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Antioxidant Capacity, Oxidative Stability And Sensory Properties Of Flavored Butter Using Dried Apricot Pulp

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ABSTRACT

In this study, various concentrations of dried apricot pulp (DAP) were added to butter at levels of 0%, 15%, 20%, and 25%. Antioxidant capacity, oxidative stability, color, and sensory attributes were assessed during 45 days of storage. Butter samples were labeled as A_0 (Control), A_{15}, A_{20}, and A_{25} corresponding to the respective levels of DAP incorporation. The addition of DAP resulted in significant reductions in pH, while titratable acidity (expressed as lactic acid %) and Free Fatty Acids (FFA) content (mg KOH g^{-1} butter) increased in a dose-dependent manner ($P< 0.05$). Moreover, fortification with DAP delayed peroxide formation in the butter samples. Additionally, DAP supplementation significantly ($P< 0.05$) increased Total Phenolic Content (TPC), improved DPPH (2,2-diphenyl-1-picrylhydrazyl) scavenging activity, and increased Total Antioxidant CCapacity (TAC) during storage. Panelists assigned higher sensory scores to the DAP-enhanced butters. These fortified butters exhibited lower fat content (ranging from 65.25 to 65.50%) compared to the control butter (73.75%). Notably, the total sugar content of samples A_{15}, A_{20}, and A_{25} was 3.69±0.06, 4.70±0.06, and 5.64±0.08, respectively. Overall, this study demonstrates the potential of all DAP ratios, particularly 25%, as rich sources of antioxidants. However, further formulation adjustments and comprehensive analyses are warranted for industrial and marketing applications.

Keywords: Antioxidant activity, Butter, Dried apricot pulp, Oxidative, Quality, Stability.

INTRODUCTION

Butter is a water-in-oil emulsion containing approximately 79–84% lipid content and enriched with vitamins A, E, D, and K (Ebrahimian *et al.*, 2023). It is widely utilized as a spread on plain or toasted bread products, a condiment on cooked vegetables, and an ingredient in various culinary applications, including baking, sauce preparation, and pan-frying (Bujancă *et al.*, 2016). Butter products are typically categorized as sweet cream unsalted, sweet cream salted, cultured unsalted, cultured salted butter, or traditional sour cream butter (Kwak *et al.*, 2013). Additionally, the Turkish Food Codex classifies butter as yayık butter, flavored butter mix, and

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flavored butter produced with various spices, vegetables, honey, other foodstuffs, and fruits (Notification No. 2005/19). Enhancing butter with natural ingredients that provide health benefits is one strategy to promote its consumption (Vidanagamage *et al.*, 2016).

Numerous studies have focused on enhancing the nutritional properties of butter due to its widespread consumption globally (Thakaeng *et al.*, 2020). These studies primarily aim to inhibit butter oxidation using plant derivatives (Bule *et al.*, 2022; Çakmakçı *et al.*, 2014; Dagdemir *et al.*, 2009; Ebrahimian *et al.*, 2023; Gramza-Michalowska *et al.*, 2007; Wojdyło *et al.*, 2005; Ziarno *et al.*, 2023).Although plant extracts have been effective in enhancing antioxidative stability, they have also been reported to compromise the sensory properties of butter. For instance, Nadeem *et al.* (2013) found that Moringa oleifera leaf extract negatively affected the taste and aroma of butter compared to the control butter. Similarly, Göksel Saraç and Dogan (2016) demonstrated that the addition of dietary fibers from vegetable and fruit wastes, such as stone pears, celery root, celery leaves, spinach, and orange, reduced butter's sensory scores. Sensory characteristics significantly influence consumer preference (Markey *et al*., 2017). Therefore, fortification should not only enhance nutritional value but also improve consumer appeal (Alqahtani *et al.*, 2023). Zakharova (2014) reported that vegetable fats, proteins, natural vegetable fillers, and fruits are used in the dairy industry to maintain traditional nutritional value and compensate for nutrient deficiencies. Consequently, fortifying dairy products with fruit can enhance functional properties, improve appearance, and add color Salehi (2021).

Among various fruits, apricot (*Prunus armeniaca* L.) is particularly popular due to its pleasant taste, unique flavor, and appealing vivid color, whether consumed fresh or dried (Ali *et al.*, 2011). Dried apricot is especially noted for being a rich source of phenolics, vitamin C, and carotenoids (Hussain *et al.*, 2013). Fructose and sucrose are the dominant sugars in apricots, contributing to their sweetness, sensory quality, and consumer satisfaction (Fan *et al.*, 2017).

Despite extensive research on fruit-fortified dairy products like yogurt, ice cream, kefir, and cheese, to our knowledge, no studies have investigated butter produced with apricot pulp. This study aims to improve the antioxidant properties of flavored butter with dried apricot pulp DAP to enhance its nutritional value, assess the impact of DAP on chemical properties, ~~and~~ enhance sensory properties such as taste and color, and develop an alternative butter variety comparable to other dairy products.

MATERIALS AND METHODS

Materials

The cream (65% milk fat) was procured from Izi Milk and Milk Product Co. (Konya, Turkey), and dried apricot was sourced from a local market in Gümüşhane, Turkey. Chemicals of analytical grade were obtained from Merck Co. (Darmstadt, Germany) and Sigma Chemical Co. (St. Louis, MO).

Methods

Preparation of DAP

The dried apricots were washed and sliced. The slices were mixed with water (1:1) and boiled for 30 minutes until softened. The mixture was then blended into a pulp using an electric blender (Waring Commercial, 38BL40, USA) and stored in a sterilized glass bottle at 4 °C until used for butter production.

Preparation of Butter Samples

The cream, adjusted to 50% fat with skim milk, was churned, washed, and divided into four parts. Apricot pulp was added to the butter samples at concentrations of 15%, 20%, and 25% (w/w), coded as A_{15}, A_{20}, and A_{25}, respectively. The fourth sample, without any additives, served as the control (A_0). The butter samples were packaged with stretch film and covered with aluminum foil to protect them from light, then stored at 4°C for two months. All analyses were conducted on days 1, 15, 30, 45, and 60, except for proximate analysis, which was performed only on the first day. The first sampling day was after one day of storage, and all butter samples were produced in duplicate.

Physicochemical Properties of DAP

The dry matter (at 105 °C) and ash content (at 550 °C) of DAP were determined using the methods described by Khairuddin *et al.* (2017). The pH was measured with a pH meter (HANNA Instruments, Italy), and color values (L*, a*, b*) were assessed using a Minolta Chromameter (CR-200) (Konica Minolta Sensing, Inc. Japan). Color values were: L (brightness), 100= White, 0= Black; a (+) red, a (−) green; b (+) yellow, b (−) blue.

Proximate and Physicochemical Properties of Butters

Dry matter, fat content, and sugar content were determined on the first day of storage, while pH, titratable acidity, free fatty acids, and color values were determined on days 1, 15, 30, 45, and 60 of storage. Dry matter (oven drying), fat content (Gerber method), the pH of butter samples was measured using a pH meter (HANNA Instruments, Italy), and color values (L*,

a*, b*) were determined using a Minolta colorimeter (Chroma Meter, CR-200, Osaka, Japan). Titratable acidity, expressed as lactic acid percentage, and Free Fatty Acid (FFA) content, expressed as mg KOH g^{-1} butter, were determined using the method described by Timtey *et al.* (2024) on days 1, 15, 30, 45, and 60 of storage.

Determination of Sugar Content

Fructose, glucose, and total sugar analyses were conducted on both DAP and butter samples on the first day of storage. The procedure of the International Honey Commission (Anonymous, 2009) was used for sugar analysis. The analysis was performed using HPLC-RID (Thermo Scientific Products Finnigan Spectra System). Sugar separation was achieved with a column (5 µm particle size, L×ID 250 mm×3 mm). The flow rate was 1.3 mL/min, and acetonitrile/water (80:20, v/v) was used as the mobile phase. The column temperature was maintained at 50±1°C, and the injection volume was 20 µL.

Determination of Peroxide Value

Peroxide value (PV) was determined to assess primary oxidation during storage. Samples were dissolved in a mixture of chloroform and glacial acetic acid and titrated with 0.002 N $Na_2S_2O_3$ using a 1% starch indicator. PV was expressed as meq O_2 kg^{-1} butter (Yatsenko *et al.*, 2020).

Determination of TPC, DPPH Radical Scavenging Capacity, and TAC

First, the extract was prepared. A sample (1 g, pulp $butter^{-1}$), 2 mL of hot distilled water, and 5 mL of ethanol were extracted in an ultrasonic bath (Sonorex Super RK 103 H, Germany). After filtering through filter paper, the extract was passed through 0.45 µm filters and used for TPC, DPPH, and TAC tests.

Total Phenolic Content (TPC) was determined using the Folin–Ciocalteu test. To calibrate the concentration of total phenolics in butter samples, the absorbance of standard Gallic acid solutions (20, 40, 60, 80, 120, and 160 µg mL^{-1}) was measured at 760 nm (Shimadzu UV-1800 240 V, Japan) , and results were expressed as mg Gallic Acid Equivalent (GAE) kg^{-1} sample (Kasangana *et al.*, 2015).

For DPPH analysis , 100 µL of the extract was mixed with 3,000 µL of DPPH solution and vortexed. After a 30-minute incubation, absorbance was measured at 517 nm using a spectrophotometer (Shimadzu UV-1800 240V, Japan), with 100 µL of methanol as the blank.

DPPH radical scavenging activity was expressed as inhibition capacity percentage (Ahmed *et al.*, 2015).

TAC was measured using the equation of the graph prepared with ascorbic acid solutions (25, 50, 100, 150, 250, 500, and 900 μg mL^{-1}), and TAC was expressed as mg Ascorbic Acid Equivalent (AAE) kg^{-1} butter. 500 μL of the extract was mixed with 2500 μL of deionized water and 1,000 μL of molybdate reagent. The mixture was vortexed and incubated at 95°C for 90 minutes, then cooled to room temperature. Absorbance was measured at 695 nm (Shimadzu UV-1800 240 V, Japan), against a blank which containes distilled water instead of the sample (Kasangana *et al.*, 2015).

Sensory Analyses

A panel of 14 trained specialists familiar with dairy products from the Food Engineering Department, Gümüşhane University, Turkey, evaluated the butter samples. Approximately 15 g of each butter sample was placed in cups labeled with random three-digit numbers. All samples were allowed to reach room temperature for 30 minutes before being served to the panelists, who were given instructions prior to sensory analysis. Bread was provided for testing the butters, and water was available for rinsing the mouth (Zine-Eddine *et al.*, 2022). Panelists evaluated the samples for colour, texture, odor, taste, rancidity and general acceptability. Sensorial attributes were scored according to Hedonic scale from 1 (lowest) to 9 (highest).

Statistical Analyses

ANOVA was employed to analyze the differences among the group means for all data. Mean values showing significant differences were compared using Duncan's multiple range tests ($P< 0.05$). The results were expressed as means of two replications. For this analysis, the SPSS 24.0 software package (SPSS Inc., Chicago, IL, USA) was used.

RESULTS AND DISCUSSION

Physicochemical Properties of DAP

Table 1 presents the physicochemical composition of DAP, highlighting its high total phenolic content (TPC), DPPH radical scavenging activity, and total antioxidant capacity (TAC). The literature reports varying results concerning the chemical composition, antioxidant properties, color, and phenolic content of dried apricot. Karabulut *et al.*, (2018) found that dry matter, glucose, and fructose contents ranged between 84.1-89.3% and 18.26-13.48%, respectively. Čanadanović-Brunet *et al.* (2013) reported a total phenolic content of 498.13±12.04 mg GAE

100 g^{-1} in dried apricot. Ivanova *et al.* (2017) documented L, a*, and b* values as 30.2-36.4, 6-12.4, and 9-21.8, respectively. These discrepancies can be attributed to different apricot varieties, geographic conditions, drying techniques and temperatures (sulphured vs. unsulphured), maturity stages, storage conditions, chemical compositions, and analytical methods.

Table 1. Physicochemical properties of Dried Apricot Pulp used during butter production.

Properties	DAP
Dry matter (%)	46.07±0.15
Ash (%)	1.60±0.11
pH	4.18±0.01
*L**	48.80±0.55
*a**	3.70±0.37
*b**	37.20±0.56
TPC (GA mg kg^{-1})	1592.08±57.45
DPPH (Inhibition %)	40.57±0.00
TAC (AA mg g^{-1})	639.11±0.94
Fructose (%)	10±0.01
Glucose (%)	18±0.01
Total sugar (%)	28±0.01

* Data are means±standard deviation.

Proximate and Physicochemical Properties of Butters

The chemical properties of butters produced with different concentrations of DAP (15, 20, and 25%) were compared with those of the control. Analyses of dry matter, fat, and sugar content were performed on the first day of storage, as detailed in Table 2. Additionally, pH, titratable acidity, Free Fatty Acids (FFA), and color properties were assessed throughout the storage period, as presented in Table 3.The addition of DAP had a statistically significant effect ($P< 0.05$) on the chemical properties. Specifically, the addition of pulp decreased dry matter and fat content while increasing sugar content, depending on the pulp concentration. These findings align with those of Mohamed and Shalaby (2016), who reported that the addition of apricot pulp to processed cheese spread reduced dry matter content.

Table 2. Proximate composition (%) of control and flavored butters.[a]

Samples[b]	Dry-matter	Fat	Fructose	Glucose	Total sugar
A_0	76.87±0.47^a	73.75±0.96^a	-	-	-
A_{15}	73.42±0.45^b	65.25±0.50^b	1.33±0.03^a	2.36±0.04^a	3.69±0.06^a
A_{20}	72.73±0.68^b	65.50±0.58^b	1.69±0.03^b	3.01±0.05^b	4.70±0.06^b
A_{25}	71.47±0.57^c	65.50±0.58^b	2.03±0.03^c	3.61±0.06^c	5.64±0.08^c

[a] (a-c): The data are presented as means±standard deviation. Significant differences among the means within the same column and row are denoted by distinct lowercase and uppercase superscript letters, respectively, at a significance level of $P< 0.05$.

[b] A_0: Control butter without DAP, A_{15}: Butter containing 15% DAP, A_{20}: Butter containing 20% DAP, A_{25}: Butter containing 25% DAP.

The pH values of butters with Dried Apricot Pulp (DAP) were consistently lower than the control sample throughout the storage period, with significant differences observed ($P< 0.05$) (Table 3). Increasing DAP concentration resulted in decreased pH values, with the lowest pH recorded in the sample containing 25% DAP at the end of storage. This decrease is attributed

to the low pH of DAP (4.18±0.01). Titration Acidity (LA%) values increased during storage, with the control sample showing lower acidity compared to other samples. Higher concentrations of DAP led to increased acidity, with all samples significantly different ($P< 0.05$).

Free Fatty Acid (FFA) values in butters fortified with DAP were higher than in the control sample, varying with DAP concentration ($P< 0.05$). Significant differences in FFA values were observed over the storage period ($P< 0.05$). This increase can be attributed to the low pH, high acidity (Table 3), and high phenolic and antioxidant activity of both DAP and the butters (Table 4). These results align with those of Shakerardekani *et al.* (2020), who reported that adding honey to pistachio butter increased FFA levels depending on the honey concentration. Importantly, the increased FFA content in DAP-fortified butters did not negatively impact sensory scores related to rancidity, as there is not always a positive correlation between FFA levels and sensory bitterness. Mahmoudi *et al.* (2019) found that adding Ziziphora clinopodioides to butter did not change acidity values during a 10-day storage period.

Table 3. Evolution of physicochemical properties of control and flavored butters during storage.

Properties	Storage (Days)	Samples			
		A_0	A_{15}	A_{20}	A_{25}
pH	1	4.65±0.11 ^{Aa}	4.26±0.01 ^{Bb}	4.24±0.01 ^{Bb}	4.21±0.01 ^{Bb}
	15	4.55±0.01 ^{Ab}	4.27±0.01 ^{Bb}	4.21±0.01 ^{Cd}	4.17±0.01 ^{Dd}
	30	4.66±0.01 ^{Aa}	4.38±0.01 ^{Ba}	4.35±0.01 ^{Ca}	4.27±0.01 ^{Da}
	45	4.53±0.01 ^{Ab}	4.18±0.01 ^{Bd}	4.11±0.01 ^{Ce}	4.10±0.01 ^{Ce}
	60	4.59±0.01 ^{Aab}	4.24±0.01 ^{Bc}	4.22±0.01 ^{Cc}	4.18±0.01 ^{Dc}
Titratable Acidity (LA %)	1	0.20±0.02 ^{Cb}	0.35±0.01 ^{Bb}	0.37±0.01 ^{Bb}	0.44±0.01 ^{Ac}
	15	0.19±001 ^{Db}	0.37±0.01 ^{Bab}	0.38±0.01 ^{Bb}	0.44±0.01 ^{Ac}
	30	0.17±0.01 ^{Dc}	0.33±0.01 ^{Cc}	0.38±0.01 ^{Bb}	0.45±0.01 ^{Abc}
	45	0.19±0.01 ^{Db}	0.37±0.01 ^{Ca}	0.41±0.01 ^{Ba}	0.47±0.01 ^{Aa}
	60	0.23±0.01 ^{Da}	0.38±0.01 ^{Ca}	0.42±0.01 ^{Ba}	0.46±0.01 ^{Ab}
FFA (mg KOH g^{-1} butter)	1	1.32±0.06 ^{De}	3.14±0.13 ^{Cc}	3.53±0.07 ^{Bab}	3.87±0.07 ^{Aa}
	15	1.76±0.06 ^{Dc}	3.20±0.06 ^{Cbc}	3.40±0.06 ^{Bc}	3.93±0.13 ^{Aa}
	30	1.60±0.11 ^{Dd}	2.10±0.06 ^{Cd}	2.27±0.06 ^{Bd}	2.44±0.06 ^{Ac}
	45	2.44±0.11 ^{Da}	3.28±0.06 ^{Cb}	3.45±0.06 ^{Bbc}	3.62±0.06 ^{Ab}
	60	1.99±0.06 ^{Db}	3.45±0.06 ^{Ca}	3.56±0.06 ^{Ba}	3.81±0.09 ^{Aa}
*L**	1	88.00±0.43 ^{Ac}	84.46±0.24 ^{Bb}	85.14±0.45 ^{Ba}	81.55±0.67 ^{Cab}
	15	89.75±0.18 ^{Ab}	84.70±0.14 ^{Bb}	82.71±0.58 ^{Cb}	80.63±0.19 ^{Dbc}
	30	87.15±0.51 ^{Ad}	80.95±0.74 ^{Cd}	83.33±0.42 ^{Bb}	78.81±0.49 ^{Dd}
	45	90.56±0.37 ^{Aa}	85.75±0.52 ^{Ba}	85.03±0.59 ^{Ba}	81.77±0.98 ^{Ca}
	60	88.21±0.52 ^{Ac}	82.39±0.33 ^{Bc}	80.43±0.32 ^{Cc}	79.79±0.91 ^{Ccd}
*a**	1	-3.84±0.07 ^{Bb}	-3.72±0.31 ^{Ba}	-3.56±0.34 ^{Bb}	-2.40±0.71 ^{Aa}
	15	-3.92±0.05 ^{Bb}	-3.23±0.29 ^{Aa}	-2.88±0.33 ^{Aa}	-2.83±0.30 ^{Aab}
	30	-3.85±0.11 ^{Ab}	-3.70±0.14 ^{Aa}	-4.09±0.38 ^{Ac}	-4.02±0.37 ^{Ad}
	45	-3.48±0.12 ^{Aa}	-3.60±0.56 ^{Aa}	-3.65±0.03 ^{Ab}	-3.83±0.19 ^{Acd}
	60	-3.51±0.17 ^{Aa}	-3.61±0.10 ^{Aa}	-3.50±0.19 ^{Ab}	-3.27±0.55 ^{Abc}
*b**	1	17.02±0.83 ^{Cb}	23.07±0.71 ^{Bb}	22.90±1.04 ^{Bab}	30.39±0.93 ^{Aa}
	15	17.11±0.29 ^{Cb}	23.96±0.77 ^{Bb}	23.18±0.86 ^{Bab}	29.06±0.96 ^{Aab}
	30	16.59±0.60 ^{Cb}	23.66±0.73 ^{Bb}	22.60±1.55 ^{Bb}	28.33±1.11 ^{Ab}
	45	16.50±0.16 ^{Db}	26.50±1.04 ^{Ba}	24.63±1.36 ^{Ca}	29.05±0.73 ^{Aab}
	60	18.17±0.50 ^{Da}	21.23±0.59 ^{Cc}	24.48±0.99 ^{Bab}	26.37±0.70 ^{Ac}

[a] (A-D and a-d): The data are presented as means±standard deviation. Significant differences among the means within the same column and row are denoted by distinct lowercase and uppercase superscript letters, respectively, at a significance level of $P< 0.05$.

[b] A_0: Control butter without DAP, A_{15}: Butter containing 15% DAP, A_{20}: Butter containing 20% DAP, A_{25}: Butter containing 25% DAP.

Carotenoid content significantly affects the color of dairy products, especially high-fat products like butter, by imparting a yellow hue (O'Callaghan *et al.*, 2016). This color characteristic is crucial for consumer acceptance.

The color parameters (L*, a*, b*) are presented in Table 3. The brightness values (L*) exhibited a significant decrease in butters containing Dried Apricot Pulp (DAP) ($P< 0.05$), while the redness (a*) and yellowness (b*) values increased with higher concentrations of DAP ($P< 0.05$). Specifically, the lowest L* value was observed in the 25% DAP sample (81.55±0.67), whereas the highest L* value was recorded in the control sample (88.00±0.43) on the initial day of storage. This observation is likely attributed to the inherent color properties of DAP, with respective values of L* (48.80±0.55), a* (3.70±0.37), and b* (37.20±0.56). Notably, there were no significant alterations in the L* value of the control sample over time ($P> 0.05$), whereas a decrease was noted in DAP-fortified samples ($P< 0.05$). Conversely, the b* values demonstrated an increase in DAP-containing butters, significantly differing from the control sample ($P< 0.05$), with the highest b* values consistently observed in the 25% DAP sample throughout storage. This phenomenon can be attributed to the elevated phenolic content in apricot, particularly beta-carotene, contributing to a more pronounced yellowish hue. Contrastingy, O'Callaghan *et al.* (2016) documented a reduction in b* values in butters following six months of storage, suggesting a transition towards a paler blue tint at 4°C. These findings diverge from those of Göksel Saraç and Dogan (2016), who observed an augmentation in all color parameters of butters upon the addition of orange dietary fiber concentrate and stone pear dietary fiber concentrate.

PV Values of Butters

PV (meq O_2 kg^{-1} butter) results for butters with DAP and the control are presented in Figure 1. PV values are crucial for assessing butter oxidation. Although traditional PV determination methods indicate butter quality, they do not distinguish between various unsaturated fatty acids undergoing oxidation, serving only as a primary oxidation indicator (Samet-Bali *et al.*, 2009).

As shown in Figure 1, no PV formation was detected on day 1 in the control sample, while it was observed on day 15 in butters with DAP. The absence of peroxide formation during the first 15 days in DAP-containing butters suggests no autooxidation occurred, with a significant increase in PV indicating the onset of autooxidation (Farag *et al.*, 1990). Higher DAP concentrations resulted in decreased PV values ($P< 0.05$), likely due to different fat and phenolic contents in the butters. Incorporating 25% DAP inhibited peroxide formation during 60 days of storage, consistent with Asha *et al.* (2015), who found that adding orange peel extract

lowered PV in butter samples during storage. Conversely, Zhao and Hall (2007) reported that high concentrations of dried grape extracts increased PV in butter model systems, attributing this to high ferrous content in grapes, which increases lipid oxidation. They also noted that dried grape extracts did not prevent free radical formation in butter model systems with sunflower oil due to restricted phenolic mobility and migration. Nadeem *et al.* (2014) found that adding sesame extract to butter with olein increased PV throughout storage. Some researchers observed higher lipid peroxidation in samples with higher concentrations of antioxidant extracts from tomatoes, due to the prooxidant properties of bioactive components (Abid *et al.*, 2017). Thus, factors such as food composition, processing conditions, extract amount, and storage significantly impact antioxidant properties. In delaying oxidation product formation, the effective DAP ratios were 15, 20, and 25% for 30, 45, and 60 days of storage, respectively. During peroxidation, radical species degrade fatty acids and other lipid components, such as carotenoids, chlorophyll pigments, and tocopherols (Hornero-Méndez *et al.*, 2001) The same authors reported that the lipid fraction in paprika is rich in polyunsaturated fatty acids, and the presence of carotenoids vulnerable to peroxidation could explain the higher PV increase in oleoresins. Mahmoudi *et al.* (2019) used Ziziphora clinopodioides essential oil at rates of 300, 600, and 900 ppm, finding that PV in butters increased at 600 ppm but decreased at 900 ppm during a 10-day storage period.

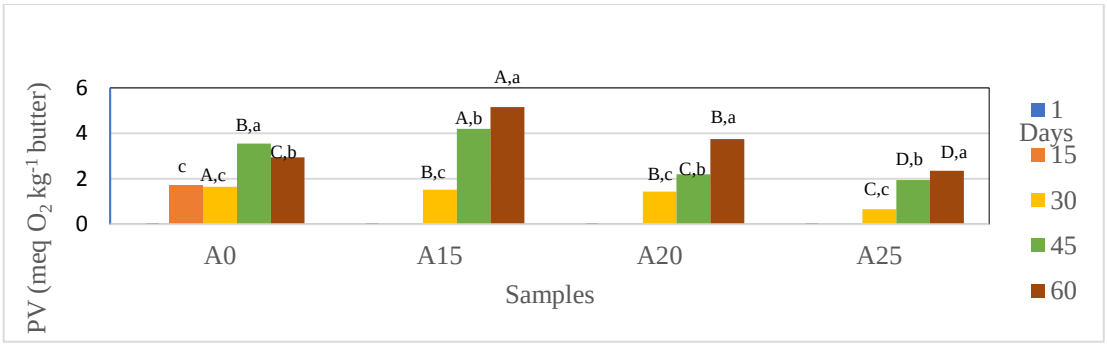

Figure 1. Evolution of PV values of control and flavored butters during storage. Data are means±standard deviation; different lowercase and uppercase superscript letters for storage and samples, respectively, indicate that the means differ significantly (P< 0.05).

TPC, DPPH Radical Scavenging Activity and TAC of Butters

Natural antioxidants exert their effects through various mechanisms, such as preventing chain initiation by scavenging radicals, chelating metals, reducing localized oxygen concentrations, and decomposing peroxides (Baiano *et al.* 2009). Table 4 presents the Total Phenolic Content (TPC), DPPH scavenging activity, and Total Antioxidant Capacity (TAC) of control butters and those enriched with Dried Apricot Pulp (DAP).

Significant differences ($P< 0.05$) were observed between the phenolic contents of control and DAP-containing butter samples. The high phenolic content of apricot pulp (1592.08±57.459 mg GAE kg^{-1} butter) accounts for these differences. As the DAP ratio increased, the phenolic content also increased, in the order $A_{25}> A_{20}> A_{15}> A_0$ on the first day of storage. However, the TPC of butters was not as high as that of apricot pulp itself, likely due to the differential distribution of phenolic substances within the butter matrix. This result aligns with Vidanagamage *et al*. (2016), who found that adding cinnamon extract to butter yielded lower phenolic content compared to the extract itself. Phenolic contents of all butter samples increased during storage, potentially due to the Folin-Ciocalteu method, which can be influenced by reducing sugars, aromatic amines, sulfur dioxide, ascorbic acid, organic acids, and other compounds (Castro-Lopez *et al.*, 2016). Nicoli *et al.* (1997) also noted that Maillard reaction products, formed during the heating of apricot, could enhance the overall antioxidant properties by minimizing the loss of natural antioxidants.

DPPH scavenging activity was higher in DAP-fortified butters than in the control (Table 4). DPPH values ranged from 22.23±0.48 to 25.20±1.08% in the control sample and from 24.82±0.48 to 30.42±0.48% in butters produced with DAP during storage. This can be attributed to the DPPH activity of the pulp (40.57±0.00%) and the heating process for pasteurization, which can generate non-nutrient antioxidant components (Nicoli *et al.*, 1997). DPPH values increased with higher apricot butter ratios ($P< 0.05$), though a significant decrease was observed at the end of storage compared to the first day in DAP-fortified butters ($P< 0.05$).

Table 4. Variations in TPC, DPPH, and TAC of control and flavored butters during storage.

Properties	Days	Samples			
		A_0	**A_{15}**	**A_{20}**	**A_{25}**
TPC (mg GAE kg^{-1} butter)	1	159.27±5.74 ^{Dd}	392.09±4.96 ^{Cd}	420.21±7.50 ^{Bb}	454.58±3.61 ^{Ad}
	15	282.19±7.30 ^{Dc}	416.05±3.80 ^{Cc}	436.88±2.95 ^{Bbc}	488.44±4.92 ^{Ac}
	30	191.04±5.89 ^{Dd}	324.90±1.04 ^{Ce}	416.04±7.22 ^{Bc}	495.21±2.95 ^{Ac}
	45	518.13±9.62 ^{Db}	931.67±7.12 ^{Cb}	1016.56±6.45 ^{Ba}	1062.40±8.74 ^{Aa}
	60	934.80±2.41 ^{Da}	944.69±3.56 ^{Ba}	1035.83±2.08 ^{Ba}	1054.59±2.69 ^{Ab}
DPPH (Inhibition %)	1	23.12±0.96 ^{Bbc}	25.94±0.42 ^{Ab}	26.25±0.20 ^{Ac}	26.70±0.10 ^{Ac}
	15	22.36±0.17 ^{Dc}	25.71±0.16 ^{Cb}	26.80±0.16 ^{Bb}	28.99±0.12 ^{Ab}
	30	25.20±1.08 ^{Ca}	27.41±0.30 ^{Ba}	30.42±0.37 ^{Aa}	30.04±0.28 ^{Aa}
	45	22.23±0.48 ^{Cc}	26.02±0.32 ^{Bb}	26.48±0.10 ^{ABbc}	26.82±0.17 ^{Ac}
	60	23.73±0.29 ^{Db}	24.82±0.15 ^{Cc}	25.37±0.19 ^{Bd}	26.64±0.07 ^{Ac}
TAC (mg AAE kg^{-1})	1	73.78±1.38 ^{Db}	113.11±081 ^{Ce}	127.56±1.38 ^{Be}	135.89±0.99 ^{Ae}
	15	81.89±1.68 ^{Da}	126.89±0.63 ^{Cd}	173.56±4.65 ^{Bd}	185.56±0.81 ^{Ad}
	30	72.11±1.22 ^{Db}	165.11±1.31 ^{Cc}	188.89±0.57 ^{Bc}	194.89±2.97 ^{Ac}
	45	67.22±0.92 ^{Dc}	174.78±1.90 ^{Cb}	193.44±2.60 ^{Bb}	206.33±1.68 ^{Ab}
	60	63.89±0.76 ^{Dd}	248.45±1.18 ^{Ca}	259.67±1.83 ^{Ba}	271.22±1.68 ^{Aa}

a (A-D and a-e): The data are presented as means±standard deviation. Significant differences among the means within the same column and row are denoted by distinct lowercase and uppercase superscript letters, respectively, at a significance level of $P< 0.05$.

b A_0: Control butter without DAP, A_{15}: Butter containing 15% DAP, A_{20}: Butter containing 20% DAP, A_{25}: Butter containing 25% DAP.

The TAC results of the samples are shown in Table 4. TAC varied with the addition of pulp ($P< 0.05$), with values ranging from 63.89±0.76 to 73.78±1.38 mg AAE kg^{-1} butter for the control sample (A_0), 113.11±0.81 to 248.45±1.18 mg AAE kg^{-1} for sample A_{15}, 127.56±1.38 to 259.67±1.83 mg AAE kg^{-1} Gallicfor sample A_{20}, and 135.89±0.99 to 271.22±1.68 mg AAE kg^{-1} butter for sample A_{25}. Storage significantly affected the TAC values of all samples ($P< 0.05$), with TAC decreasing in the control sample while increasing in butters with DAP during storage. This can be attributed to the high antioxidant (639.11±0.94 mg AAE kg^{-1}) and phenolic content of apricot pulp. Additionally, there was a strong positive correlation between antioxidant capacity and phenolic content during storage (Martínez-Flores (Martinez-Flores *et al.*, 2015).The increase in phenolic content of butters with DAP during storage can also be linked to the 28% total sugar content, phenolic content, DPPH activity, and TAC of apricot pulp. The interactions between phenolic compounds and components of spices, herbs, and fruits, as well as their partitioning between aqueous and oily fractions, also play a role (Baiano *et al.*, 2009). Kopjar *et al.* (2016) noted that the addition of sugars such as sucrose and trehalose to model systems containing phenolics like catechin, quercetin, and gallic acid influenced antioxidant activity through a synergistic effect, where sugars can preserve or even enhance polyphenol activity (Peinado *et al.*, 2010).

Sensory Evaluation

The primary factors influencing consumer butter purchases are color and taste. The sensory properties of the butter samples, detailed in Table 5, revealed significant differences in color and texture among the samples ($P< 0.05$). The incorporation of Dried Apricot Pulp (DAP) notably enhanced the color scores of the butters, with DAP-fortified samples receiving higher preference from panelists compared to the control. As the concentration of DAP increased, the color scores improved correspondingly ($P< 0.05$), with the highest scores observed in the sequence $A_{25}> A_{20}> A_{15}> A_0$. Notably, the storage period did not significantly impact the color and texture of the butter samples ($P> 0.05$).

The addition of apricot pulp also had a significant effect on odor values compared to the control sample ($P< 0.05$). Taste scores were consistently higher in DAP-fortified butters than in the control, with the peak score recorded for sample A_{20} up to day 15. After this period, no significant differences were observed among the apricot butter samples.

The improvement in taste over time may be attributed to the gradual diffusion of flavor compounds from the apricot into the butter. Furthermore, rancidity and overall acceptability scores were higher for the DAP-fortified butters, demonstrating significant differences from the

control (P< 0.05). These findings suggest that the addition of apricot pulp, irrespective of the ratio, enhances sensory properties and is preferred by panelists.

Table 5. Variations in Sensory properties of control and flavored butters during storage

Samples	Storage (Days)	Colour	Texture	Odor	Taste	Rancidity	General Acceptability
A_0	1	3.57 ± 0.20^{aD}	3.93 ± 0.10^{D}	3.86 ± 0.40^{B}	3.86 ± 0.21^{C}	5.86 ± 1.21^{B}	5.57 ± 0.61^{B}
	15	3.57 ± 0.00^{aD}	4.08 ± 0.30^{C}	3.93 ± 0.51^{B}	3.65 ± 0.30^{C}	5.79 ± 1.11^{B}	5.50 ± 0.51^{B}
	30	$3.43\pm0.00a^{C}$	3.93 ± 0.30^{C}	3.72 ± 0.40^{B}	3.36 ± 0.30^{B}	5.79 ± 1.11^{A}	5.36 ± 0.71^{B}
	45	$3.43\pm0.00a^{C}$	3.71 ± 0.00^{C}	3.64 ± 0.71^{B}	3.36 ± 0.30^{B}	5.58 ± 1.01^{B}	5.22 ± 0.50^{B}
	60	$3.36\pm0.30a^{C}$	3.57 ± 0.00^{C}	3.58 ± 0.40^{C}	3.43 ± 0.40^{B}	5.65 ± 1.11^{B}	5.15 ± 0.40^{C}
A_{15}	1	6.22 ± 0.11^{C}	6.36 ± 0.30^{C}	$7.79\pm0.11a^{A}$	7.36 ± 0.71^{B}	7.61 ± 0.14^{A}	7.58 ± 0.40^{A}
	15	6.29 ± 0.21^{C}	6.29 ± 0.00^{B}	7.57 ± 0.00^{bA}	7.36 ± 0.31^{B}	7.43 ± 0.40^{AB}	7.72 ± 0.60^{B}
	30	6.50 ± 0.10^{B}	6.07 ± 0.71^{B}	7.36 ± 0.10^{bA}	7.29 ± 0.40^{A}	7.07 ± 0.51^{A}	7.65 ± 0.30^{A}
	45	6.36 ± 0.30^{B}	6.07 ± 0.71^{B}	7.36 ± 0.10^{bA}	7.22 ± 0.50^{A}	7.00 ± 0.41^{AB}	7.43 ± 0.61^{A}
	60	6.43 ± 0.20^{B}	5.93 ± 0.71^{B}	7.43 ± 0.00^{bAB}	7.07 ± 0.51^{A}	6.86 ± 0.40^{AB}	7.15 ± 0.21^{B}
A_{20}	1	8.29 ± 0.00^{B}	7.36 ± 0.30^{B}	8.00 ± 0.20^{A}	8.65 ± 0.50^{aA}	8.79 ± 0.11^{A}	8.43 ± 0.20^{aA}
	15	8.29 ± 0.21^{B}	7.50 ± 0.30^{A}	8.29 ± 0.00^{A}	8.50 ± 0.51^{aA}	8.57 ± 0.20^{A}	8.36 ± 0.10^{abB}
	30	8.36 ± 0.30^{A}	7.57 ± 0.20^{A}	8.22 ± 0.50^{A}	7.36 ± 0.10^{bA}	8.36 ± 0.71^{A}	8.22 ± 0.11^{abA}
	45	8.22 ± 0.30^{A}	7.50 ± 0.30^{A}	8.07 ± 0.51^{A}	7.29 ± 0.21^{bA}	8.22 ± 0.91^{A}	8.07 ± 0.10^{bA}
	60	8.07 ± 0.10^{A}	7.36 ± 0.30^{A}	7.93 ± 0.30^{A}	7.36 ± 0.30^{bA}	8.07 ± 0.71^{A}	8.07 ± 0.10^{bA}
A_{25}	1	8.86 ± 0.00^{aD}	8.07 ± 0.10^{A}	7.64 ± 0.10^{aA}	7.36 ± 0.10^{abB}	8.86 ± 0.00^{A}	8.07 ± 0.51^{A}
	15	8.79 ± 0.11^{aA}	8.15 ± 0.21^{A}	7.57 ± 0.20^{abA}	7.43 ± 0.00^{aB}	8.65 ± 0.30^{A}	8.15 ± 0.40^{B}
	30	8.64 ± 0.10^{abA}	8.08 ± 0.30^{A}	7.43 ± 0.20^{abA}	7.36 ± 0.10^{abA}	7.86 ± 1.41^{A}	7.93 ± 0.30^{A}
	45	8.50 ± 0.10^{bcA}	7.93 ± 0.30^{A}	7.00 ± 0.41^{bA}	7.07 ± 0.10^{bA}	7.43 ± 1.01^{AB}	7.79 ± 0.11^{A}
	60	8.36 ± 0.10^{cA}	7.72 ± 0.40^{A}	7.00 ± 0.00^{bB}	7.15 ± 0.21^{abA}	7.14 ± 0.61^{AB}	7.64 ± 0.10^{AB}

a (A-D and a-c): The data are presented as means±standard deviation. Significant differences among the means within the same column and row are denoted by distinct lowercase and uppercase superscript letters, respectively, at a significance level of P< 0.05.

b A_0: Control butter without DAP, A_{15}: Butter containing 15% DAP, A_{20}: Butter containing 20% DAP, A_{25}: Butter containing 25% DAP.

CONCLUSIONS

This study aimed to improve the functional properties and oxidative stability of butter while introducing an alternative variety to other dairy products by incorporating dried apricot pulp, known for its significant phenolic content and antioxidant activity, without compromising sensory perception. The results of this study demonstrated an increase in phenolic content with the addition of dried apricot pulp. Moreover, it was observed that the addition of 25% dried apricot pulp effectively reduced peroxide values, indicating a decrease in primary oxidation. Butters fortified with dried apricot pulp exhibited higher sensory scores, particularly in terms of taste and color. All concentrations of dried apricot pulp (15, 20, and 25%) were found to be acceptable, with the 25% concentration being the most preferred by panelists. Butter is a staple dairy product commonly consumed with jam and honey during breakfast. However, the high sugar content in jam and honey may limit its consumption for individuals with weight management issues or conditions such as diabetes. The addition of 25% dried apricot pulp, which contains only 5.64±0.08% sugar, was sufficient to enhance the taste and sweetness of butter, making it a viable alternative to traditional spreads. Furthermore, the lower fat content in butter fortified with dried apricot pulp may appeal to individuals seeking healthier food options with functional properties. Overall, the sensory evaluation revealed that butter fortified

with dried apricot pulp received favorable scores compared to regular butter. This suggests that the production of butter with dried apricot pulp not only enhances its antioxidant properties but also improves sensory perception. Importantly, unlike previous studies, no sensory limitations were identified with the addition of dried apricot pulp. Future research should focus on optimizing production processes for commercial and industrial-scale applications.

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REFERENCES

1. Abid, Y., Azabou, S., Jridi, M., Khemakhem, I., Bouaziz, M. and Attia, H. 2017: Storage stability of traditional Tunisian butter enriched with antioxidant extract from tomato processing by-products. *Food Chemistry*, **233**: 476-482.

2. Ahmed, D., Khan, M. M. and Saeed, R. 2015: Comparative analysis of phenolics, flavonoids, and antioxidant and antibacterial potential of methanolic, hexanic and aqueous extracts from adiantum caudatum leaves. *Antioxidants (Basel)*, **4(2)**: 394-409.

3. Ali, S., Masud, T. and Abbasi, K. S. 2011: Physico-chemical characteristics of apricot (Prunus armeniaca L.) grown in Northern Areas of Pakistan. *Scientia Horticulturae*, **130(2)**: 386-392.

4. Alqahtani, N. K., Alnemr, T. M., Alqattan, A. M., Aleid, S. M. and Habib, H. M. 2023: Physicochemical and Sensory Properties and Shelf Life of Block-Type Processed Cheeses Fortified with Date Seeds (Phoenix dactylifera L.) as a Functional Food. *Foods*, **12(3)**: 679.

5. Asha, A., Manjunatha, M., Rekha, R. M., Surendranath, B., Heartwin, P., Rao, J., Magdaline, E. and Sinha, C. 2015: Antioxidant activities of orange peel extract in ghee (butter oil) stored at different storage temperatures. *Journal of Food Science and Technology-Mysore*, **52(12)**: 8220-8227.

6. Baiano, A., Terracone, C., Gambacorta, G. and La Notte, E. 2009: Changes in Quality Indices, Phenolic Content and Antioxidant Activity of Flavored Olive Oils during Storage. *Journal of the American Oil Chemists Society*, **86(11)**: 1083-1092.

7. Bujancă, G., Costescu, C. I., Velciov, A.-B., Mişcă, C. D. and Rinovetz, A. 2016: Comparative study of varieties of butter on the Romanian market *International Multidisciplinary Scientific GeoConference: SGEM*, **1**: 479-484.

8. Bule, G., Awegachew, E. and Hassen, Y. 2022: Evaluation of selected spices and herb extracts on oxidative stability, microbial and sensory quality of fermented cow milk butter. *J Food Sci Nutr. 2022; 5 (7): 1-7*, **2**.

9. Čanadanović-Brunet, J. M., Vulić, J. J., Ćetković, G. S., Đilas, S. M. and Tumbas-Šaponjac, V. T. 2013: Bioactive compounds and antioxidant properties of dried apricot. *Acta periodica technologica*, **(44)**: 193-205.

10. Castro-Lopez, C., Sanchez-Alejo, E. J., Saucedo-Pompa, S., Rojas, R., Aranda-Ruiz, J. and Martinez-Avila, G. C. 2016: Fluctuations in phenolic content, ascorbic acid and total carotenoids and antioxidant activity of fruit beverages during storage. *Heliyon*, **2(9)**: e00152.

11. Çakmakçı, S., Gündoğdu, E., Dağdemir, E. and Erdoğan, Ü. 2014: Investigation of the possible use of black cumin (Nigella sativa L.) essential oil on butter stability. *Kafkas Univ Vet Fak Derg*, **20(4)**: 533-539.

12. Dagdemir, E., Cakmakci, S. and Gundogdu, E. 2009: Effect of Thymus haussknechtii and Origanum acutidens essential oils on the stability of cow milk butter. *European Journal of Lipid Science and Technology*, **111(11)**: 1118-1123.

13. Ebrahimian, M., Mehdizadeh, T. and Aliakbarlu, J. 2023: Chemical and microbiological stability and sensorial properties of traditional Iranian butter incorporated with pomegranate peel extract. *International Journal of Dairy Technology*, **76(1)**: 178-186.

14. Fan, X., Zhao, H., Wang, X., Cao, J. and Jiang, W. 2017: Sugar and organic acid composition of apricot and their contribution to sensory quality and consumer satisfaction. *Scientia Horticulturae*, **225**: 553-560.

15. Farag, R. S., Ali, M. N. and Taha, S. H. 1990: Use of Some Essential Oils as Natural Preservatives for Butter. *Journal of the American Oil Chemists Society*, **67(3)**: 188-191.

16. Göksel Saraç, M. and Dogan, M. 2016: Incorporation of dietary fiber concentrates from fruit and vegetable wastes in butter: effects on physicochemical, textural, and sensory properties. *European Food Research and Technology*, **242(8)**: 1331-1342.

17. Gramza-Michalowska, A., Korczak, J. and Regula, J. 2007: Use of plant extracts in summer and winter season butter oxidative stability improvement. *Asia Pac J Clin Nutr*, **16(1)**: 85-88.

18. Hornero-Méndez, D., Pérez-Gálvez, A. and Mínguez-Mosquera, M. I. 2001: A rapid spectrophotometric method for the determination of peroxide value in food lipids with high carotenoid content. *Journal of the American Oil Chemists' Society*, **78(11)**: 1151-1155.

19. Hussain, P., Chatterjee, S., Variyar, P., Sharma, A., Dar, M. and Wani, A. 2013: Bioactive compounds and antioxidant activity of gamma irradiated sun dried apricots (Prunus armeniaca L.). *Journal of Food Composition and Analysis*, **30(2)**: 59-66.

20. Ivanova, D., Valov, N., Valova, I. and Stefanova, D. 2017: Optimization of convective drying of apricots. *Tem journal*, **6(3)**: 572.

21. Karabulut, I., Bilenler, T., Sislioglu, K., Gokbulut, I., Ozdemir, I. S., Seyhan, F. and Ozturk, K. 2018: Chemical composition of apricots affected by fruit size and drying methods. *Drying Technology*, **36(16)**: 1937-1948.

22. Kasangana, P. B., Haddad, P. S. and Stevanovic, T. 2015: Study of Polyphenol Content and Antioxidant Capacity of Myrianthus Arboreus (Cecropiaceae) Root Bark Extracts. *Antioxidants (Basel)*, **4(2)**: 410-426.

23. Kopjar, M., Loncaric, A., Mikulinjak, M., Srajbek, Z., Srajbek, M. and Pichler, A. 2016: Evaluation of Antioxidant Interactions of Combined Model Systems of Phenolics in the Presence of Sugars. *Nat Prod Commun*, **11(10)**: 1445-1448.

24. Kwak, H.-S., Ganesan, P. and Mijan, A. 2013: Butter, ghee, and cream products. *Milk and dairy products in human nutrition: production, Composition and Health*, **390**: 411.

25. Mahmoudi, R., Khezri, S., Ghajarbeygi, P., Kaboudari, A., Panahzadeh, M., Mousavi, S. M. and Familsatarian, B. 2019: Ziziphora clinopodioides essential oil effects on the physicochemical and microbial characteristics of cow milk butter during the storage at 4 C. *Journal of Chemical Health Risks*, **9(4)**: 303-309.

26. Martinez-Flores, H. E., Garnica-Romo, M. G., Bermudez-Aguirre, D., Pokhrel, P. R. and Barbosa-Canovas, G. V. 2015: Physico-chemical parameters, bioactive compounds and microbial quality of thermo-sonicated carrot juice during storage. *Food Chemistry*, **172**: 650-656.

27. Mohamed, A. and Shalaby, S. 2016: Texture, chemical properties and sensory evaluation of a spreadable processed cheese analogue made with apricot pulp (Prunus armeniaca L.). *International Journal of Dairy Science*, **11(2)**: 61-68.

28. Nadeem, M., Abdullah, M., Hussain, I., Inayat, S., Javid, A. and Zahoor, Y. 2013: Antioxidant Potential of Moringa oleifera Leaf Extract for the Stabilisation of Butter at Refrigeration Temperature. *Czech Journal of Food Sciences*, **31(4)**: 332-339.

29. Nadeem, M., Situ, C., Mahmud, A., Khalique, A., Imran, M., Rahman, F. and Khan, S. 2014: Antioxidant Activity of Sesame (Sesamum indicum L.) Cake Extract for the Stabilization of Olein Based Butter. *Journal of the American Oil Chemists Society*, **91(6)**: 967-977.

30. Nicoli, M. C., Anese, M., Parpinel, M. T., Franceschi, S. and Lerici, C. R. 1997: Loss and/or formation of antioxidants during food processing and storage. *Cancer Letters*, **114(1-2)**: 71-74.
31. O'Callaghan, T. F., Faulkner, H., McAuliffe, S., O'Sullivan, M. G., Hennessy, D., Dillon, P., Kilcawley, K. N., Stanton, C. and Ross, R. P. 2016: Quality characteristics, chemical composition, and sensory properties of butter from cows on pasture versus indoor feeding systems. *Journal of Dairy Science*, **99(12)**: 9441-9460.
32. Peinado, J., de Lerma, N. L. and Peinado, R. A. 2010: Synergistic antioxidant interaction between sugars and phenolics from a sweet wine. *European Food Research and Technology*, **231(3)**: 363-370.
33. Salehi, F. 2021: Quality, physicochemical, and textural properties of dairy products containing fruits and vegetables: A review. *Food Science & Nutrition*, **9(8)**: 4666-4686.
34. Samet-Bali, O., Ayadi, M. A. and Attia, H. 2009: Traditional Tunisian butter: Physicochemical and microbial characteristics and storage stability of the oil fraction. *Lwt-Food Science and Technology*, **42(4)**: 899-905.
35. Shakerardekani, A., Behmaram, K. and Bostan, A. 2020: The Effect of Replacing Honey with Sugar on Oxidative Stability Properties of Pistachio Butter. *Pistachio and Health Journal*, **3(4)**: 33-49.
36. Thakaeng, P., Wongsakul, S. and Yusoff, M. M. 2020: Development of value-added butter through the addition of green tea (Camellia sinensis L.) extract. *International Food Research Journal*, **27(3)**: 465-474.
37. Timtey, J. A., Alemawor, F., Ellis, W. O., Agbenorhevi, J. K. and Pepra-Ameyaw, N. B. 2024: Evaluation of Yield and Physicochemical Quality of Pentadesma butyracea Butter Obtained by Different Traditional Extraction Methods in Ghana. *International Journal of Food Science*, **2024(1)**: 5282230.
38. Vidanagamage, S. A., Pathiraje, P. M. H. D. and Perera, O. D. A. N. 2016: Effects of Cinnamon (Cinnamomum verum) extract on functional properties of butter. *International Conference of Sabaragamuwa University of Sri Lanka 2015 (Icsusl 2015)*, **6**: 136-142.
39. Wojdyło, A., Oszmiański, J., Sokół-Łętowska, A. and Korzeniowska, M. 2005: Butter stabilization by plant phenolic antioxidants. *Polish journal of food and nutrition sciences*, **14(Suppl. 1)**: 121-127.
40. Yatsenko, O., Yushchenko, N., Kuzmyk, U., Pasichnyi, V., Kochubei-Lytvynenko, O., Frolova, N., Korablova, O., Mykoliv, I. and Voitsekhivskyi, V. 2020: Research of milk fat oxidation processes during storage of butter pastes. *Slovak Journal of Food Sciences*, **14**.

41. Zakharova, L. M. 2014: Development and Introduction of New Dairy Technologies. *Foods and Raw Materials*, **2(2)**: 68-74.

42. Zhao, B. and Hall, C. A. 2007: Antioxidant activity of raisin extracts in bulk oil, oil in water emulsion, and sunflower butter model systems. *Journal of the American Oil Chemists Society*, **84(12)**: 1137-1142.

43. Ziarno, M., Kozłowska, M., Ratusz, K. and Hasalliu, R. 2023: Effect of the Addition of Selected Herbal Extracts on the Quality Characteristics of Flavored Cream and Butter. *Foods*, **12(3)**: 471.

44. Zine-Eddine, Y., Kzaiber, F., Oussama, A. and Boutoial, K. 2022: Physicochemical and sensorial characterisation of marinated white cheese made from goat milk with olive oil and thyme. *Acta Scientiarum Polonorum Technologia Alimentaria*, **21(4)**: 401-409.