	2.8	2.2	3.8	4.4	4.4
3	3.5	2.2	3.8	4.5	4.5
4	4.0	2.9	3.7	4.3	4.3
5	3.5	2.3	3.7	4.5	4.5
6	3.7	2.6	3.6	4.5	4.5
7	3.5	2.2	3.6	4.5	4.5
8	3.5	2.2	3.6	4.5	4.5

PBMAs – Product types

Sample No	Type
1	Almond (3%)
2	Almond (2.5%)
3	Almond (4.5%)
4	Almond (3.5%)
5	Almond (3%)
6	Almond (3%)
7	Almond (2.5%)
8	Almond (2.5%)
9	Oat (12%)
10	Oat (12%)
11	Oat (8%) & Seeds (Sesame 0.5%, sunflower 1%, pumpkin 0.5%)
12	Oat (8%) & Hazelnut (2.5%)
13	Rice (5.1%) & Coconut (1.5%)
14	Peanut (3%)

PBMAs Characteristics - Synopsis

- Most PBMAs were nut (almond, peanut, hazelnut and walnut) based.
- Almond-based samples accounted for almost 57% of the samples.
- No sugar was added in the majority of of the samples.
- A small number of the samples were enriched in protein, calcium, and vitamins.
- Almond and oat-based milk dominated the PBMAs market in Greece.

Plant based milk alternative characteristics – Declared composition (g/100 ml)

Sample No	Fat	SFA	Protein	Carbohydrate	Sugars	Edible fibre
1	1.7	0.1	0.7	0.5	0.5	1.8
2	1.5	0.1	0.7	2.8	2.8	1
3	2.9	0.2	1.3	3.4	3.2	<0.5
4	2.2	0.2	1	<0.5	<0.5	<0.5
5	1.7	0.1	0.7	4.4	3.6	0.4
6	1.7	0.1	0.7	3	2	0.4
7	1.7	0.1	3.2	2.9	2.9	1.3
8	2.0	0.2	3.2	5.2	4	1.3
9	1.5	0.3	1.2	8.0	4.9	1.7
10	1.5	0.2	3.2	8.4	6.2	2
11	0.8	0.1	0.3	2.7	1.6	0.2
12	2.2	0.2	1.2	5.6	3.5	1.7
13	1.5	1	0.2	5	2.7	0.2
14	1.7	0.2	0.7	0.5	0.5	1.8

Comparison – Declared composition (g/100 ml)

Type	Fat	SFA	Protein	Carbohydrate	Sugars	Edible fibre
Cow	3.6[b]	2.3[b]	3.2[b]	4.7	4.7[b]	-
Goat	3.6[b]	2.5[b]	3.7[b]	4.4	4.4[b]	-
PBMAs	1.8[a]	0.2[a]	1.3[a]	4.0	3.0[a]	1.2
Significance	P<0.001	P<0.001	P<0.001	NS	P<0.01	-

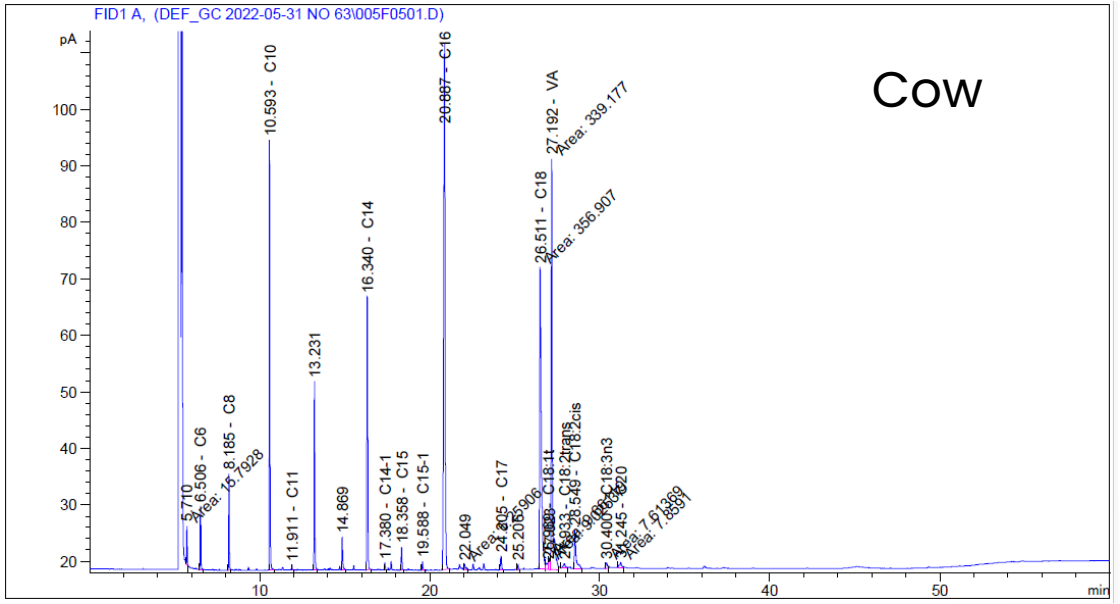
Nutritional Components Comparison

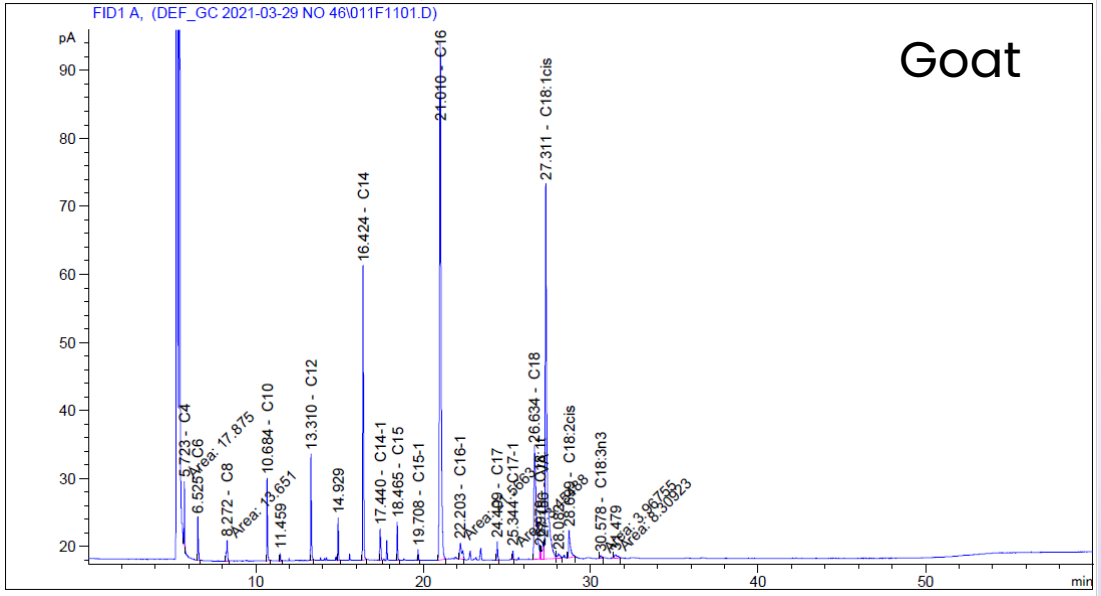
- **Fat Content**
  - Cow and goat milk have similar fat content (3.6%)
  - Plant-based milk has significantly lower fat content (1.8%)
- **Saturated Fatty Acids (SFA)**
  - Slightly higher in goat milk (2.5%) compared to cow milk (2.3%)
  - Plant-based milk has a much lower SFA content (0.2%)
- **Protein Content**
  - Goat milk contains the highest protein (3.7%), followed by cow milk (3.2%)
  - Plant-based milk has significantly less protein (1.3%)
- **Carbohydrates and Sugars**
  - Plant-based milk has lower carbohydrate content (4.0%) with only 3.0% being sugars

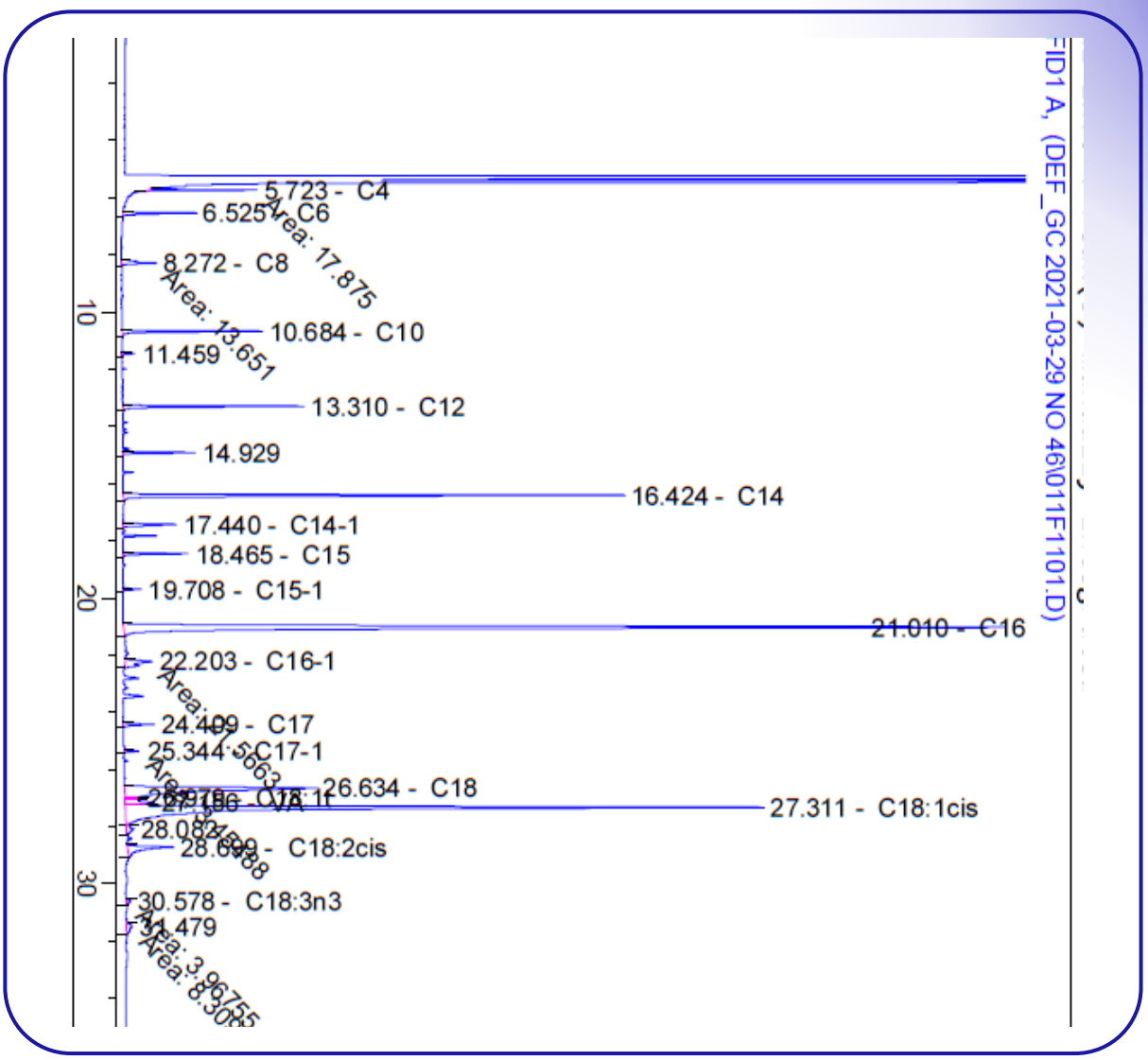
Fatty Acid Composition

Fatty acid	Cow	Goat	PBMAs
C4:0	1.29		
C6:0	1.25	1.61	
C8:0	0.96	2.23	7.73
C10:0	2.33	8.53	7.66
C11:0	0.39	0.20	37.67
C12:0	2.98	4.09	2.82
C13:0	0.95	1.23	
C14:0	10.74	9.80	
C14:1	1.10	0.34	
C15:0	1.08	0.83	
C15:1	0.71	0.24	
C16:0	34.50	27.66	8.01
C16:1	1.33	0.67	0.38
C17:0	0.62	0.68	
C17:1	0.50	0.24	
C18:0	10.35	12.85	3.04
C18:1 *trans*-11		0.56	
C18:1 *trans-11* (VA)	1.44	1.33	
C18:1 *cis*-9	23.23	22.17	57.03
C18:2 *n-6 trans*	0.69	0.96	24.61
C18:2 *n-6 cis*	2.23	2.35	
C18:3 *n-6*	0.59	0.29	
C18:3 *n-3*	0.37	0.58	0.43
C18:2 *cis-9 trans-11* (CLA)	0.47	0.46	
C20:0	0.32	0.32	0.18
C21:0			0.2
C20:5		0.12	0.27

Cow and Goat Milk Fatty Acid Analysis



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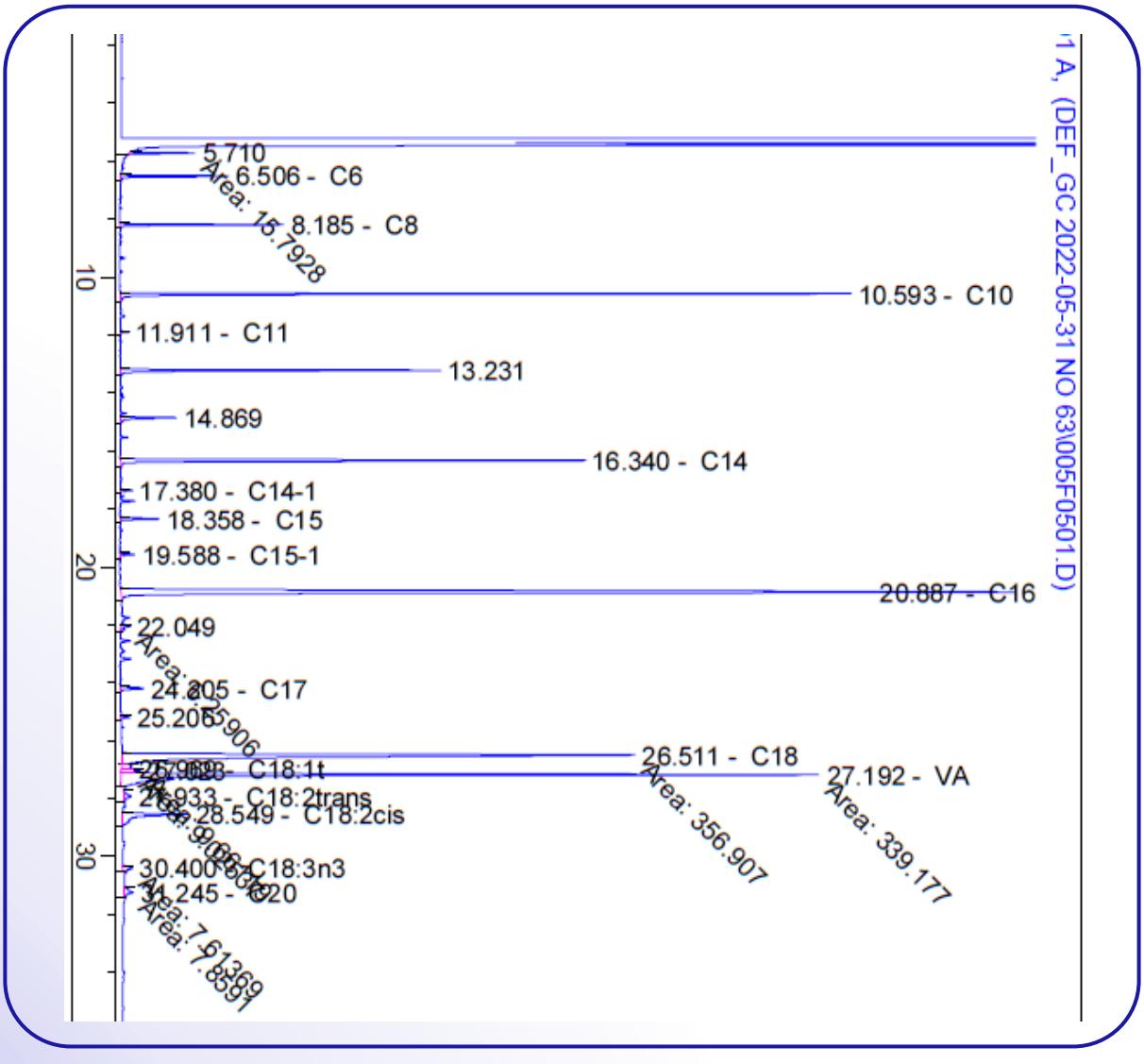
5.723 - C4
6.525 - C6
Area: 17.875
8.272 - C8
Area: 13.651
10.684 - C10
11.459
13.310 - C12
14.929
16.424 - C14
17.440 - C14-1
18.465 - C15
19.708 - C15-1
21.010 - C16
22.203 - C16-1
24.409 - C17
25.344 - C17-1
26.634 - C18
27.311 - C18:1cis
28.688 - C18:2cis
30.578 - C18:3n3
31.479
Area: 3.96755
Area: 8.30
10
20
30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6.506 - C6
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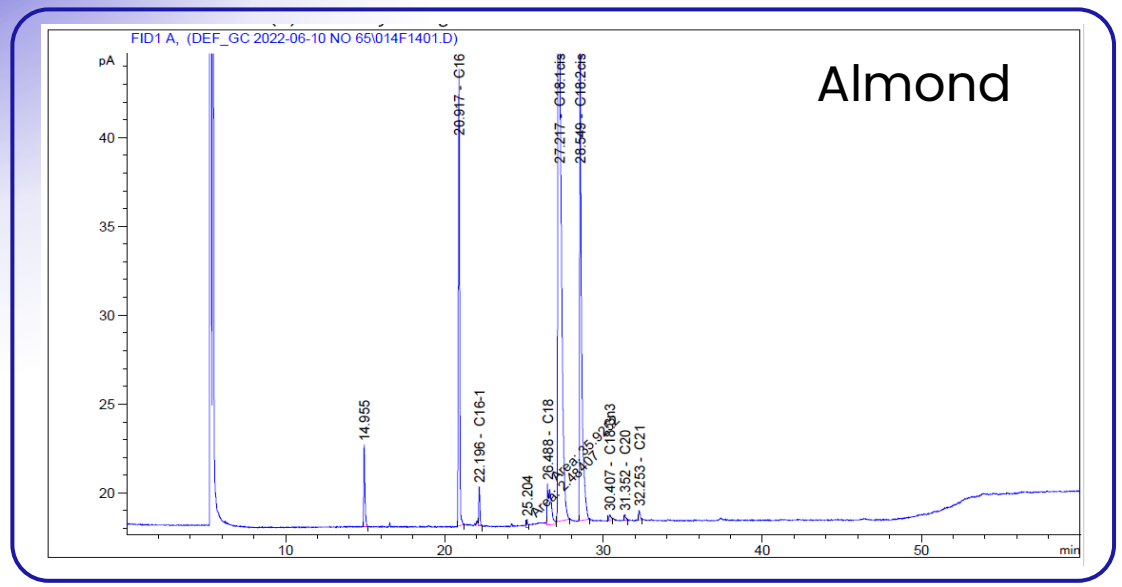
8.185 - C8
10.593 - C10
11.911 - C11
13.231
14.869
16.340 - C14
17.380 - C14-1
18.358 - C15
19.588 - C15-1
20.887 - C16
22.049
24.205 - C17
25.206
26.511 - C18
27.192 - VA
Area: 356.907
Area: 339.177
28.549 - C18:2cis
30.400 - C18:3n3
Area: 7.61369
10
20
30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Almond
pA
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22.196 - C16-1
25.204
26.488 - C18
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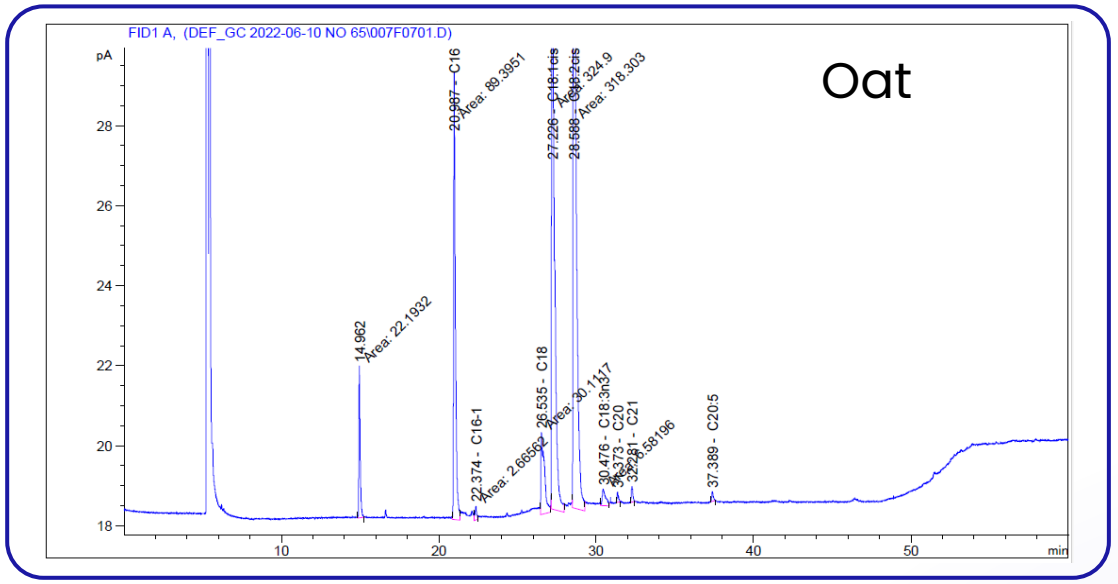
28.549 - C18:2cis
30.407 - C18:3n3
31.352 - C20
32.253 - C21
min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22.374 - C16-1
Area: 2.66562
26.535 - C18
Area: 30.1137
27.226 - C18:1cis
Area: 324.9
28.568 - C18:2cis
Area: 318.303
30.476 - C18:3n3
31.373 - C20
32.281 - C21
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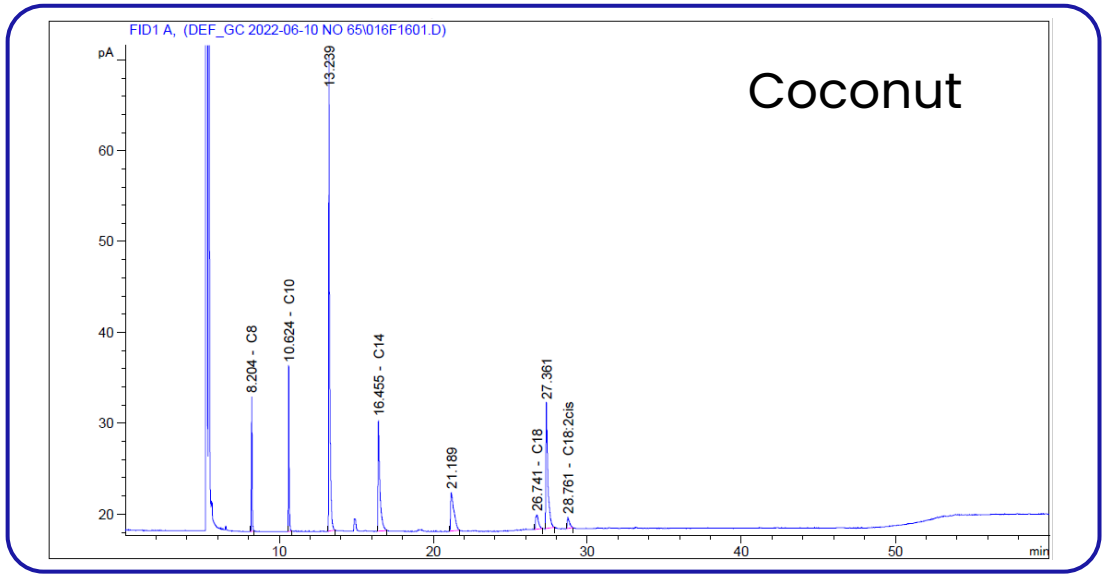
min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Coconut
pA
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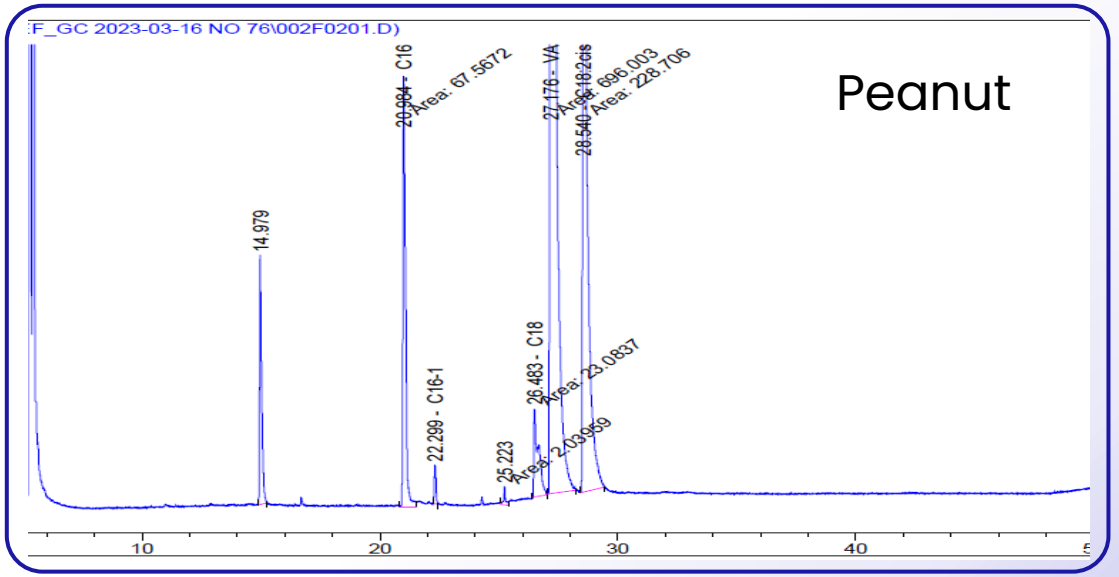
13.239
16.455 - C14
21.189
26.741 - C18
27.361
28.761 - C18:2cis
min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Peanut
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22.299 - C16-1
25.223
26.483 - C18
27.176 - VA
Area: 696.003
28.540 - C18:2cis
Area: 228.706
Area: 23.0837

Fatty Acid Composition – Lipid classes

Lipid Class	Cow	Goat	PBMAs
SFA	67.04	69.95	17.91
MUFA	29.08	25.55	57.32
PUFA	3.88	4.50	24.77

Fat nutritional indices

Type	PUFA/SFA	AI	TI	h/H
Cow	0.06^{a}	2.66^{b}	3.55^{b}	0.55^{a}
Goat	0.06^{a}	2.45^{b}	3.23^{b}	0.62^{a}
PBMAs	1.86^{b}	0.56^{a}	0.48^{a}	8.45^{b}
Significance	P<0.001	P<0.001	P<0.001	P<0.001
Recommendation	Ratio higher than 0.45 is recommended	<3	<3	High values are desirable

Fat nutritional indices

Type	PUFA/SFA	AI	TI	h/H
Cow	0.06	2.66	3.55	0.55
Goat	0.06	2.45	3.23	0.62
PBMAs	1.86	0.56	0.48	8.45
Recommendation	Ratio higher than 0.45 is recommended	<3	<3	High values are desirable

Nutritional Quality Indices Comparison

- **Cow and goat milk**
- Both types had low PUFA/SFA ratios and higher AI and TI indices, indicating higher potential risks for cardiovascular health.
  - TI values exceeded the recommended value of 3 to lower the risk of blood clot formation.

- **PBMAs**
  - All examined nutritional indices were within the recommended range for health fat consumption.
  - The h/H ratio was exceptionally high indicating a much more favourable impact on cholesterol levels.

Nutritional Impact of Milk Consumption on Daily Fat Intake

- **Overall Dietary Context**
  - Nutritional indices should be considered within the framework of overall dietary intake rather than focusing on individual food items.

- **EFSA Guidelines**
  - The recommended daily fat intake for an adult is approximately 70g.

- **Contribution to Daily Fat Intake**
  - Plant-Based Milk Alternatives (PBMA): One portion (250 ml) contributes about 3 - 10% of the daily intake considered marginal to moderate.
  - Cow or Goat Milk: One portion (250 ml) contributes approximately 13% of the daily intake, considered moderate.

Points for consideration

- A direct comparison of the nutritional fat profile in PBMAs with that of cow or goat milk may not be entirely suitable; however, given that consumers choose between animal-based and plant-based milks, such a comparison is very timely.

- Milk fat is considered the most complex among natural fats due to its composition, which consists of too many different fatty acids.

Conclusions

Cow and Goat Milk

Both types have low PUFA/SFA ratios and higher AI and TI indices, indicating higher potential risks for cardiovascular issues compared to plant-based milk.
The low h/H ratios further reflect this trend.

PBMAs

Exhibit a superior nutritional profile with a high PUFA/SFA ratio, low AI and TI indices, and a high h/H ratio, aligning with healthier dietary recommendations.

Final Remarks

- Understanding the nutritional composition of different types of milk allows for better dietary choices.

- Considering the overall nutritional profile - including fat, protein, and fiber content, as well as fatty acid composition - each type of milk offers unique benefits that contribute to a healthy, balanced diet when consumed appropriately.

Further reading on fatty acid composition & nutritional indices

- Kasapidou, E., Stergioudi, R. A., Papadopoulos, V., Mitlianga, P., Papatzimos, G., Karatzia, M. A., ... & Basdagianni, Z. (2023). Effect of Farming System and Season on Proximate Composition, Fatty Acid Profile, Antioxidant Activity, and Physicochemical Properties of Retail Cow Milk. *Animals*, 13(23), 3637.
- Kasapidou, E., Basdagianni, Z., Papatzimos, G., Papadopoulos, V., Tsiftsi, E., Neki, I., ... & Mitlianga, P. (2023). Chemical composition, antioxidant profile and physicochemical properties of commercial non-cocoa-and cocoa-flavoured plant-based milk alternatives. *European Food Research and Technology*, 1-16.
- Kasapidou, E., Karatzia, M. A., Mitlianga, P., & Basdagianni, Z. (2022). Effects of Production Systems and Seasons on Retail-Goat-Milk Fatty-Acid Composition and Nutritional Indices in Greece. *Animals*, 12(17), 2204.

animals

MDPI

Article

Effect of Farming System and Season on Proximate Composition, Fatty Acid Profile, Antioxidant Activity, and Physicochemical Properties of Retail Cow Milk

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Simple Summary: Consumer perception of organic cow milk is associated with the assumption that organic milk differs from conventionally produced milk. This study examined the effect of the farming system and season on the quality attributes of retail cow milk. Over one year, milk samples originating from conventional and organic production systems were collected monthly and assessed for their nutritional content, proximate composition, fatty acid profile, nutritional value, total phenolic content, antioxidant activity, and physicochemical characteristics. Results show that nutrient content remained consistent across production systems, except for a slightly higher fat level in organic milk. Fatty acid composition varied between systems and seasons, with organically produced milk showing higher polyunsaturated fatty acids. Nutritional indices related to lipid quality showed no significant differences between production systems and seasons. Total phenolic content remained consistent, while antioxidant activity was system-dependent and seasonal. Season influenced both free radical-scavenging activity (DPPH) and ferric reducing-antioxidant power (FRAP). Milk physicochemical characteristics, including pH, electrical conductivity, and freezing-point depression, were mainly influenced by season. Overall, this study provides detailed insights into the multifaceted interactions between production systems, seasons, and diverse characteristics of retail cow milk.

Abstract: Consumers differentiate milk-quality characteristics in relation to the production system, but data on retail milk composition are limited. This study investigated how farming methods and seasons affect proximate composition, fatty acid profile, antioxidant activity, and physicochemical characteristics of commercial cow's milk. Milk samples, both conventional (n = 84, 7 manufacturers) and organic (n = 24, 2 manufacturers), were collected monthly over a year. Farming system did not significantly affect milk composition other than fat content, whereas seasonal effects were notable, impacting the contents of ash, protein, and added water. Fatty acid composition exhibited variations influenced by both production system and season. Compared to conventionally produced milk, organically produced milk exhibited higher levels of polyunsaturated fatty acids (4.54 vs. 3.88, $p < 0.01$) and a lower atherogenicity index (2.23 vs. 2.50, $p < 0.05$). The antioxidant activity showed that conventionally produced milk exhibited better radical-scavenging activity (DPPH) (14.54 vs. 12.30 μM TE/mL, $p < 0.01$). Seasonal variations were evident in both free radical-scavenging activity (DPPH), with values of 12.29 μM TE/mL in winter and 15.58 μM TE/mL in spring ($p < 0.05$), and ferric reducing-antioxidant power (FRAP), with levels of 21.81 μM TE/mL in autumn and 27.94 μM TE/mL in spring ($p < 0.05$). Season significantly affected ($p < 0.001$) milk pH, electrical conductivity, refractive index, and freezing-point depression. In conclusion, this study showed that the farming system has a limited impact on retail milk quality compared to the significant influence of season.

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animals

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Article

Effects of Production Systems and Seasons on Retail-Goat-Milk Fatty-Acid Composition and Nutritional Indices in Greece

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Simple Summary: The consumption of goat milk is constantly increasing. However, there are not many studies on the nutritional profile of retail goat milk. This study examined the effects of production systems (conventional and organic) and seasons (spring, summer, autumn and winter) on the fatty acid composition and nutritional indices related to the healthy fat consumption of fluid goat milk sold in the supermarkets. The production system did not significantly affect milk fatty-acid composition nor its nutritional value, whereas seasonal effects were observed. Overall, retail goat milk had a desirable nutritional value, irrespective of production system and season.

Abstract: An increased consumer interest in goat milk has been registered in recent years due to its health-related benefits. This study aimed to investigate the effects of production systems and seasons on fatty-acid composition and nutritional indices for the healthy fat consumption of retail goat milk. The study lasted one year, and milk samples (n = 160) from 14 brands (10 conventional and 4 organic) were collected on a monthly basis. Organic milk had a marginally lower fat and protein content compared with conventionally produced milk according to the declared chemical composition. The production system did not significantly affect milk fatty-acid composition and its nutritional value, indicating that there were no major differences in the feeding strategies between conventionally and organically raised ewes. Seasonal effects were observed in the fatty-acid profile and the nutritional indices. Lower content of saturated fatty acids (SFAs), hypocholesterolemic/hypercholesterolemic ratio (h/H) and linoleic acid/α-linolenic acid (LA/ALA) ratio values were observed in summer. Retail goat milk had a desirable nutritional value, irrespective of production system and season, due to the following characteristics: low atherogenic index (AI) and LA/ALA ratio values, and high h/H ratio, desirable fatty acid (DFA) values and health-promoting index values. In conclusion, neither production nor season significantly impacted the fatty-acid composition and the fat-consumption nutritional indices of retail goat milk produced in Greece.

Keywords: goat milk; retail; conventional; organic; chemical composition; fatty-acid composition; season; management; dairy

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1. Introduction

Dairy goat farming is rapidly increasing worldwide due to the growing demand for goat dairy products [1]. Following this trend, goat-milk production has also increased by almost 20% in the period of 2016–2020 in Greece. Furthermore, the increase in organic milk production is impressive, reaching 164% in the same period (Table 1; Hellenic Agricultural Organization—Demeter; personal communication). Consumers prefer goat-milk products due to their health and nutritional benefits, such as greater digestibility, enhanced lipid metabolism and lower allergenicity [2,3]. Regarding fatty-acid composition, goat milk

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ORIGINAL PAPER

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Chemical composition, antioxidant profile and physicochemical properties of commercial non-cocoa- and cocoa-flavoured plant-based milk alternatives

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Abstract
In recent years, there has been a significant rise in the popularity of plant-based milk alternatives (PBMAs). This work examined the nutritional value, antioxidant profile and physicochemical characteristics of commercial non-cocoa- and cocoa-flavoured PBMAs. The examined products were either nut or oat-based ones. In the absence of protein fortification, the products' protein content was found to be low. Fat content was also low, whereas carbohydrate and sugar contents were related to sugar addition. Oleic, linoleic and α-linolenic acids were the primary unsaturated fatty acids. PBMAs have low Atherogenicity (AI) and Thrombogenicity (TI) indices and high hypocholesterolaemic:hypercholesterolaemic fatty acid ratio (h/H). The antioxidant profile significantly differed ($P < 0.001$) between non-cocoa- and cocoa-flavoured PBMAs. The antioxidant profile of cocoa-flavoured PMBAs improved due to the polyphenols present in cocoa beans. The physicochemical characteristics of the analysed PBMAs demonstrated great versatility. The nutritional profile of PBMAs also showed considerable variability, influenced by factors, such as product type and ingredient formulation. Additionally, differences in the nutritional composition and physicochemical properties were observed between non-cocoa and cocoa-based PBMAs.

Keywords Plant-based milk alternatives · Cocoa · Chemical composition · Fatty acid composition · Physico-chemical characteristics · Antioxidants

Introduction

Plant-based milk alternatives (PBMAs) are becoming increasingly popular in recent years [1]. According to the Market and Research Report from Fortune Business Inside (2022) [2], the global dairy alternatives market was valued at USD 22.25 billion in 2021. The market is expected to grow from USD 25.19 billion in 2022 to USD 61.43 billion by 2029 at a CAGR (Compound Annual Growth Rate) with a CAGR of 13.58% during the forecast period, driven mainly by the growing demand for plant-based milk alternatives. Lactose intolerance, allergies to cow milk, the prevalence of hypercholesterolemia, lifestyles, such as veganism and flexitarianism, sustainability as related to greenhouse emissions, animal welfare and calorie concern are the principal factors that led to the development of plant-based milk alternatives [3–7].

PBMAs are extracts of plant material dissolved in water, imitating cow milk in consistency and appearance [8, 9]. Homogenisation and thermal treatment are employed to improve plant-derived beverages' suspension and microbial stability. PBMAs can be classified into the following five categories (a) cereal-based, such as oat, rice, corn and spelt milk, (b) legume-based, such as soya, peanut, lupin and cowpea milk, (c) nut-based, such as almond, coconut, hazelnut, pistachio and walnut milk (d) seed-based, such as sesame, flax, hemp and sunflower milk and (e) pseudo-cereal-based, such as quinoa, teff and amaranth milk [9]. The nutritional properties of PBMAs are affected by the plant

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Thank you

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