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PRODUCTION OF FERMENTED RED BEET JUICE POWDER BY USING SPRAY AND DRUM DRIER

Gamze Kaya, Taner Baysal

Ege University, Faculty of Engineering, Department of Food Engineering, Izmir, Turkey

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Abstract

In this study, red beet juice (RBJ) was produced by lacto-fermented method in order to facilitate preservation and enhance the flavor of beet juice. RBJ was inoculated with *Lactobacillus plantarum* L2-1 and incubated at 30 °C for 72 hours. The viable cell counts of *L. plantarum* culture reached $1.3x10^8$ CFU/ml after fermentation. Quality characteristics such as pH, titratable acidity, total soluble solids, total sugar, invert sugar, sucrose content and color of fermented RBJ were determined. In order to extend the shelf life of product, the powder of RBJ was produced by using a spray and drum dryer. The effects of maltodextrins with different dextrose equivalent (25% and 50%) were evaluated during drying process. Then, the total dry matter, particle size, and bulk density were analyzed to determine the quality of powder product. According to sensory analysis of reconstituted products, powder product which was produced with drum dryer was most preferred product than other products.

Keywords: Red beet juice, lacto-fermented method, red beet juice powder, drying

FERMENTE PANCAR SUYU TOZUNUN PÜSKÜRTMELİ VE VALSLİ KURUTUCU İLE ÜRETİMİ

Özet

Bu çalışmada, pancar suyunun lezzetini artırmak ve muhafazasını kolaylaştırmak için laktoferment yöntemi ile pancar suyu üretilmiştir. Pancar suyuna *Lactobacillus plantarum* L2-1 ile inoküle edilmiş ve 30 °C'de 72 saat inkübe edilmiştir. Fermantasyondan sonra *L. plantarum* sayısı $1.3x10^8$ KOB/ml olarak belirlenmiştir. Fermente pancar suyunun pH, titrasyon asitliği, suda çözünür kuru madde, toplam şeker, invert şeker, sakkaroz içeriği ve renk gibi kalite özellikleri analiz edilmiştir. Ürünün raf ömrünü artırmak amacıyla püskürtmeli ve valsli kurutucu kullanılarak pancar tozu üretilmiştir. Ayrıca, kurutma işlemi sırasında farklı dekstroz eşdeğerliğine sahip (%25 ve %50) maltodekstrinlerin etkisi araştırılmıştır. Daha sonra toz ürünün kalite özelliklerini belirlemek amacıyla toplam kuru madde, partikül boyutu ve yığın yoğunluğu analizleri yapılmıştır. Toz ürünlerin sulandırılması ile elde edilen ürünlerin duyusal analiz sonuçlarına göre, valsli kurutucu ile üretilen ürün diğerlerinden daha fazla beğenilmiştir.

Anahtar kelimeler: Pancar suyu, laktoferment yöntemi, pancar suyu tozu, kurutma

* Corresponding author /Yazışmalardan sorumlu yazar;
tanbay@hotmail.com, (+90) 232 311 3043, (+90) 232 342 7592

INTRODUCTION

Red beet (*Beta vulgaris*) is a traditional and popular vegetable in many parts of the world (1). It contains 87.3% moisture, 1.6% protein, 9.1% carbohydrates, 0.8% fiber, 0.1% fat, and 1.1% ash. Red beet is generally processed before consumption which influences the stability of betalains in turn which affects the acceptability and health properties. Betalain pigment mixtures can be used as a natural additive for food, drugs and cosmetic products in the form of beet juice concentrate or beet powder (2). Intense red-colored beets are most popular for consumption, both cooked and raw as salads or juice. In order to improve the red color of tomato pastes, sauces, soups, desserts, jams, jellies, breakfast cereals, the powder of red beet is used industrially (3). The use of betalains as food colorant is approved by European Union and betalains are labeled as E-162 (2).

Fermentation is one of the oldest methods of food preservation, which extend the shelf life of product and also improves the nutritional value (4, 5). It is difficult to preserve vegetable juices because of low acidity and high concentration of spoilage and spore-forming bacteria. Therefore, vegetable juice can be offered fermented. Production of fermented vegetable juices cannot be realized without microorganisms. Fermentation may be spontaneous by using the red beet's own lactic acid bacteria or may be controlled using a starter culture. Lactic acid bacteria are used as starter cultures (lactofermentation) (6).

Lactic acid fermentation of vegetables is widely practiced technology which improves flavour, healthy effects, and safety (7, 8). Consumption of lactic acid fermented vegetable juices has increased worldwide. These juices are mainly produced from cabbage, red beets, carrots, celery, and tomatoes, and may be called "new functional foods" (8).

Red beet is mainly consumed as lactofermented juice, as pickled preserves or as a cooked vegetable. To the best of our knowledge, no data on the production of lactofermented RBJ and powder and the effects of maltodextrins with different dextrose equivalent on drying of red beet juice have been reported in the literature. The main objective of this study is to carry out production of lactofermented RBJ and produce the powder of RBJ by using a spray and drum dryer in order to minimize transportation, storage costs, microbial spoilage and deterioration by chemical reactions. Also, quality characteristics of lactofermented RBJ and powder products were determined after production.

MATERIALS AND METHODS

Materials

Red beets (*Beta vulgaris*) were purchased from local market in Izmir, Turkey. Red beets were stored in a refrigerator at +4 °C and 85-90% humidity before processing. *Lactobacillus plantarum* L2-1 (Labor Wiesby, Germany) was used in the study. Freeze-dried (lyophilized) cultures were stored at -18 °C until used. The inoculum was prepared by growing the culture at 30 °C for 24 h in MRS broth (Merck, Germany). Viable cell counts (CFU/ml) of the inoculum were determined by the standard plate method with MRS medium after 48 h of incubation at 30 °C.

Methods

Processing methods

Fermented beet juice production

Red beets were washed and peeled by peeling machine. RBJ was obtained with Moulinex (JU5000–800 W) juice extractor. Raw RBJ was heated for 5 min at 90 °C. After heating, the beet juice was cooled to 30 °C for inoculation with lactic culture. *L. plantarum* L2-1 was used as a starter culture to produce fermented RBJ after being sub-cultured in MRS broth. Lyophilized culture was dissolved in saltwater solution for activation. Then, raw RBJ was inoculated with activated culture at 30 °C. At the end of the fermentation period (72 h at 30 °C), fermented RBJ was subjected to pasteurisation at 90 °C for 5 min and cooled to 25 °C (Figure 1).

Red beet ⇒ Washing and peeling ⇒ Beet juice extraction ⇒ Raw beet juice ⇒

Heating (90 °C, 5 min) ⇒ Cooling ⇒ Inoculation (*Lactobacillus plantarum*) ⇒

(30 °C, 72 h, pH 3.8-4.2) ⇒ Fermented beet juice

Figure 1. Fermented beet juice production

Powder Production

FBJ powders were produced by spray and drum dryer. Firstly, 50% maltodextrin-containing product produced with drum dryer. Then, 50% and 25% maltodextrin-containing product produced with spray dryer. Drying conditions in spray dryer were at inlet temperature of 180 °C, outlet temperature of 100 °C and flow rate of 10 ml/min. The working parameters of drum dryer were 3 bar pressure and 2.5 min/cycle speed of rotation.

Methods of analysis

pH and total acidity

pH was determined using a pH meter (Inolab WTW, Weilheim, Germany). Total acidity was measured by titrating sample up to pH 8.1 with 0.1 N NaOH using digital pH meter (Inolab) and results were expressed as g/100 mL with reference to lactic acid (9).

Color

Color of RBJ and powders were measured by using the Hunter-Lab Colorflex (CFLX 45-2 Model Colorimeter; HunterLab, Reston, VA) based on three color coordinates, namely L*, a* and b*. The cylindrical quartz cell containing the sample was placed directly into the colorimeter, and post processing L*, a* and b* values were recorded. The L* (lightness: L*=0 for black, L*=100 for white), a* (redness-greenness: a*<0 for green, a*>0 for red) and b* (yellowness-blueness: b*<0 for blue, b*>0 for yellow) indexes of the CIELAB (Commission Internationale de l'éclairage, L*, a*, b*) colorimetric system were used to evaluate the color.

Total soluble matter

Total soluble matter (°Brix) of juice was determined by an automatic digital refractometer at 20 °C (Krüss DR 201, Germany) (10).

Total dry matter

Total dry matter of fermented beet juice powders was determined by infrared moisture measurement device (Shimadzu MOC-63U) at 105 °C.

Physical analysis of powders

Particle size and bulk density were analyzed to determine the quality of powder product (11).

Analysis of carbohydrates

Total sugar, invert sugar, and sucrose content were determined by Lane Eynon Method (9).

Viable cell counts

Viable cell counts (CFU/ml) were determined by the standard plate method with Lactobacilli MRS medium after 48 h of incubation at 30 °C (9).

Sensory evaluation

Samples were given to ten panelists, and they were asked to rank the samples based on their preferences for taste, color and smell. The sample score sheet consisted of 5 scores (from 1:dislike to 5:like) (12).

Statistical analysis

The mean values and standard deviations were calculated by Excel (Microsoft Corp., USA). The results were submitted to ANOVA and Duncan test to evaluate differences between treatments using SPSS 15 (SPSS Inc., Chicago, USA); and significance level was set at $P < 0.05$. Statistically significant differences were compared with treatment groups. Each experiment was repeated 3 times.

RESULTS AND DISCUSSION

The red beet juice and powders were produced and changes on quality characteristics such as pH, total soluble solids, color, titratable acidity were determined. Also, bulk density, particle size, total dry matter was analyzed for powder products.

Fermentation is carried out spontaneously using microorganisms in vegetables or by the addition of starter culture (13). During fermentation, pH decreases and lactic acid increases in vegetable juices reported in literature (Table 1).

In this study, it was determined that the viable cell counts of *L. plantarum* culture reached $1.3x10^8$ CFU/ml after 72 h of fermentation at 30 °C. Similarly, Huang et al. (2005) found that lactic acid bacteria of red beet juice fermented at 30 °C for 72 h was $9.2x10^8$ CFU/ml (14).

Table 1. pH of some vegetables after fermentation

Food	Starter culture	pH after fermentation	References
Carrot	*L. plantarum* *L. xylosus* *L. delbrueck*	pH 3.81 (32 °C 19 h) pH 4.96 (32 °C 19 h) pH 3.82 (40 °C 19 h)	Gökmen and Acar,1992
Cucumber	*L. plantarum*	pH 3.82 (35 °C 12 h)	Kurtar, 1998
Beet	*L. plantarum*	pH 4.2 (30 °C 48 h)	Yoon et al. 2004
Cabbage	*L. plantarum* *L. casei*	pH 3.6 (30 °C 72 h) pH 3.4 (30 °C 72 h)	Yoon et al. 2005

Total sugar, invert sugar, and sucrose content of fermented red beet juice decreased during fermentation (Table 2). It means that *L. plantarum* consumed the sugar and decreased the lactic acid concentration in culture medium. In parallel to our results, Kurtar (1998) reported that total sugar content of lactofermented vegetable juice decreased from 3.84 g/100 ml to 1.66 g/100 ml after fermentation (15). Also, invert sugar content decreased from 3.1 g/100 ml to 1.64 g/100 ml. Özler and Kılıç (1996) found that invert sugar content of turnip juice decreased to 0.2-0.4 g/100 ml at the end of fermentation (16). In addition, Öztürk (2009) indicated that sucrose content of turnip juice decreased to 1.14 g/100 ml (17).

Table 3 presents the change in physical and chemical parameters of fermented beet juice and reconstituted products. The pH of fermented red beet juice was found to be 4.15. The pH of fermented red beet powders were higher than red beet juice (P<0.05), with values ranging from 4.32 to 4.42. Several previous studies stated a significant decrease in pH values after fermentation. Huang et al. (2005) found that pH of red beet juice was 6.3 and it decreased to 4.2 after fermentation (14).

During fermentation, the lowering of pH was most probably because of accumulation of organic acids, mainly lactic acid (18-20). The increase in concentration of lactic acid was because of bioconversion of starch to sugar and finally to lactic acid, which resulted in further decrease in starch and sugar concentration in the fermented medium (6, 21-22). Yoon et al. (2006) reported a similar increase in lactic acid concentration and simultaneous decrease in pH during production of probiotic cabbage juice by lactic acid bacteria (19).

The titratable acidity of fermented RBJ was 0.55 g/100 ml, and acidity of reconstituted powders were changed between 0.17-0.22 (P<0.05). Similar results were obtained by Huang et al. (2005) in red beet juice fermentation (14). They reported that that acidity of red beet juice fermented by *L. plantarum* increased from 0.13 g/100 ml to 0.56 g/100 ml after 72-h fermentation. Furthermore, Kurtar (1998) found that acidity of fermented cucumber increased from 0.14 g/100 ml to 0.52 g/100 ml (15).

The total soluble solids of RBJ and fermented RBJ were found to be 7.3 and 6.5, respectively. This is due to the bioconvertion of sugars to lactic acid. Gökmen and Acar (1992) reported that total soluble solid content of carrot juice fermented by *L. plantarum* decreased from 8.5% to 7.35% (23).

The L* value of RBJ and fermented RBJ were found to be 0.72 and 4.04, respectively. The L* value of red beet juice increased after fermentation. This might be attributed to the decrease in turbidity of lactofermented red-beet juice. Similarly, Rodrigues et al. (2011) observed that L* value of apple juice increased during fermentation (24). The a* value of RBJ and fermented RBJ were found to be 3.93

Table 2. Total sugar, invert sugar, and sucrose content of fermented red beet juice

Analysis	Days		
	0	2	4
Total sugar	4.42±0.2[c]	3.60±0.3[b]	3.14±0.3[a]
Invert sugar	0.95±0.1[c]	0.47±0.1[b]	0.30±0.2[a]
Sucrose	3.47±0.1[c]	3.13±0.2[b]	2.85±0.1[a]

[a to c]Different letters within rows are significantly different (P<0.05)

and 18.58, respectively. Increase in a* value after fermentation might be due to the cell disruption and intracelluler components passed through the water. Similarly, Gobbetti et al. (2009) found that a* value of tomato juice increased during fermentation (25).

Table 3. Physical and chemical parameters of fermented beet juice and reconstituted products

Analysis	Fermented beet juice	Reconstituted product (%25 MD, spray dryer)	Reconstituted product (%50 MD, spray dryer)	Reconstituted product (%50 MD, drum dryer)
pH	4.15[a]	4.32[b]	4.33[b]	4.42[c]
Total soluble solids (°Brix)	6.5[a]	6.1[b]	6.1[b]	6.1[b]
L*	4.04[a]	0.21[b]	0.39[c]	2.88[d]
a*	18.58[a]	0.82[b]	1.92[c]	11.96[d]
b*	4.32[a]	0.17[b]	0.47[c]	2.54[d]
Titratable acidity (g/100 mL)	0.55[a]	0.22[b]	0.19[c]	0.17[d]

[a to c]Different letters within rows are significantly different (*P*<0.05)

As shown in Table 4, bulk density of powder products were changed between 0.33-0.83. There were significant differences evaluated between powder products (*P*<0.05). Powder product produced by drum dryer and containing 50% maltodextrin had the lowest particle size value.

Sensory analysis of fermented RBJ and reconstituted products are presented in Table 5. According to results of analysis, panelists gave the highest score to fermented RBJ. In addition, powder product which was produced with drum dryer was most preferred product than other powder products.

Conclusion

In this study, red beet juice (RBJ) was produced by lacto-fermented method with *Lactobacillus plantarum* L2-1 and quality characteristics were determined. The results indicated that pH, total sugar, invert sugar, sucrose, total soluble solid content of red beet juice decreased after fermentation. Fermentation improved the color of red beet juice. Juice powders have many benefits and economic potentials over their liquid counterparts such as reduced volume or weight, reduced packaging, easier handling and transportation, and much longer shelf life. Powder products were obtained by drum and spray dryer. Powder product including 50% maltodexrin produced by drum dryer has the lowest particle size and also it was most preferred by panelists compared to the others.

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Table 4. Some properties of lactofermented red-beet juice powders

Analysis	Powder product containing %25 MD (spray dryer)	Powder product containing %50 MD (spray dryer)	Powder product containing %50 MD (drum dryer)
Bulk density	0.59[a]	0.33[b]	0.83[c]
Particle size	300[a]	333[b]	229[c]
Total dry matter	94.03[a]	92.16[b]	94.28[c]

[a to c]Different letters within rows are significantly different (*P*<0.05)

Table 5. Sensory analysis of fermented red-beet juice and reconstituted products

Product	Taste	Color	Smell	Total effect
Fermented red-beet juice	3.6	4.4	3.8	4.4
Powder product containing %25 MD (spray dryer)	2.4	3.2	2.6	3.2
Powder product containing %50 MD (spray dryer)	2.6	3.6	2.6	3
Powder product containing %50 MD (drum dryer)	3	3	3.4	3.8

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