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EFFECT OF MINERAL SALT REPLACERS ON THE PHYSICOCHEMICAL, MICROBIAL AND SENSORY PROPERTIES OF YOGURT DRINK, AYRAN

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ABSTRACT
Reducing the salt content of foods often impairs the taste, consumer acceptability and the shelf life. Impact of mineral salt replacers on chemical, microbiological and sensory properties of Ayran samples during 20 days of storage were investigated. Ayran samples having 0.5% salt/salt replacers were produced as follows; A (control): 100% NaCl, B: 100% KCl, C: 70%KCl + 30% NaCl, D: 50% NaCl + 50% KCl, E: 30%KCl + 70% NaCl, F: Pansalt® (57% NaCI+ 28% KCI + 12% $MgSO_4$ + 2% L-lysine+ 1% Silicon Dioxide). Except for sample F, Ayran samples had similar pH values on day 1 and their pH decreased by day 10. Use of Pansalt® and NaCl:KCl at the ratios of 7:3 and 1:1 resulted in acceptable yogurt drinks. *Lactobacillus bulgaricus* counts of A, D and F decreased on day 10, while *Streptococcus thermophilus* counts of A, C, E and F increased on day 20.
Keywords: sodium reduction, ayran, salt replacers

MİNERAL TUZ İKAME MADDELERİNİN AYRANIN FİZİKOKİMYASAL, MİKROBİYAL VE DUYUSAL ÖZELLİKLERİ ÜZERİNE ETKİSİ

ÖZ
Gıdalarda tuzun azaltılması genellikle, tat, tüketici kabul edilebilirliği ve raf ömrünü olumsuz etkilemektedir. Bu çalışmada, mineral tuz ikame maddelerinin Ayran örneklerinin 20 günlük depolama süresince kimyasal, mikrobiyolojik ve duyusal özellikleri üzerine etkileri araştırılmıştır. Çalışmada %0.5 tuz/tuz ikamesi içeren ayran örnekleri şu şekildedir: A (kontrol): %100 NaCl, B: %100 KCl, C: %70KCl + %30 NaCl, D: %50 NaCl + %50 KCl, E: %30 KCl + %70 NaCl, F: Pansalt® (57% NaCI+ 28% KCI + 12% $MgSO_4$ + 2% L-lisin+ 1% Silicon Dioxide). Ayran örnekleri, F örneği dışında 1. günde benzer pH değerlerine sahipti ve pH'ları 10. günde azaldı. Sonuçlar, Pansalt® ve 7:3 ve 1:1 oranında NaCl:KCl karışımı kullanımı ile kabul edilebilir Ayran üretilebildiğini göstermiştir. Depolamanın 10. gününde A, D ve F örneklerinde *Lactobacillus bulgaricus* sayılarında azalma meydana gelirken, A, C, E ve F örneklerinde 20. günde *Streptococcus thermophilus* sayıları artış göstermiştir.
Anahtar kelimeler: sodyumun azaltılması, ayran, tuz ikame maddeleri

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INTRODUCTION

The term "salt" refers to the table salt "NaCl" in common use and provides about 90% of the sodium in the diet (Kloss et al., 2015). In recent years, reducing the salt consumption has gained much interest and many efforts have been made to limit the use of salt in processed foods. High sodium intake from consuming salt is linked with high blood pressure and related health problems such as cardiovascular diseases and hypertension (Cook et al., 2007). There is also evidence that overconsumption of the salt can damage the kidneys, heart and aorta and may cause osteoporosis (He and McGregor, 2009). Processed foods comprise around 75 to 80% of the dietary salt intake while 10 to 15% of the salt is added during cooking or at the table, and only 5 to 10% is naturally occurring in the foods (Kloss et al., 2015). Growing concerns on the health risks of excessive salt intake led World Health Organization (WHO) and food legislators around the world to take action for reducing the salt in food products (WHO, 2007). Daily salt intake should be less than 5 grams (<2 g/day sodium) for reducing the high blood pressure according to the WHO. The WHO HEARTS program was established in 2016 to reduce cardiovascular diseases, and one of the targets of the program was a 30% relative reduction in mean population intake of salt/sodium by 2025 (WHO, 2016a). The "SHAKE Technical Package for Salt Reduction" was published by WHO as a guidance for the development, implementation and monitoring of salt reduction strategies in order to achieve a reduction in population salt intake (WHO, 2016b).

Reducing the salt content of foods is a challenge and often impairs the taste and consumer acceptability. Apart from the taste, for many food products salt has vital role in many technological aspects such as structure, preservation and shelf life (Doyle and Glass, 2010). Extensive amount of research has been conducted regarding salt reduction and several approaches developed such as use of salt replacers, salt enhancers, modulation of salt spatial distribution and particle size (Wilson et al., 2012).

Ayran is among the dairy foods that contain salt and is a type of fermented milk drink widely consumed in Turkey. Previous studies showed that certain mineral salt compounds such as KCl and $MgSO_4$ have a potential to mimic salty taste of NaCl (Cepanec et al., 2017; Cruz et al., 2011). Use of salt replacers containing potassium, magnesium, and calcium have been investigated in various cheeses (Grummer et al., 2012; Akan and Kınık, 2018; Dugat-Bony et al., 2019; Mozuraitye et al., 2019) and butter (de Souza et al., 2013). Potassium chloride is one of the most common mineral salt replacers (Cepanec et al., 2017), and potassium intake may also have a positive effect on health (He and MacGregor, 2001). It was reported that replacement of NaCl with KCl can cause bitter and metallic flavor and soft and pasty body defects in cheese (Cruz et al., 2011). However, several studies have claimed that partial replacement of NaCl with KCl in soft and semi-hard cheeses had no influence on the physicochemical and organoleptic properties of cheese if the substitution was less than 30% (Costa et al., 2019; Grummer et al., 2012; Soares et al., 2016). The unpleasant bitter and metallic aftertaste of mineral salt replacers could be more pronounced at high concentrations and when used solely; however, moderate concentrations could prevent that (Sinopoli and Lawless, 2012). It is necessary to carry out initial studies for food formulations to determine the right concentration of sodium replacers to successfully replace sodium chloride without impairing the sensory properties. No previous study was done to the author's knowledge on the use of salt replacers in Ayran. This study investigated the impact of mineral salt replacers at different replacement ratios on the physicochemical, microbial and sensory properties of Ayran.

MATERIAL AND METHODS

Production of Ayran Samples

Ayran samples were produced at Harran University Pilot Dairy Plant. Milk for Ayran production was prepared by mixing the skim milk powder (Pinar A.S.), cream (35% milk fat) (Pinar A.S.) and water at room temperature to have 6.1% NFDM and 1.8% fat. Milk was then homogenized at 144 bar (Hommak F-HM20, İzmir, Turkey) after heating to 60ºC and pasteurized at 90˚C for 5 min using heating tank. After cooling down to 45˚C, inoculated with direct vat starter culture (YF-L903 50U, Chr Hansen) containing *Lactobacillus delbruckii* subsp. *Bulgaricus (L. bulgaricus)* and *Streptococcus thermophilus (S. thermophilus)* (1:1) at the prescribed amount (1/5 of the 50U package was used for 100 kg milk) . Incubation was ended at pH 4.6, containers were taken out of the incubation room, and 0.5% salt/salt replacers were added directly while they were still at around 45˚C, stirred well and cooled down to room temperature in cold water bath. After that, they were filled in 250 ml cups, sealed with foil using Ayran filling machine (Sezmak, İstanbul, Turkey) and cooled down to 4˚C at cold store. Ayran samples differed in their salt type as: A (control): 100% NaCl, B: 100% KCl, C: 70%KCl + 30% NaCl, D: 50% NaCl + 50% KCl, E: 30%KCl + 70% NaCl, F: Pansalt (%57 NaCI+ %28 KCI + %12$MgSO_4$ + %2 L-lysine+ %1 silicon dioxide. Samples were then cold stored at 4˚C. Trial was replicated for twice.

Composition and pH

Total solids (IDF, 1982), titratable acidity and ash (Oysun, 1996) were determined by gravimetric method. Fat was analyzed by Gerber method (IDF, 1991). Mineral contents (Ca, P, Mg, Na and K) were measured according to method used by Peng et al. (2009) by VARIAN-CCD Simultaneous ICP-AES (Optima 5300 DV PerkinElmer Inc., USA) with 3 repetitions for each replicate. pH was measured at room temperature directly by inserting the probe of the pHmeter (Thermo Scientific Orion, Fort Collins, USA) into samples and measurements were taken on day 1, 10 and 20 with two repetitions. All other composition analyses were done in the first week of the production.

Viscosity

Viscosity was measured at day 1, 10 and 20 using Brookfield Viscometer (Brookfield Model RVDV-II+, Brookfield engineering Laboratories. Inc., Middlesbrough, UK.) with spindle no 3 at 100 rpm and 15s (Özer et al., 1997). Sample temperature was 4˚C during measurement.

Whey Separation

Whey separation was measured at day 1, 10 and 20. 100 ml sample was placed in graduated cylinder and kept at 4˚C for 1 day. Whey separation was measured as a percentage of released water to the total volume of the sample (Özünlü, 2005).

Sensory Evaluation

Sensory evaluation was done on day 1 and day 20. A total of 18 panelists conducted the sensory panel. Ayran samples were evaluated for overall liking, flavor and consistency using a 9-point hedonic scale (with 1 = extremely dislike, 5 = neither like nor dislike, and 9 = extremely like), and for saltiness, a just-about-right (JAR) 5-point intensity scale was used with 3 being just about right, 1= not enough salt and 5 = too much salt. Panelists were also asked to rank the samples in order from the most preferred to the least. Samples were evaluated using ranking test model according to Drake (2008).

Microbiological analysis

S. thermophilus and *L. bulgaricus* counts were determined on day 1, 10 and 20. Ayran samples were diluted using 0.1% sterile peptone water and 1 mL aliquot dilutions were poured onto plates of the selective agars in triplicate. M17 agar was used for the enumeration of *S. thermophilus* and *L. bulgaricus* was incubated at MRS agar anaerobically (Rybka and Kailasaphaty 1996). All plates were incubated at 37 ºC for 48 h. Anaerobic conditions were obtained using Anaerocult A sachets (Merck). Enumeration of the yeast and mould was done after incubating sample aliquots (1mL) dispersed on Potato Dextrose Agar at 25 ºC for 4-5 days (Taniwaki et al. 2001).

Statistical analysis

Statistical analysis was performed by SPSS version 16 (SPSS Inc., Chicago, IL) using One-way ANOVA. Differences between means were evaluated by Tukey multiple comparisons test with 95% confidence level.

RESULTS AND DISCUSSION

Chemical Properties

Chemical properties of the Ayran milk is given in Table 1. Ayran milk used for the production of the Ayran samples contained 6.1% NFDM, 1.8% fat, 0.68% ash. Its acidity was 0.18% (lactic acid) and pH was 6.64, and both were in normal range for milk (Metin, 2012). All ayran samples had 1.75±0.03% fat and 7.58±0.25% NFDM. We did not see any significant difference between NFDM and fat content between Ayran samples (*P*<0.05). Except for sample F, Ayran samples had similar pH values on day 1 and their pH decreased by day 10 (Fig. 1). No further significant decrease in pH was observed at day 20 (*P*>0.05). The lower pH value of sample F could be due to the composition of Pansalt®. Akan and Kınık (2018) also reported a lower pH with the use of Pansalt® in white cheese as compared to control white cheese samples. Fitzgerald and Buckley (1985) observed a lower pH in Cheddar cheeses salted with $MgCl_2$. There was no significant difference between the pH of the Ayran samples at day 10, while at day 20 sample B, C and D exhibited slightly lower pH than others. A decrease in pH with storage has also been reported by other studies (Gülmez and Güven, 2003; Özünlü, 2005), and it was attributed to the growth of the starter bacteria during storage. Mineral content (Na, K, Mg, Ca and P) and total ash of Ayran samples are given in Table 2. Total ash content of the Ayran samples did not differ (*P*<0.05). No difference was observed between Ca and P contents of the Ayran samples (*P*>0.05). The difference between Na, K and Mg contents of Ayran samples were proportional to the added mineral salt amounts. The achieved reduction in the Na content of the Ayran samples with the use of salt replacers was 51, 34, 26, 16 and 21% respectively for sample B, C, D, E and F. Mg content of the sample F was significantly higher than the others due to the Mg content of the added Pansalt (*P*<0.05).

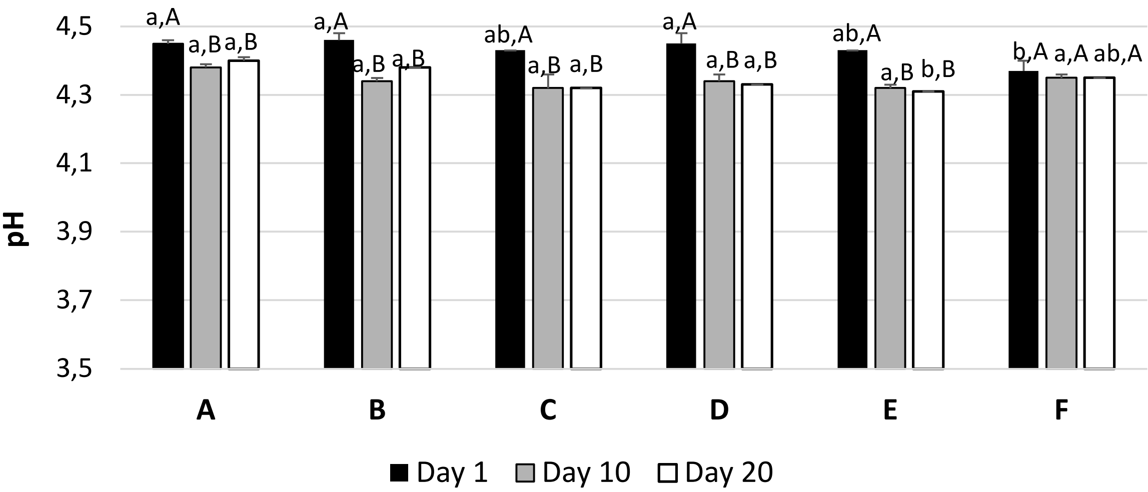

Figure 1. Mean pH values of the Ayran samples during storage
A (control): 100% NaCl, B: 100% KCl, C: 70% KCl + 30% NaCl, D: 50% NaCl + 50% KCl, E: 30% KCl + 70% NaCl, F: Pansalt® (%57 NaCI + %28 KCI + %12 MgSO4 + %2 L-lysine + %1 silicon dioxide

Values with different superscript letters are significantly different (*P*<0.05)
a-b Denote for the differences between treatment groups while A-B denote for the differences between storage for each sample.

Table 1. Mean pH, titratable acidity and composition of Ayran milk used for Ayran production

Parameter	Milk
pH	6.64 ± 0.03
Titratable acidity (% lactic acid)	0.178 ± 0.020
NFDM (%)	6.1 ± 0.3
Fat (%)	1.8 ± 0.2
Ash (%)	0.68 ± 0.05

Table 2. Mean total ash, Na, K, Mg, Ca and P content of the Ayran samples

Parameter	Control	Reduced sodium				
	A	B	C	D	E	F
Ash, %	1.02±0.02 [a]	1.02±0.00 [a]	1.06±0.04 [a]	1.03±0.02 [a]	1.04±0.01 [a]	0.98±0.03 [a]
Na, mg/100 ml	345.82±15.32[a]	169.06±8.30[d]	229.44±17.30[c]	257.16± 2.13[b]	288.66±5.35 [b]	271.65±15.40 [b]
K, mg/100 ml	129.78±9.15[e]	348.02±9.56[a]	276.84±9.28[b]	232.29±2.77[c]	192.54±8.56[d]	183.54±10.87[d]
Mg, mg/100 ml	11.45±0.50 [a]	11.47±0.70 [a]	11.29±0.74 [a]	10.82±0.12 [a]	10.96±0.48 [a]	18.04±0.89[b]
Ca, mg/100 ml	93.16±4.13 [a]	92.86±3.73 [a]	90.59±1.84 [a]	90.58±0.92[a]	89.65±3.41 [a]	93.24±4.94 [a]
P, mg/100 ml	68.41±2.87 [a]	69.60±2.46 [a]	68.70±3.01 [a]	68.56±3.55 [a]	66.25±3.21 [a]	67.34±4.84 [a]

[a-e] Values with different superscript letter in the same row are significantly different (P<0.05)
A (control): 100% NaCl, B: 100% KCl, C: 70% KCl + 30% NaCl, D: 50% NaCl + 50% KCl, E: 30% KCl + 70% NaCl, F: Pansalt® (%57 NaCI + %28 KCI + %12 MgSO4 + %2 L-lysine + %1 silicon dioxide

Physical Properties

Whey separation occurs in Ayran as a phase separation by time due to the sedimentation of destabilized proteins. Occurrence of the whey separation in Ayran is unavoidable at some point during storage; however, a fast whey separation is unwanted, and the length of the time required for the phase separation to occur is a quality criterion of Ayran. Whey separation and viscosity results of the samples are given in Table 3. Use of mineral salt replacers did not influence the whey separation significantly (P>0.05). The average whey separation was 10% at day 1. A significant increase was observed at day 10 for all samples, and then stayed stable showing no significant difference at day 20. Increase in serum separation during storage has also been observed by other researchers (Atamer et al., 1999; Özünlü, 2005). It was shown that, higher acidity reduces the whey separation in Ayran (Akbulut and Bozkurt, 2020; Özünlü, 2005; Özdemir and Kılıç, 2004). The stability of Ayran samples in terms of serum separation between day 10 and 20 could be due to the lower pH levels as compared to the initial pH. Use of salt replacers did not influence the viscosity of the Ayran samples on day 1 (P>0.05). There was an increase in the viscosity of the sample A, B, C and E. The increase in the viscosity of those samples during the storage could be due to the decrease in pH as reported in previous studies (Özdemir and Kılıç 2004, Tamucay-Özünlü and Koçak 2010). Viscosity of the sample F was stable during the storage just like its stable pH. Vicosity of the sample F was lower than the other samples at day 10 and 20. The lowest viscosity was observed at sample D at day 20.

Sensory Properties

Mean 9-point hedonic liking scores for overall liking, flavor and consistency are given in Table 4. Highest overall liking scores belonged to control (A), and sample E and F had the closest scores to sample A (P<0.05). Replacing the NaCl completely with KCl resulted in an unfavorable effect on all sensory parameters. Overall liking, flavor, consistency and saltiness scores changed proportional to KCl replacement, and samples having the least amount of KCl replacement (E) received higher scores. Previous studies reported that replacement of salt with KCl can cause bitter and metallic flavor; however, if the substitution is less than 30% there was no influence on the physicochemical and organoleptic properties of cheese (Cruz et al., 2011; Costa et al., 2018, Costa et al., 2019; Grummer et al., 2012; Soares et al., 2016). Flavor scores of the sample D, E and F were higher, and found to be similar with control ($P<0.05$). Consistency scores were similar for all samples except for B. It was interesting to see that the least acceptable sample B in terms of saltiness and flavor received low consistency scores as well, even though it wasn't any less viscous than the other samples (Table 3). Storage didn't influence the overall liking and flavor scores, while there was an increase in consistency scores by storage time in general which is in accordance with our viscosity results.

Table 3. Mean whey seperation and viscosity of Ayran samples

	Whey separation (%)			Viscosity (cP)		
	Storage time (days)					
	1	10	20	1	10	20
A	11±3^{a,A}	27±0^{a,B}	30±0^{a,B}	129±2^{a,B}	141±10^{a,AB}	160±2^{a,A}
B	11±1^{a,A}	24±5^{a,B}	29±5^{a,B}	139±3^{a,A}	151±6^{a,B}	166±14^{a,B}
C	8±3^{a,A}	23±2^{a,B}	28±2^{a,B}	136±23^{a,A}	144±2^{a,A}	155±8^{ab,A}
D	11±2^{a,A}	25±2^{a,B}	28±1^{a,B}	136±8^{a,A}	136±7^{ab,A}	123±3^{c,A}
E	8±2^{a,A}	21±5^{a,B}	27±1^{a,B}	113±7^{a,B}	154±8^{a,A}	152±7^{ab,A}
F	9±3^{a,A}	24±4^{a,B}	28±2^{a,B}	134±9^{a,A}	112±4^{b,A}	134±5^{bc,A}

$^{a-c}$ Values with different superscript letter in the same row are significantly different ($P<0.05$)
$^{A-B}$Values with different superscript letter in the same column are significantly different ($P<0.05$)
A (control): 100% NaCl, B: 100% KCl, C: 70% KCl + 30% NaCl, D: 50% NaCl + 50% KCl, E: 30% KCl + 70% NaCl, F: Pansalt® (%57 NaCI + %28 KCI + %12 MgSO4 + %2 L-lysine + %1 silicon dioxide

Table 4. Mean 9-point hedonic liking scores for sensory attributes and ranking for preference results of Ayran samples

Sample	Attribute					
	Overall liking		Flavor		Consistency	
	Day 1	Day 20	Day 1	Day 20	Day 1	Day 20
A	6.0±0.3^{aA}	6.9±0.1^{aA}	5.9±0.0^{aA}	6.6±0.4^{aA}	6.0±0.3^{aB}	7.2±0.1^{aA}
B	2.7±0.8^{cA}	3.4±0.6^{cdA}	2.9±0.9^{cA}	4.4±0.7^{dA}	4.7±0.6^{bB}	6.2±0.1^{cA}
C	3.9±0.9^{bcA}	4.7±0.4^{cA}	4.3±1.2^{bA}	5.3±0.6^{cdA}	5.3±0.5^{abB}	6.5±0.2^{bcA}
D	5.1±0.8^{bA}	6.0±0.2^{bA}	5.4±0.8^{abA}	5.7±0.0^{bcA}	6.0±0.0^{aB}	7.0±0.1^{aA}
E	5.8±0.6^{abA}	6.3±0.2^{abA}	5.8±1.1^{aA}	6.4±0.6^{abA}	6.0±0.1^{aB}	7.0±0.1^{aA}
F	5.6±1.2^{abA}	6.3±0.8^{abA}	5.5±0.8^{abA}	6.4±0.1^{abA}	6.1±0.2^{aA}	6.7±0.6^{abA}

^{a} Values with different superscript letter in the same column are significantly different ($P<0.05$)
$^{A-B}$Values with different superscript letter in the same row are significantly different ($P<0.05$)
A (control): 100% NaCl, B: 100% KCl, C: 70% KCl + 30% NaCl, D: 50% NaCl + 50% KCl, E: 30% KCl + 70% NaCl, F: Pansalt® (%57 NaCI + %28 KCI + %12 MgSO4 + %2 L-lysine + %1 silicon dioxide

Saltiness scores of the Ayran samples are given in Table 5. Mean JAR scores showed that, samples that do not contain added NaCl (B) were found not enough salty, even though KCl was used as replacement. However, 70% replacement of NaCl with KCl found to be ideal (JAR) by the panelists. Sample D, E, F and A received higher mean JAR scores. Some of the panelists scored the samples "too much salty" despite the fact that the highest salt (NaCl) concentration was 0.5%. This could be due to different saltiness preferences of people. We could have a better picture of saltiness evaluation results in Fig. 2, where we can see what percentage of the panelists found the samples JAR, having too much or too low salt. Here we could see that, number of the panelists who found the samples too much salty is low. More than 85% of the panelists found sample B not enough salty (89% on day 1, and 94% on day 20). Saltiness of the control (A) was found ideal (JAR) by 56% of the panelists; around 30% of them found it not enough while 6 to 17% found too salty. The closest sample to control in terms of having ideal saltiness scores (with 39% on day 1 and 44% on day 20) was sample F, a commercial salt replacer Pansalt having a mixture of KCl, $MgSO_4$ and L-lysine for 43% NaCl replacement. KCl and $MgSO_4$ have been applied to replace NaCl in several cheeses and while they cause undesirable after tastes such as bitterness, metallic and sharp taste, at low concentrations no significant differences were observed (Sheibani et al., 2013). In previous studies L-lysine was used as bitter blocking agent (Khetra et al., 2016) and it has been reported that it can also contribute to the salty taste (Zhang et al., 2014).

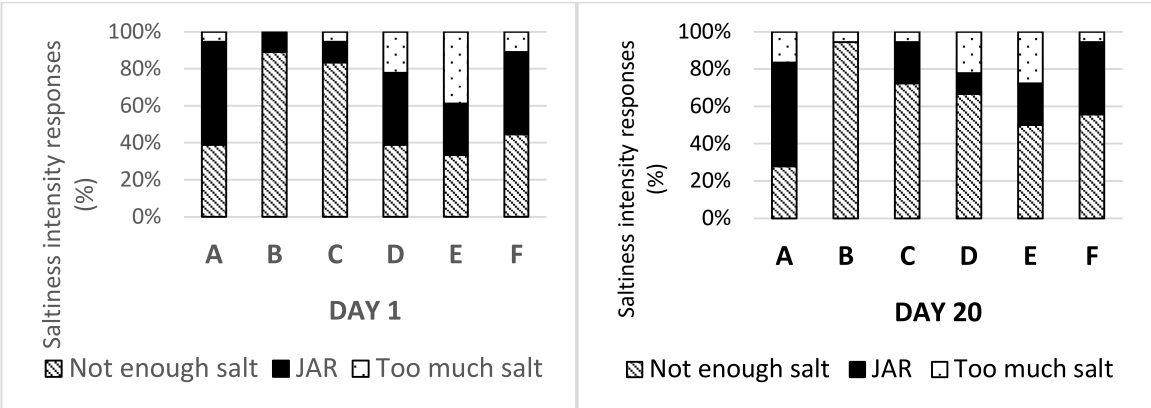

Figure 2. Saltiness intensity responses of Ayran samples
A (control): 100% NaCl, B: 100% KCl, C: 70% KCl + 30% NaCl, D: 50% NaCl + 50% KCl, E: 30% KCl + 70% NaCl, F: Pansalt® (%57 NaCI + %28 KCI + %12 MgSO4 + %2 L-lysine + %1 silicon dioxide

Table 5. Mean JAR scores for saltiness of Ayran samples

Attribute	Day	Sample					
		A	B	C	D	E	F
Saltiness	1	4.5±0.1^{abA}	2.4±0.9^{cA}	2.9±0.9^{cbA}	4.1±0.6^{abA}	4.9±0.4^{aA}	4.3±0.2^{abA}
	20	4.7±0.1^{aA}	2.3±0.5^{bA}	3.75±0.5^{aA}	4.1±0.1^{aA}	4.8±0.1^{aA}	4.2±0.2^{aA}

$^{a-b}$ Values with different superscript letter in the same row are significantly different (P<0.05)
A (control): 100% NaCl, B: 100% KCl, C: 70% KCl + 30% NaCl, D: 50% NaCl + 50% KCl, E: 30% KCl + 70% NaCl, F: Pansalt® (%57 NaCI + %28 KCI + %12 MgSO4 + %2 L-lysine + %1 silicon dioxide

It is interesting to note that, sample E was found too salty by around 30% of the panelists, which is even higher than the control. Replacing the NaCl with KCl at 50% and below resulted in higher saltiness scores, however there was also a proportional increase in "too much salt" sensation. Storage didn't influence the JAR scores significantly (P>0.05).

Microbiological Properties

We did not find any yeast and mould growth in samples during 20d. Starter bacteria counts (*S. thermophilus* and *L. bulgaricus*) are given in Table 6. Use of salt replacers didn't influence *S. thermophilus* counts at any storage point and counts were stable in first 10 days. At day 20, there was an increase in *S. thermophilus* counts for all samples except for sample B and D. As for the *L.*

bulgaricus, we did not observe differences between samples at day 1, however statistically significant differences were observed at day 10 and day 20 ($P<0.05$). Changes in the yogurt bacteria counts during storage show differences in different studies. Tamuçay-Özünlü and Koçak (2010) didn't see any change in yogurt bacteria counts during 14 days of storage while Avşar et al. (2001) observed an increase after 7 days of storage contrary to Kurultay et al. (1998) and Şimşek et al. (2007), who reported a decrease in the counts after 15 days.

Table 6. Change in the mean *S. thermophilus* and *L. bulgaricus* counts of Ayran samples

	S. thermophilus count (log cfu/g)			*L. bulgaricus count (log cfu/g)*		
	Storage time (days)					
	1	10	20	1	10	20
A	$8.53\pm0.01^{a,A}$	$8.41\pm0.03^{a,A}$	$9.02\pm0.18^{a,B}$	$4.85\pm0.00^{a,B}$	$4.27\pm0.00^{a,A}$	$4.60\pm0.11^{a,B}$
B	$8.39\pm0.14^{a,A}$	$8.51\pm0.06^{a,A}$	$8.75\pm0.02^{a,A}$	$4.35\pm0.49^{a,A}$	$4.51\pm0.01^{b,A}$	$4.56\pm0.07^{a,A}$
C	$8.51\pm0.08^{a,A}$	$8.58\pm0.03^{a,A}$	$8.86\pm0.03^{a,B}$	$5.02\pm0.23^{a,A}$	$4.42\pm0.10^{ab,A}$	$4.58\pm0.02^{a,A}$
D	$8.35\pm0.17^{a,A}$	$8.54\pm0.11^{a,A}$	$8.90\pm0.15^{a,A}$	$5.04\pm0.06^{a,B}$	$4.51\pm0.04^{b,A}$	$4.46\pm0.05^{a,A}$
E	$8.44\pm0.18^{a,A}$	$8.49\pm0.00^{a,A}$	$9.06\pm0.02^{a,B}$	$4.78\pm0.25^{a,A}$	$4.45\pm0.04^{ab,A}$	$4.49\pm0.07^{a,A}$
F	$8.38\pm0.01^{a,A}$	$8.59\pm0.00^{a,A}$	$8.97\pm0.13^{a,B}$	$4.99\pm0.13^{a,B}$	$4.43\pm0.09^{ab,A}$	$4.57\pm0.11^{a,AB}$

$^{a-c}$ Values with different superscript letter in the same row are significantly different ($P<0.05$)
$^{A-B}$Values with different superscript letter in the same column are significantly different ($P<0.05$)
A (control): 100% NaCl, B: 100% KCl, C: 70% KCl + 30% NaCl, D: 50% NaCl + 50% KCl, E: 30% KCl + 70% NaCl, F: Pansalt® (%57 NaCI + %28 KCI + %12 MgSO4 + %2 L-lysine + %1 silicon dioxide

CONCLUSION

In this study our results showed that replacement of salt (NaCl) with mineral salt replacers to produce Ayran with acceptable levels of saltiness sensation is possible. According to our results we suggest that, replacement of NaCl with KCl should not exceed 30% and to be able to go above a 30% NaCl replacement, other salt replacers such as $MgSO_4$ and bitter blocking agents as used in Pansalt® in our study should be considered.

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CONFLICT OF INTEREST

The authors have declared no conflict of interest.

AUTHORS' CONTRIBUTIONS

Çağım Akbulut Çakır contributed to the planning and analysis of the experimental study, did the statistical evaluation of the data and wrote the manuscript. Ayşe Bozkurt contributed to the analysis of the experimental study and laboratory work. All authors read and approved the final manuscript.

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