https://doi.org/10.48047/AFJBS.6.15.2024.3373-3387

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Fatty acid composition of traditional and industrial butter available on Algerian Market

El hachemi Sassi [1], Djilali Benabdelmoumene [2], Said Dahmouni [2]

[1]University of AHMED ZABANA Relizane, Laboratory of Sciences and Techniques of Animal Production, Abdelhamid Ibn Badis University, Mostaganem, Algeria

[2]University of Abdelhamid Ibn Badis, Laboratory of Applied Animal Physiology, Abdelhamid Ibn Badis University, Mostaganem, Algeria

Corresponding author: hsassitaa_27@yahoo.fr

Article History
Volume 6, Issue 15, 2024
Received : 03 May 2024
Accepted : 28 Aug 2024
Published: 07 Sep 2024
doi:10.48047/AFJBS.6.15.2024.3373-3387

Abstract
Butter is a widely consumed dairy product, and its nutritional composition can vary significantly depending on the production method. This study aimed to analyze and compare the fatty acid composition of 25 traditional and 25 industrial butter samples sourced from various regions across Algeria. The analysis focused on saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA), degree of unsaturation, and peroxidability index. Fatty acid content was determined using capillary gas chromatography following the American Oil Chemistry Society (AOCS) standard procedures.
The results revealed significant differences between traditional and industrial butter. Traditional butter had a lower SFA content (48.93 ± 0.2%) compared to industrial butter (61.14 ± 0.2%). Conversely, traditional butter showed a higher MUFA content (31.01 ± 0.2%) compared to industrial butter (28.65 ± 0.2%). Similarly, traditional butter had a markedly higher PUFA content (10.03 ± 0.1%) than industrial butter (6.67 ± 0.1%). Moreover, the degree of unsaturation and the peroxidability index were also greater in traditional butter (15.82 and 19.34, respectively) compared to industrial butter (12.85 and 15.52, respectively).
These findings suggest that traditional butter offers a more favorable fatty acid profile, with higher unsaturated fat content, which may have implications for consumer health and product quality. Further studies should investigate the potential health benefits of traditional butter and explore the impact of local production methods on its nutritional properties.
Keywords: traditional butter, industrial butter, fat composition, degree of saturated, polyunsaturated fatty acid, peroxidability index.

Introduction

Butter is a widely consumed dairy product, often used in raw form, cooked in various dishes, or incorporated into commercial food products as a source of milk fat (Panel, 2015). It is traditionally produced through the process of cream churning, which separates butterfat from cow's milk (Jaroslawa, 2011). The lipids in butter are categorized as complex fats due to their composition, which includes triacylglycerols, phospholipids, tocopherols, and carotenoids (Jensen, 2002; Bouterfa et al., 2019). Over 400 different fatty acids have been identified in butter (Jensen et al., 1991; Jaroslawa, 2011), some of which, such as oleic acid (C18:1), are known for their significant nutritional and biological benefits (Pariza, 2004; Wahle et al., 2004; Field et al., 2009). These nutritional properties make butter a potential source of essential fatty acids, which play a crucial role in maintaining human health.

The composition of butterfat is influenced by a range of factors, including genetic and physiological traits of dairy cows, their diet, and the methods used in butter production. Additionally, the seasonal variations in raw milk composition can play a role in affecting the quality of butter. In the western regions of Algeria, seasonal changes have been shown to impact milk components such as casein fractions, which in turn affect dairy products like butter (Sassi et al., 2019; Chadli et al., 2024). In addition to these natural variations, butter manufacturing processes can involve specific technological interventions that further modify the composition of milk fat. For example, in some European and Asian countries, microbial lipases—enzymes produced by microorganisms—are introduced during the production process. These lipases catalyze the interesterification of fatty acids, which redistributes them on the triglycerides, enhancing both the nutritional profile and sensory qualities of the final product (Pabai, 1995; Annemieke et al., 2017). Similarly, crystallization techniques or methods based on the solubility and volatility of triglycerides may be employed to refine the product's texture and firmness (Kaylegian et al., 1993). Such modifications are designed to improve the sensory properties of butter, including its color, flavor, and nutritional value.

The Algerian dairy industry, which includes both traditional and industrial butter production methods, offers a unique context for exploring these factors. Research on the technological properties of lactic acid bacteria isolated from sheep's milk in Algeria demonstrates the importance of local microbial environments in shaping dairy product characteristics (Ketrouci et al., 2021). However, the specific manufacturing processes and their impact on butter composition in Algeria remain underexplored. Given that Algeria's climatic conditions, cattle breeds, and local dietary practices may all contribute to variations in the composition of butter, further research is warranted. This study aims to investigate the impact of different butter manufacturing processes in Algeria on the fatty acid composition of butter, with a focus on identifying potential nutritional and sensory benefits that may be unique to the region.

Materials and methods

A total of 50 samples of full-fat butter, comprising both traditional and industrial varieties, were collected from various supermarkets across Algeria. After purchase, each butter sample was transferred into a screw-top plastic container and stored at a temperature of 4°C in a refrigerator to preserve its integrity until analysis.

Fat Extraction and Analysis

The extraction and determination of fat content were carried out using the Rose-Gottlieb method, following the procedures outlined in AOAC No. 905.02 (AOAC, 2000). This well-established method ensured accurate and consistent extraction of fat from the butter samples. To prepare the samples for fatty acid analysis, the fat was transmethylated into fatty acid methyl esters (FAME) (Zineb et al., 2024). This process involved the use of a mixture of concentrated sulfuric acid (95%) and methanol, in accordance with the AOCS Official Method Ce 2–66 (AOCS, 2000).

Gas Chromatography (GC) Analysis

The composition of fatty acids was analyzed using gas chromatography (GC), following the specifications of the Polish Standard [PN-EN ISO 5508]. The analysis was conducted on an Agilent 6890N gas chromatograph, which was equipped with a split/splitless injector and a flame ionization detector (FID). For the separation of fatty acids, an Rtx 2330 Restek capillary column with a highly polar stationary phase was used. The column measured 100 m in length, with an internal diameter of 0.25 mm and a film thickness of 0.1 µm.

The column temperature was initially set at 120°C and programmed to increase gradually to 210°C, with a total run time of 120 minutes. This temperature program was optimized to ensure proper separation of the fatty acid methyl esters.

Standards and Calibration

To ensure the accurate identification of individual fatty acids, two reference standards were used: the milk fat standard CRM 164 (Community Bureau of Reference, EU, Brussels, Belgium) and the Supelco 37 standard No: 47885-U (Sigma Aldrich). These standards enabled the precise quantification of fatty acids, and results were expressed as the percentage of total resolved methyl esters.

Statistical Analysis

A one-way analysis of variance (ANOVA) was performed to assess the significance of differences in fatty acid content between butter samples produced using different manufacturing processes (traditional vs. industrial). Statistical significance was determined at a p-value < 0.05. All statistical calculations were conducted using Statistica 9 PL software (StatSoft, Inc., 2010).

Results and discussion

Table 01: Saturated fatty acids composition (%) of traditional and industrial butter

Fatty acid type	Traditional butter	Industrial butter
C14 :0	9.11 ± 0.1^{a}	7.66 ± 0.1^{b}
C15 :0	0.02 ± 0.01	0 ± 0
C16 :0	30.55 ± 0.2^{b}	40.11 ± 0.2^{a}
C18 :0	9.07 ± 0.1^{b}	1 ± 0.01^{b}
C20 :0	0.21 ± 0.01^{a}	0.8 ± 0.01^{b}
C22 :0	0.1 ± 0.01	0.1 ± 0.01
SFA	48.93 ± 0.2^{b}	61.14 ± 0.2^{a}

$^{a–b}$: Mean values with different letters in the same column are significantly different (P<0.05)

The composition of saturated fatty acids (SFAs) in the butter samples is presented in Table 1. Six SFAs were identified in both the traditional and industrial butter samples. Notably, industrial butter contained a significantly higher percentage of SFAs (61.14%) compared to traditional butter (48.93%), indicating that the manufacturing process substantially increased the SFA content **(**$p < 0.001$**)**. Among the identified SFAs, palmitic acid (C16:0) was the most abundant, with a higher concentration in industrial butter (40.11%) than in traditional butter (30.55%). Myristic acid (C14:0) was the second most prevalent, present at 9.11% in traditional butter and 7.66% in industrial butter.

In contrast, stearic acid (C18:0) was more abundant in traditional butter (9.07%) compared to industrial butter, where it accounted for only 1%.

These findings are consistent with studies on butter from other countries. For example, Annemieke et al. (2017) reported similar SFA profiles in Dutch butter, while Tomaszewska et al. (2016) observed comparable trends in Polish butter. Research conducted in the USA (Plans et al., 2015) and Ireland (Cullinane et al., 1984) also identified palmitic, stearic, and myristic acids as the primary SFAs in butter. A recent study by Mehmet and Serap (2024) confirmed the predominance of these SFAs in butter samples, aligning with earlier findings by Aly et al. (2009) and Kasapçopur et al. (2021), who consistently reported these three fatty acids as the main SFAs in butter. Similarly, Rady and Badr (2003) found that cow's butter contained 49.43% SFAs, with palmitic acid being the major component (22.81%), followed by stearic acid (10.21%) and myristic acid (6.79%). In Trabzon butter**,** Tulay Ozcan et al. (2016) identified palmitic acid (32.65%)**,** stearic acid (11.48%), and myristic acid (11.38%) as the predominant SFAs.

SFAs, which are typically solid at room temperature, are known to increase cholesterol levels in the bloodstream. Nutritional guidelines recommend that SFAs should not exceed 30% of the total dietary fat intake (Jiri Brat and Jan Pokorny, 1999), as excessive consumption of these fatty acids is linked to hypercholesterolemia and cardiovascular diseases (Oliveira et al., 2015). The high palmitic acid content observed in industrial butter may be attributed to the use of palm oil fractions or palm kernel oils, which are rich in medium-chain fatty acids. In contrast, the higher stearic acid content in traditional butter, considered neutral with respect to plasma cholesterol, could be the result of using hydrogenated oils or interesterified fats in the production process.

However, not all SFAs are detrimental to health. As Jaroslawa et al. (2021) pointed out, short- and medium-chain SFAs are important components of milk fat. These fatty acids are highly digestible, serve as quick energy sources, and are less likely to contribute to obesity. Additionally, several studies have highlighted the antimicrobial properties of certain SFAs. For instance, Rutkowska et al. (2011) and Ozcan et al. (2016) demonstrated that some short- and medium-chain SFAs exhibit antiviral, antifungal, and antibacterial properties, particularly against Gram positive bacteria.

Table 02: Monoinsaturated fatty acids composition (%) of traditional and industrial butter

Fatty acid type	Traditional butter	Industrial butter
C14:1	0.18 ± 0.01	0.1 ± 0.01
C16:1	2.08 ± 0.02^{a}	1 ± 0.01 ^{b}

C18:1 n-9	28.5 ± 0.2 [a]	27.28 ± 0.2 [a]
C20:1 n-9	0.25 ± 0.01 [a]	0.27 ± 0.01 [a]
C22:1 n-9	0.01 ± 0.001 [a]	0.02 ± 0.001 [a]
MUFA	31.01 ± 0.2 [a]	28.65 ± 0.2 [b]

[a–b]: Mean values with different letters in the same column are significantly different (P<0.05)

The monounsaturated fatty acids (MUFA) identified in the butter samples included tetradecenoic (C14:1)**,** palmitoleic (C16:1)**,** oleic (C18:1 n-9)**,** eicosenoic (C20:1 n-9), and erucic acid (C22:1 n-9). Traditional butter exhibited a slightly higher MUFA content (31.01%) compared to industrial butter (28.65%). Among the MUFAs**,** oleic acid (C18:1) was the predominant fatty acid in both traditional and industrial butter samples. Despite this dominance, there was no statistically significant difference in oleic acid content between the two butter types (28.5 ± 0.2% in traditional vs. 27.28 ± 0.2% in industrial butter). However, a significant difference was observed in palmitoleic acid (C16:1) levels, with traditional butter containing 2.08 ± 0.02%, compared to 1.00 ± 0.01% in industrial butter **(**$p < 0.05$**).**

The high concentration of oleic acid in both butter types is consistent with findings from similar studies on margarine and shortening (Wagner et al., 2000; Bhanger & Anwar, 2004; Hoffmann, 2007; Kroustallaki et al., 2011; Meremae et al., 2012; Bakeet et al., 2013). Salomon et al. (2009) reported oleic acid as the major fatty acid in high-fat foods, accounting for 93.63% of total fatty acids, though heat treatment reduced its content to 90.49%, highlighting its sensitivity to processing conditions. Additionally, Garti et al. (2019) found a higher oleic acid value (36.29%) in their study, compared to the present findings (28.5% in traditional butter and 27.28% in industrial butter), which may be attributed to differences in feed, processing techniques, or geographical factors.

Oleic acid is known for its beneficial health effects, particularly its role in improving plasma lipid profiles and reducing mortality from chronic heart diseases (Hu et al., 2001; Willett, 2006). Monounsaturated fats, like oleic acid, have been shown to increase high-density lipoprotein cholesterol (HDL-C) levels while reducing plasma triglycerides, without significantly impacting low-density lipoprotein cholesterol (LDL-C) levels. Furthermore, MUFAs protect LDL-C from oxidative damage, which is crucial in preventing atherosclerosis (Iman M. Taher et al., 2018). They also exhibit antiatherogenic properties and have been found to inhibit cancer cell proliferation (Field et al., 2009). Given their health benefits, it is recommended that MUFAs constitute up to 15% of total daily energy intake (ITFPCHD, 2003).

Table 03: Polyunsaturated fatty acids composition (%) of traditional and industrial butter

Fatty acid type	Traditional butter	Industrial butter
C18:2 n-6	7.9 ± 0.1 [a]	4.66 ± 0.1 [b]
C18:3 n-6	0.01 ± 0.001 [a]	0.05 ± 0.001 [a]
C18:3 n-3	0.5 ± 0.01	0.5 ± 0.01
C20:2	0.17 ± 0.01 [a]	0.11 ± 0.01 [b]
C20:3 n-6	0.5 ± 0.01 [a]	0.2 ± 0.01 [b]
C20:3 n-3	0.08 ± 0.01 [a]	0.06 ± 0.01 [a]
C20:4 n-3	0.09 ± 0.01 [a]	0.05 ± 0.01 [b]
C20:5 n-3	0.13 ± 0.01 [b]	0.17 ± 0.01 [a]
C22:5 n-3	0.13 ± 0.01 [a]	0.11 ± 0.01 [b]
C22:6 n-3	1.25 ± 0.02 [a]	1.07 ± 0.02 [b]
PUFA	10.03 ± 0.1 [a]	6.67 ± 0.1 [b]
n-6	8.58 ± 0.1 [a]	5.02 ± 0.1 [b]
n-3	2.18 ± 0.02 [a]	1.89 ± 0.02 [b]

[a–b]: Mean values with different letters in the same column are significantly different (P<0.05)

The mean polyunsaturated fatty acid (PUFA) content in traditional and industrial butter samples was 10.03 ± 0.1% and 6.67 ± 0.1%, respectively (Table 03). This indicates a significantly higher PUFA concentration in traditional butter compared to industrial butter ($p < 0.05$). Linoleic acid (C18:2 n-6) was the most abundant PUFA in both butter types, with levels of 7.9 ± 0.1% in traditional butter and 4.66 ± 0.1% in industrial butter. These values are higher than those found in cooking butter, as reported by Eman M. Taher et al. (2018), and are consistent with the lower linoleic acid content observed in Trabzon butter and other edible oils (Ozcan et al., 2016; Dixit & Das). Linoleic acid is a key component in the reduction of total and low-density lipoprotein cholesterol (LDL-C) levels, contributing to improved cardiovascular health.

Traditional butter also contained higher concentrations of Omega-6 fatty acids (8.58 ± 0.1%) compared to industrial butter (5.02 ± 0.1%). Additionally, traditional butter had more Omega-3 fatty acids (2.18 ± 0.02%) than industrial butter (1.89 ± 0.02%). A balanced Omega-6 to Omega-3 ratio is crucial for reducing inflammation and promoting heart health. Although no significant differences were observed in the levels of C18:3 n-6 and C18:3 n-3 between the two butter types, traditional butter had slightly higher amounts of these essential fatty acids.

Alpha-linolenic acid (C18:3 n-3), an essential fatty acid that must be obtained through diet, plays a vital role in various biological processes, including brain function and anti-inflammatory responses. Traditional butter also exhibited higher levels of docosahexaenoic acid (DHA, C22:6 n-3), a crucial Omega-3 fatty acid, at 1.25 ± 0.02%, compared to 1.07 ± 0.02% in industrial butter. DHA is particularly important for cognitive development and heart health.

PUFAs are recognized for their essential role in human nutrition, providing numerous functional and health-promoting benefits, such as supporting cardiovascular health, reducing inflammation, and regulating lipid metabolism. Studies have consistently highlighted the importance of PUFAs in traditional dairy products. For instance, Sagdic et al. (2004) determined PUFA levels in various traditional butters, reporting 1.44 ± 0.01% in goat's yayik butter, 2.96 ± 0.06% in ewe's yayik butter, and 1.34 ± 0.01% in cow's yayik butter. These results suggest that traditional butters, particularly those made from goat milk, possess superior organoleptic qualities and higher PUFA concentrations. Similarly, Idoui et al. (2010) found substantial amounts of linoleic acid in traditional butter from Eastern Algeria, with concentrations ranging from 7.03% to 11.15%, depending on the sample.

The higher PUFA content in traditional butter, especially its richness in linoleic acid, Omega-6, and Omega-3 fatty acids, underscores its nutritional superiority compared to industrial butter. The presence of these essential fatty acids in traditional butter, alongside the better Omega-6 to Omega-3 ratio, suggests potential health benefits, particularly in terms of heart health and anti-inflammatory properties.

Table 04: Degree of unsaturation and peroxidability index of traditional and industrial butter

Fatty acid type	Traditional butter	Industrial butter
Degree of Unsaturation	15.82 [a]	12.85 [b]
Peroxidability Index	19.34 [a]	15.52 [b]
LCFAs	78.87 ± 0.8 [b]	96.96 ± 0.8 [a]
VLCFAs	1.49 ± 0.02 [a]	1.3 ± 0.02 [b]

[a–b]: Mean values with different letters in the same column are significantly different (P<0.05)

Long-chain fatty acids (LCFAs) and very-long-chain fatty acids (VLCFAs), as shown in Table 04, were found to be higher in industrial butter (LCFAs: 96.96 ± 0.8%, VLCFAs: 1.3 ± 0.02%) compared to traditional butter (LCFAs: 78.87 ± 0.8%, VLCFAs: 1.49 ± 0.02%). VLCFAs, which are characterized by a chain length of ≥22 carbons, play essential roles in various physiological processes, including skin barrier formation, liver homeostasis, myelin maintenance, spermatogenesis, retinal function, and the resolution of inflammation (Akio, 2012). These fatty acids are also critical for brain health and immune cell function (Battina et al., 2022).

Traditional butter exhibited a higher degree of unsaturation (15.82%) and a higher peroxidability index (19.34%) compared to industrial butter (degree of unsaturation: 12.85%, peroxidability index: 15.52%). The increased unsaturated fatty acid content in traditional butter makes it more susceptible to oxidation and the development of off-flavors (Focant et al., 1998). It is well established that a high polyunsaturated fatty acid (PUFA) content in milk fat can lead to oxidation within 24 hours of refrigeration (McDonald and Scott, 1977), which can negatively impact the sensory properties and consumer acceptance of dairy products like ice cream (Abd El-Rahman et al., 1997). In contrast, milk fat with a high monounsaturated fatty acid (MUFA) content is less prone to oxidation.

Unsaturated fatty acids, especially PUFAs, can oxidize to form hydroperoxides, which subsequently degrade into secondary oxidation products, such as aldehydes and ketones. These compounds can impart off-flavors, even when present in low concentrations, potentially affecting the overall quality of butter and other dairy products (Fox and McSweeney, 1998).

Conclusion

The increasing demand for traditional foods in Algeria reflects a broader trend toward healthier, more natural products, driven by consumer interest in their potential health benefits and cultural heritage. This study provided an in-depth comparison of the fatty acid profiles of traditional and industrial butters, uncovering key differences that may influence both their nutritional value and health implications. While both butter types shared common fatty acids, traditional butter exhibited significantly higher levels of beneficial fatty acids such as myristic, stearic, palmitic, oleic, and linoleic acids. These fatty acids are known to contribute to various physiological functions, including energy provision, cellular health, and cardiovascular benefits.

The composition of fatty acids in butter is determined by a range of interrelated factors. The species of dairy animals, their diet, and milk composition are crucial, but the differences between traditional and industrial butters also stem from variations in manufacturing processes, environmental conditions, and the unique flora of the pastures on which animals graze. Traditional butter, in particular, benefits from the use of artisanal methods that are closely tied to local ecological and cultural practices. Geographical factors, including diverse meadow and pasture ecosystems, further enhance the nutrient content of traditional butter, particularly in terms of its polyunsaturated and monounsaturated fatty acid profiles.

These findings suggest that traditional butter not only holds cultural and gastronomic significance but may also offer superior nutritional benefits due to its higher content of essential fatty acids. The richness in oleic and linoleic acids, for example, points to its potential for supporting heart health and regulating cholesterol levels, as these fatty acids are known to reduce LDL cholesterol while increasing HDL cholesterol. The higher levels of stearic acid, which has a neutral effect on blood cholesterol, and myristic acid, which is vital for immune function, also suggest additional health benefits associated with traditional butter.

Given the complexity of factors influencing butter composition—ranging from animal feed and species to regional climatic conditions and pasture biodiversity—this study highlights the importance of preserving traditional production methods. Traditional butter, shaped by local terroir and artisanal practices, offers a distinctive product that reflects both the natural environment and cultural heritage of its region of origin.

In light of these findings, future research should delve deeper into the broader health impacts of the specific fatty acid differences observed in traditional versus industrial butter. Longitudinal studies could explore how the consumption of these distinct fatty acid profiles affects cardiovascular health, metabolic function, and overall well-being over time. Additionally, further investigation into the environmental sustainability of traditional versus industrial butter production could offer valuable insights for promoting healthier, more sustainable food systems. Understanding these factors will not only inform consumer choices but also provide producers with guidance on maintaining the nutritional integrity of butter while meeting the growing demand for traditional, health-promoting foods in Algeria and beyond.

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