e-ISSN: 2757-8836
ORIGINAL ARTICLE
J. Raw Mater. Process. Foods vol.4(1), (2023) 40-46

Recieved: 24/06/2023 Revised: 04/09/2023 Accepted article published: 11/09/2023 Published online: 14/09/2023

Oxidative stability of yogurts fortified with lyophilized purslane throughout storage

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DOI: https://doi.org/10.57252/jrpfoods.2023.4

Abstract

One of the primary problems of the dairy industry is providing oxidatively stable yogurts throughout storage. Fortifying yogurts with antioxidants or foods with antioxidantive qualities could be a technique for enhancing oxidative stability and extending shelf life of yogurts. The goal of this research is to produce yogurts fortified with lyophilized purslane in order to improve the oxidative characteristics of the yogurt and to prolong the shelf life of the end product. For this purpose, eight different yogurt samples were fermented by considering the lyophilized purslane concentration (0.25-0.5%) and storage time (0-7-14-21 days) as processing parameters. Some oxidative properties of yogurt samples including peroxide value, malondialdehyde content and p-anisidine value were determined. The data were statistically analyzed by Analysis of Variance. The peroxide values of the yogurts were improved by the addition of lyophilized purslane. The malondialdehyde content of fortified yogurts was in the range of 0.86-6.02 µg MDA/g. The presence of lyophilized purslane slightly decreased the p-anisidine value of yogurt samples. Statistical results showed that storage time was the most important factor affecting oxidative stability of samples during storage. In order to ensure desired oxidative stability characteristics, the lyophilized purslane-fortified yogurt fermentation and storage parameters were established to be 0.5% lyophilized purslane ratio and 7 days of storage. The production of yogurts enriched by lyophilized purslane is a promising technique that can improve oxidative stability of yogurts.

Keywords: Yogurt, lyophilization, Purslane, Oxidative stability

1.INTRODUCTION

Yogurt is a fermented dairy product manufactured by the activitiy of lactic acid bacteria (LAB), primarily Lactobacillus delbrueckii subsp. bulgaricus and Streptococcus thermophilus strains. Yogurt production involves six main steps including; milk standardization (fat and dry matter content), inoculation of LAB, lactic acid fermentation, cooling, packaging and storage (Aktar, 2022). Yogurt is a creamy, semi-solid material with a distinct tangy flavor (Lesme et al., 2020). It contains proteins, calcium, B vitamins, and probiotics, which are beneficial microorganisms that may assist with intestinal health. Therefore, yogurt is frequently considered as a functional food due to its potential health benefits that goes beyond basic nutrition (Hill et al., 2017).

Fortified yogurts are the yogurts that have been enriched with either nutrients or different types of food (Gahruie et al., 2015). The fortification is generally utilized to improve the nutritional profile of yogurt and provide additional health benefits to consumers (Seregelj et al.,2021). Vitamins, minerals, probiotics, fiber, and omega-3 fatty acids are the most common nutrients added to fortified yogurts (de Moura et al., 2019). In a study, yogurt samples were fortified with different amounts of olive leaf powder, and it was discovered that fortification with olive leaf powder extended the shelf life of samples (Pourghorban et al., 2022). After 21 days of storage, yogurts fortified with 5 different vegetable oils (contain n-3 fatty acids) had still remarkable amounts of linolenic acid (Dal Bello et al., 2015).

Yogurt's oxidative stability may change during storage. The oxidative stability of yogurt refers to its ability to resist oxidation, which can lead to the degradation of nutrients, off-flavors, and changes in quality parameters (Citta et al., 2017). Several factors including packaging, oxygen exposure, presence of antioxidants, storage temperature can affect the oxidative stability of yogurt during storage (Khan et al., 2019). The oxidative stability of yogurt can also be influenced by factors such as the quality of the initial milk, the presence of other ingredients, and the specific processing methods employed (Serra et al., 2008). It is important to control the oxidative stability of yogurt to ensure shelf life during possible long-term storage periods. It was discovered that lipid peroxidation increased until the seventh week of shelf life of yogurt samples for both regular and berry-fortified (Citta et al., 2017). The addition of walnut oil and guar gum into fermentation media lowered the formation of malondialdehyde by improving the oxidative stability of the fortified yogurts (Baba et al., 2018).

Purslane is an edible plant that is cultivated in various countries. Purslane is well-known for its high nutritional value (Srivastava et al., 2021). It contains essential nutrients like vitamins A, C, and E, as well as minerals such as potassium, magnesium, and calcium (Naeem et al., 2013). Purslane is also a good source of mono and polyunsaturated fatty acids (MUFA and PUFA), particularly omega-3 fatty acids (Nemzer et al., 2020). Purslane plant exhibits antioxidant properties due to the presence of various phytochemicals, such as flavonoids and phenolic acids (Erkan, 2012). As this implies, finding an application for the valuable purslane plant in the food industry is important.

To the best of our knowledge, no studies have been published on the fortification of yogurts with lyophilized purslane and the evaluation of oxidative characteristics of samples during storage. The objective of this research was to manufacture yogurts fortified with lyophilized purslane and investigate the oxidative properties during storage, with the aim of enhancing oxidative stability and extending the shelf-life of the yogurts.

2. MATERIALS AND METHOD

2.1. Materials

The cow milk utilized in the yogurt fermentation was obtained from Sivas Damızlık Sığır Yetiştiricileri Birliği (Sivas, Türkiye). The initial dry matter and fat content of cow milk were 17.9% and 3% respectively. The starter culture (Y551, 10U) used in lactic acid fermentation was purchased from Maysa Gıda (Istanbul, Türkiye). The purslane plant was provided from a local market and freeze-dried in a lyophilizer (Labconco, 700801030, USA).

2.2. Manufacturing of fortified yogurts

The set style yogurt samples were manufactured in the local dairy processing plant of Sivas Cumhuriyet University Food Research and Application Center (Sivas, Türkiye). Eight different yogurts were manufactured by considering lyophilized purslane ratio (0.25-0.5%) and storage time (0-7-14-21 days) as processing parameters (Table 1). The standardized milk was mixed with lyophilized purslane at the given ratios and pasteurized at 80 ℃ for 30 minutes in a pasteurization unit (Ortinox, Ankara, Türkiye). The lactic acid fermentation was performed by the addition of 200 ml milk and lyophilized purslane mixture and 3% of stater culture in 250 ml plastic cups. The fermentation was completed since the pH dropped to 4.6 in an incubation room at 43 ℃. The individual plastic cups were aseptically packed after fermentation. Moreover, regular yogurt (without lyophilized purslane) samples were also produced under specified conditions (Table 1). All yogurt samples were stored at 4 °C in a refrigerator (Bosch, Germany).

2.3. Determination of peroxide value of fortified yogurts

The peroxide value (PV) of the yogurt samples was determined by the AOCS standard titrimetric method of Cd 8b-90 (AOCS, 2009). The analyses were performed twice. The PV of the yogurts was calculated as milliequivalents (meq) of oxygen per kilogram of sample.

2.4. Determination of p-anisidine value of fortified yogurts

The p-anisidine value (p-AnV) of the yogurt samples was measured by the AOCS standard (Cd18-90) spectrophotometric method (AOCS, 1992). The measurements were conducted twice.

2.5. Determination of malondialdehyde content of fortified yogurts

The malondialdehyde (MDA) content of the samples was analyzed by a spectrophotometric method (Papastergiadis et al., 2012).The absorbances were measured at 532 nm by using a UV-vis spectrophotometer (Optima SP3000, Japan). The MDA content of fortified yogurts was expressed as µg MDA per gram sample..

2.6. Statistical Analyses

In order to investigate the effects of lyophilized purslane ratio and storage time on PV, p-AnV and MDA contents of fortified yogurt samples statistically analyzed with General Factorial Design by Analysis of Variance (ANOVA) was used (Minitab 19 software, UK).

3. RESULTS AND DISCUSSION

3.1. The PV of fortified yogurts

The PV is mostly used for measuring the early stages of oxidation of food products with unsaturated fatty acids. The PV of regular yogurt samples was in the range of 5.84-27.66 meq O2 /kg sample while the yogurts fortified with lyophilized purslane had a range of 2.66-17.92 meq O2 /kg sample (Table 1). In general, PV of fortified yogurts decreased compared to regular types. Furthermore, the PV of fortified yogurts fermented with 0.5% lyophilized purslane was slightly lower than that of yogurts produced with 0.25% lyophilized purslane. This result could be associated with antioxidant property of purslane plant (Binici et al., 2021; Erkan, 2012; Uddin et al., 2012). The lower the PV, the higher the concentration of lyophilized purslane in the fermentation media. As the storage period progressed, the PV of the fortified yogurts relatively increased regardless of purslane ratio. The PV values of the yogurts fortified with the encapsulated gac oil powder were slightly increased throughout storage (Tuyen et al., 2015). The PV of yogurts fortified with microencapsulated flaxseed oil microcapsules increased gradually during the storage (Goyal et al., 2016). Previous researches, as well as the present study, have found that dairy products fortified with PUFA or PUFA containing foods are prone to oxidation during manufacturing and storage.

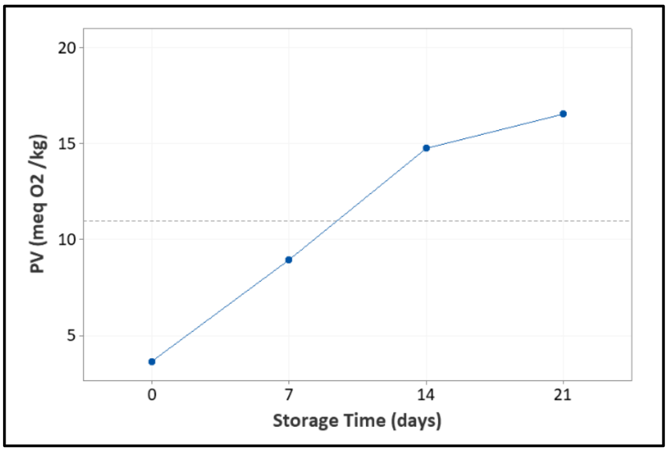

Figure 1. The main effect plot of storage time on PV of fortified yogurts

3.2. The p-AnV of fortified yogurts

The p-Anv is another indicator of initial lipid oxidation. Fats and oils are considered as fresh since the p-AnV is either equal to or less than 5 (Pratap Singh et al., 2020). The p-AnV values of fortified yogurts were lower than the PV values, indicating that breakdown into secondary oxidation products did not occur (Table 1). Moreover, the p-AnV of fortified yogurt samples was mostly less than 5 (Table 1). These findings demonstrated that the fortified yogurts hadn't yet fully oxidized and were hence safe for human consumption. However, the p-AnV of fortified yogurts fermented with 0.5% lyophilized purslane was higher compare to the yogurts produced with 0.25% lyophilized purslane. This result could be associated with the PUFA content of lyophilized purslane (Nemzer et al., 2020). The lower the concentration of lyophilized purslane in fortified yogurts, the lower the PUFA and p-AnV levels. The p-AnV of fortified yogurts slighlty increased since the storage progressed. The p-AnV of fortified yogurt with 5 different vegetable oils significantly increased during the 21 days of storage period (Dal Bello et al., 2015). Since the specific limitations for PV and p-AnV of dairy products are npt formally identified, a very low level of oxidation during storage of all the fortified yogurts at 4°C for up to 21 d might be expected. The ANOVA results for p-AnV of fortified yogurts were listed in Table 2. As it can be seen from the ANOVA table both the factors, lyophilized purslane ratio and storage time ($p<0.05$) were important ($R2=0.92$ and $R2adj=0.80$). The main effect plots statistically agreed that increasing the lyophilized purslane ratio and storage period raised the p-AnV of fortified yogurts (Figure 2).

3.3. The MDA values of fortified yogurts

Another test based on the formation of malondialdehyde (MDA) was performed to

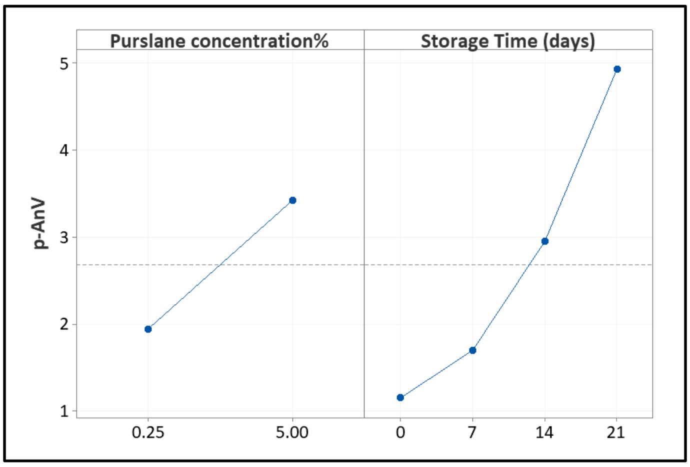

Figure 2. The main effect plots of storage time and purslane concentration on p-AnV of fortified yogurts

evaluate the spontaneous lipoperoxidation of fortified yogurts that occurs during processing and storage. Both regular and fortified yogurt showed a slight increase in lipoperoxidation, particularly after 14 days. However, the levels of lipid peroxidation were rather low, with a maximum value of 7.19 g MDA/g (Table 1). MDA levels decreased in the presence of lyophilized purslane throughout storage. Furthermore, some increases in MDA formation were identified at more prolonged times (14-21 days) in both regular and fortified with purslane yogurts. The MDA results were in accordance with previous studies related to yogurt fortification (Citta et al., 2017; Pourghorban et al., 2022). A pearson correlation was established between MDA and p-AnV data of yogurt samples and the 'r' value was calculated as 0.91. The Pearson correlation value confirmed that the MDA and p-AnV values highly correlated. The ANOVA model developed for MDA of fortified yogurts was found to be insignificant, indicating that the chosen factors and their levels had no noteworthy impact on MDA of fortified yogurts (Table 2).

Table 1. Oxidative stability parameters of yogurt samples during storage

Samples	Purslane Concentration (%)	Storage Time (days)	PV (meq O_2 /kg)	MDA (µg MDA/g)	p-An value
1	0.25	0	2.66	1.05	0.81
2	0.25	7	7.00	1.42	1.06
3	0.25	14	16.44	2.91	2.25
4	0.25	21	17.92	3.12	3.65
5	0.5	0	4.61	0.86	1.49
6	0.5	7	10.84	1.42	2.34
7	0.5	14	13.02	5.93	3.65
8	0.5	21	15.12	6.02	6.21
9	**Control groups**	0	5.84	1.80	1.77
10		7	17.04	3.16	2.51
11		14	21.06	6.76	5.44
12		21	27.66	7.19	8.46

*SD=Standard deviations; SD_{PV}=5.32; $SD_{p\text{-}Anv}$=2.23; SD_{MDA}=1.99

Table 2. ANOVA table of oxidative parameters of fortified yogurts

		p-An value				MDA (µg MDA/g)				PV (meq O_2 /kg)			
Source	DF	Adj SS	Adj MS	F-Value	p-Value	Adj SS	Adj MS	F-Value	p-Value	Adj SS	Adj MS	F-Value	p-Value
Purslane concentration %	1	4.37	4.37	14.05	*0.03*	4.11	4.11	2.63	0.20	0.02	0.02	0.00	0.96
Storage Time (days)	3	16.88	5.63	18.09	*0.02*	22.06	7.35	4.70	0.12	205.77	68.59	10.80	*0.04*
Error	3	0.93	0.31			4.69	1.56			19.05	6.35		
Total	7	22.18				30.85				224.84			

4. CONCLUSION

The production and storage of yogurt fortified with lyophilized purslane were achieved. The addition of lyophilized purslane into the fermentation media generally improved the oxidative properties of yogurts. Storage time was the important factor that affects oxidative stability of yogurts either fortified or regular. The concentration of lyophilized purslane has a minor effect on the peroxide values of the fortified yogurts. Therefore, the fermentation of lyophilized purslane fortified yogurts could be accomplished by adding 0.5% lyophilized purslane, and storage period should be limited to 7 days to maintain oxidative stability.

Ethical Approval

None.

Declaration of Interests

The authors of this study declared no conflict of interests.

Funding

None.

Acknowledgements

I would like to express special thanks to Sivas Cumhuriyet University Food Research and Application Center for the production of yogurt samples.

Author Contribution

Concept: ABA
Design: ABA
Data collecting: ABA
Statistical analysis: ABA
Literature review: ABA
Writing: ABA
Critical review: ABA

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