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

Merve Bulut[1], and Engin Gündoğdu[1*]

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

1 Department of Food Engineering, Faculty of Engineering and Natural Sciences, Gümüşhane University, Gümüşhane 29100, Türkiye.
*Corresponding author; engingundogdu@gumushane.edu.tr

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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*,

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98   a*, b*) were determined using a Minolta colorimeter (Chroma Meter, CR-200, Osaka, Japan).

99   Titratable acidity, expressed as lactic acid percentage, and Free Fatty Acid (FFA) content,

100 expressed as mg KOH g^{-1} butter, were determined using the method described by Timtey *et al.*

101 (2024) on days 1, 15, 30, 45, and 60 of storage.

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103 **Determination of Sugar Content**

104 Fructose, glucose, and total sugar analyses were conducted on both DAP and butter samples

105 on the first day of storage. The procedure of the International Honey Commission (Anonymous,

106 2009) was used for sugar analysis. The analysis was performed using HPLC-RID (Thermo

107 Scientific Products Finnigan Spectra System). Sugar separation was achieved with a column (5

108 μm particle size, L×ID 250 mm×3 mm). The flow rate was 1.3 mL/min, and acetonitrile/water

109 (80:20, v/v) was used as the mobile phase. The column temperature was maintained at 50±1°C,

110 and the injection volume was 20 μL.

111

112 **Determination of Peroxide Value**

113 Peroxide value (PV) was determined to assess primary oxidation during storage. Samples

114 were dissolved in a mixture of chloroform and glacial acetic acid and titrated with 0.002 N

115 $Na_2S_2O_3$ using a 1% starch indicator. PV was expressed as meq O_2 kg^{-1} butter (Yatsenko *et al.,*

116 2020).

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118 **Determination of TPC, DPPH Radical Scavenging Capacity, and TAC**

119 First, the extract was prepared. A sample (1 g, pulp butter^{-1}), 2 mL of hot distilled water, and

120 5 mL of ethanol were extracted in an ultrasonic bath (Sonorex Super RK 103 H, Germany).

121 After filtering through filter paper, the extract was passed through 0.45 μm filters and used for

122 TPC, DPPH, and TAC tests.

123 Total Phenolic Content (TPC) was determined using the Folin–Ciocalteu test. To calibrate the

124 concentration of total phenolics in butter samples, the absorbance of standard Gallic acid

125 solutions (20, 40, 60, 80, 120, and 160 μg mL^{-1}) was measured at 760 nm (Shimadzu UV-1800

126 240 V, Japan) , and results were expressed as mg Gallic Acid Equivalent (GAE) kg^{-1} sample

127 (Kasangana *et al.,* 2015).

128 For DPPH analysis , 100 μL of the extract was mixed with 3,000 μL of DPPH solution and

129 vortexed. After a 30-minute incubation, absorbance was measured at 517 nm using a

130 spectrophotometer (Shimadzu UV-1800 240V, Japan), with 100 μL of methanol as the blank.

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

133 TAC was measured using the equation of the graph prepared with ascorbic acid solutions (25,
134 50, 100, 150, 250, 500, and 900 μg mL^{-1}), and TAC was expressed as mg Ascorbic Acid
135 Equivalent (AAE) kg^{-1} butter. 500 μL of the extract was mixed with 2500 μL of deionized water
136 and 1,000 μL of molybdate reagent. The mixture was vortexed and incubated at 95°C for 90
137 minutes, then cooled to room temperature. Absorbance was measured at 695 nm (Shimadzu
138 UV-1800 240 V, Japan), against a blank which contains distilled water instead of the sample
139 (Kasangana *et al.*, 2015).

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

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151 **Statistical Analyses**
152 ANOVA was employed to analyze the differences among the group means for all data. Mean
153 values showing significant differences were compared using Duncan's multiple range tests ($P<$
154 0.05). The results were expressed as means of two replications. For this analysis, the SPSS 24.0
155 software package (SPSS Inc., Chicago, IL, USA) was used.

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

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165 100 g^{-1} in dried apricot. Ivanova *et al.* (2017) documented L, a*, and b* values as 30.2-36.4, 6-
166 12.4, and 9-21.8, respectively. These discrepancies can be attributed to different apricot
167 varieties, geographic conditions, drying techniques and temperatures (sulphured vs.
168 unsulphured), maturity stages, storage conditions, chemical compositions, and analytical
169 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.

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171 **Proximate and Physicochemical Properties of Butters**

172   The chemical properties of butters produced with different concentrations of DAP (15, 20,
173 and 25%) were compared with those of the control. Analyses of dry matter, fat, and sugar
174 content were performed on the first day of storage, as detailed in Table 2. Additionally, pH,
175 titratable acidity, Free Fatty Acids (FFA), and color properties were assessed throughout the
176 storage period, as presented in Table 3.The addition of DAP had a statistically significant effect
177 ($P< 0.05$) on the chemical properties. Specifically, the addition of pulp decreased dry matter
178 and fat content while increasing sugar content, depending on the pulp concentration. These
179 findings align with those of Mohamed and Shalaby (2016), who reported that the addition of
180 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.

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

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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

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234 lowered PV in butter samples during storage. Conversely, Zhao and Hall (2007) reported that

235 high concentrations of dried grape extracts increased PV in butter model systems, attributing

236 this to high ferrous content in grapes, which increases lipid oxidation. They also noted that

237 dried grape extracts did not prevent free radical formation in butter model systems with

238 sunflower oil due to restricted phenolic mobility and migration. Nadeem *et al.* (2014) found

239 that adding sesame extract to butter with olein increased PV throughout storage. Some

240 researchers observed higher lipid peroxidation in samples with higher concentrations of

241 antioxidant extracts from tomatoes, due to the prooxidant properties of bioactive components

242 (Abid *et al.,* 2017). Thus, factors such as food composition, processing conditions, extract

243 amount, and storage significantly impact antioxidant properties. In delaying oxidation product

244 formation, the effective DAP ratios were 15, 20, and 25% for 30, 45, and 60 days of storage,

245 respectively. During peroxidation, radical species degrade fatty acids and other lipid

246 components, such as carotenoids, chlorophyll pigments, and tocopherols (Hornero-Méndez *et*

247 *al.,* 2001) The same authors reported that the lipid fraction in paprika is rich in polyunsaturated

248 fatty acids, and the presence of carotenoids vulnerable to peroxidation could explain the higher

249 PV increase in oleoresins. Mahmoudi *et al.* (2019) used Ziziphora clinopodioides essential oil

250 at rates of 300, 600, and 900 ppm, finding that PV in butters increased at 600 ppm but decreased

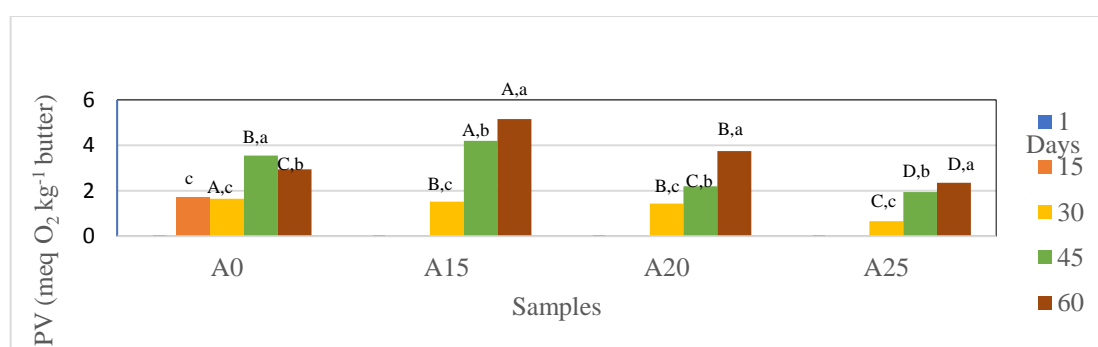251 at 900 ppm during a 10-day storage period.

252

253 **Figure 1.** Evolution of PV values of control and flavored butters during storage. Data are means±standard
254 deviation; different lowercase and uppercase superscript letters for storage and samples, respectively, indicate
255 that the means differ significantly ($P < 0.05$).
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257 **TPC, DPPH Radical Scavenging Activity and TAC of Butters**

258 Natural antioxidants exert their effects through various mechanisms, such as preventing chain

259 initiation by scavenging radicals, chelating metals, reducing localized oxygen concentrations,

260 and decomposing peroxides (Baiano *et al.* 2009). Table 4 presents the Total Phenolic Content

261 (TPC), DPPH scavenging activity, and Total Antioxidant Capacity (TAC) of control butters

262 and those enriched with Dried Apricot Pulp (DAP).

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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.

284   The TAC results of the samples are shown in Table 4. TAC varied with the addition of pulp
285   (P< 0.05), with values ranging from 63.89±0.76 to 73.78±1.38 mg AAE kg^{-1} butter for the
286   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
287   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^{-}
288   ^{1} butter for sample A$_{25}$. Storage significantly affected the TAC values of all samples (P< 0.05),
289   with TAC decreasing in the control sample while increasing in butters with DAP during storage.
290   This can be attributed to the high antioxidant (639.11±0.94 mg AAE kg^{-1}) and phenolic content
291   of apricot pulp. Additionally, there was a strong positive correlation between antioxidant
292   capacity and phenolic content during storage (Martínez-Flores (Martinez-Flores *et al.,*
293   2015).The increase in phenolic content of butters with DAP during storage can also be linked
294   to the 28% total sugar content, phenolic content, DPPH activity, and TAC of apricot pulp. The
295   interactions between phenolic compounds and components of spices, herbs, and fruits, as well
296   as their partitioning between aqueous and oily fractions, also play a role (Baiano *et al.,* 2009).
297   Kopjar *et al.* (2016) noted that the addition of sugars such as sucrose and trehalose to model
298   systems containing phenolics like catechin, quercetin, and gallic acid influenced antioxidant
299   activity through a synergistic effect, where sugars can preserve or even enhance polyphenol
300   activity (Peinado *et al.,* 2010).

302   **Sensory Evaluation**
303   The primary factors influencing consumer butter purchases are color and taste. The sensory
304   properties of the butter samples, detailed in Table 5, revealed significant differences in color
305   and texture among the samples (P< 0.05). The incorporation of Dried Apricot Pulp (DAP)
306   notably enhanced the color scores of the butters, with DAP-fortified samples receiving higher
307   preference from panelists compared to the control. As the concentration of DAP increased, the
308   color scores improved correspondingly (P< 0.05), with the highest scores observed in the
309   sequence A$_{25}$> A$_{20}$> A$_{15}$> A$_0$. Notably, the storage period did not significantly impact the color
310   and texture of the butter samples (P> 0.05).
311   The addition of apricot pulp also had a significant effect on odor values compared to the
312   control sample (P< 0.05). Taste scores were consistently higher in DAP-fortified butters than
313   in the control, with the peak score recorded for sample A$_{20}$ up to day 15. After this period, no
314   significant differences were observed among the apricot butter samples.
315   The improvement in taste over time may be attributed to the gradual diffusion of flavor
316   compounds from the apricot into the butter. Furthermore, rancidity and overall acceptability
317   scores were higher for the DAP-fortified butters, demonstrating significant differences from the

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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±0.00a^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±0.00a^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±0.30a^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±0.11a^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^{aaA}	8.79±0.11^A	8.43±0.20^{aaA}
	15	8.29±0.21^B	7.50±0.30^A	8.29±0.00^A	8.50±0.51^{aaA}	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^{aaA}	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 $^{a B}$	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

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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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