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Physical Properties of Fermented Milk Tablets

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ABSTRACT: Nowadays, milk tablets are considered favorable due to several advantages, including good taste and chewing properties, ease of transport, increased bioavailability, ease of storage, stability of active ingredients and improved functional properties.This study seeks to investigate the characteristics of fermented milk tablets in relation to its use as a beverage producing tablet. The effects of effervescent agent contents (0, 20, 40, 50, 60 %) (citric acid, tartaric acid and sodium bicarbonate) on physical and sensory properties of fermented milk tablets were evaluated. Physical properties, including weight and diameter of the tablet containing different percentages of effervescent agent (i.e. 0-60 %) did not differ significantly ($P \leq 0.05$). Increasing the level of the effervescent agent (i.e. 0-60%) led to hardness reduction, as well as the friability value and dissolution time of this tablet in water. Regarding the sensory properties of the fermented milky drink produced by tablets, the appearance, mouth feel and flavor acceptability of fermented milk tablets containing 40 % effervescent agent had the highest significant score ($P \leq 0.05$).

Keywords: *Effervescent Agents, Fermented Milk, Physical Properties, Tablet.*

Introduction

Fermentation of milk by lactic acid bacteria (LAB) (Lactobacillales) is employed to extend the shelf life of milk. Different types of fermented milks are concentrated fermented milks, such as fresh cheese, Greek style yoghurt, labneh, yoghurt and lactic drinks such as doogh (in Iran) and ayran (in Turkey). The most important factors influencing the acceptability of these products are good health effects, desirable nutritional characteristics, unique sensory properties, and long shelf-life (Chandan, 1999; Salminen *et al.*, 1998).

Doogh (yoghurt drink) is a typical Iranian fermented milk produced from yoghurt by adding potable water, yoghurt culture starter, salt and some aqueous extracts of local herbs. This dairy product is exported from Iran and consumed in Afghanistan, Armenia, Azerbaijan, Balkans, Turkey and to a lesser extent in other parts of the middle east and central asia (Foroughinia *et al*., 2007).

The consumption of fermented milk products has increased in the world due to its nutritional benefits, including high digestibility and absorbable calcium content. These products are useful as healthy drinks and supply a quarter of the body's daily calcium and vitamins B requirements, because its consumption results in strong bones and teeth. As the most significant mineral in the milk and dairy products,

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calcium is able to mitigate the risk of cancer (Foroughinia *et al*., 2007).

Iranian manufacturers of milk-based drinks, especially doogh, face a number of problems, that consist of,

- Contamination with acidic refrigeration-resistant mold
- The problem of physical instability due to phase separation in the timespan between production and consumption
- Need for large storage and transportation equipment
- Their short shelf-life (15-21 days) (Kiani *et al.,* 2010).

Nowadays, milk tablets are considered as favorable due to several advantages, including good taste and chewing properties, ease of transport, increased bioavailability, ease of storage, stability of active ingredients and improved functional properties (Lee *et al*., 2016; Wu *et al*., 2012). Khaowphan *et al*. (2010) studied about the nutritional value and stability of goat's milk tablet during storage in plastic bottles and aluminum bags. Lee *et al*. (2016) endeavored to investigate the characteristics of milk tablets supplemented with nano-powdered eggshell or nano-powdered oyster shell and showed that the quality of all the test milk tablets was similar to that of the control sample.

Tableting of the fruits, such as pineapple, pitaya, guava and mango (Saifullah *et al.*, 2014), green and ripe mango fruit powder (Ong *et al.*, 2013) and pitaya fruit and guava (Zea *et al.*, 2013) are other kinds of food ingredients tablet for facile handling.

It should be pointed out that, there is limited information available on the production of fermented milk tablets for drinking or chewing tablets. Thus, the objective of this study is to investigate the effects of effervescent agents content (0, 20, 40, 50, 60 %) (citric acid, tartaric acid and sodium bicarbonate) on physical and sensory properties of fermented milk tablets in order to achieve facile and transportable fermented milk drinks (the final product of which after mixing with water is similar to doogh).

Materials and Methods

- Preparation of fermented milk tablets

In this study, yoghurt was prepared from raw bovine skim milk. The milk was pasteurized at 90 °C for 5 min. The starter culture R704 was added at 42 ℃ according to Chr. Hansen Co. (Denmark). After the incubation at 42 ˚C (with 1.4 % lactic acid), all the samples were cooled down to 4℃. Yoghurt was dried in spray drier at the inlet air temperature of 170 ˚C and the outlet air temperature of 50 ˚C with the flowrate of 500 L.rpm^{-1}. Yogurt powder with different percentages of effervescent agent (citric acid, tartaric acid and sodium bicarbonate) (0, 20, 40, 50, 60 %) and salt (0.1 – 0.2 %) were blended to obtain a homogenous powder. The tablets were compressed on a single punch tablet machine (Ko Erwek, Germany). The targeted tablet weight was set at 2 g. The powder of each tablet was weighed using a digital scale with an accuracy range of ±0.001 g. The procedure was completed by unloading and removing the bottom punch and ejecting the tablet from the die.

- Evaluation of powder properties

The fermented milk powder properties including moisture, densities and particle size of powder was determined by the method described in Ng *et al*. (2012). Moisture was determined by oven drying at 102 °C for 3 hours. Different types of densities including absolute, tapp and bulk densities of powders were measured. The values of bulk density and tap density were used to calculate the Hausner ratio and Carr index using equations 1 & 2 respectively. These indices were used to calculate flowability. Powder's flowability can be obtained using Table 2. The particle size of powder was measured using a particle size analyzer (Malvern Mastersizer 2000, UK).

Hausner ratio (HR) $= \boldsymbol{\rho}_{Tapped}/\boldsymbol{\rho}_{Bulk}$ Eq.1

Carr's index $= (\boldsymbol{\rho}_{Tapped} - \boldsymbol{\rho}_{Bulk}) \times 100 / \boldsymbol{\rho}_{Tapped}$ Eq.2

Where:

$\boldsymbol{\rho}_{\mathbf{Tapped}}$**:** Impact density

$\boldsymbol{\rho}_{\mathbf{Bulk}}$**:** Bulk density

- *Evaluation of tablets properties*

- *Weight*

The weight variation test was determined by weighing 20 tablets, individually, calculating the average weight and comparing the individual tablet weight to the average (Khaowphan *et al*., 2010).

- *Density*

Six tablets were randomly selected, and their weight was recorded individually on a digital scale. A chloroform solution was used for measuring the density of tablets. The chloroform solution was poured into a graduated cylinder and the volume change of the liquid inside was recorded (Podczeck and Sharma, 1996).

- *Hardness*

Six tablets were randomly selected and individually placed in a tablet hardness tester (D100 digital model PTB, Germany) and tablet hardness was measured according to Newton (Aulton, 1988).

- *Friability value*

Twenty tablets were dusted by a dusting brush and weighed (W_1), before they were placed in a Roches friabilator (Pharma test® Model PTFR-A, Pharmatest, Germany) at the rotating speed of 25 rpm. After 4 min, the tablets were taken off, dedusted and weighed again (W_2). The friability value (F %) of tablet was calculated from the difference between the weights of the tablet prior to and after rotation (Equation 3) (Remington & Gennaro, 1995).

$F \% = [(W_1 - W_2)/ W_1] \times 100$ Eq.3

- *Dissolution time*

Six tablets were weighed and each was put in 50 ml of water (at 23 $^{\circ}$C) and duration of dissolution (disappearance) of tablets were recorded using a digital stopwatch (Adiba *et al*., 2011).

- *Phase separation*

Tablets were dissolved in water into a graduated cylinder and duration of two phase separation was recorded using a digital stopwach.

- *Sensory evaluation*

The sensory evaluation was conducted in cooperation with 30 specialized panelists. The tablet was dissolved in water and sensory characteristic (appearance, mouth feel and flavor acceptability) of the final product (like Doogh) were evaluated. The participants were given water and biscuits intermittently after each round of sensory evaluation test (Zea *et al*., 2013).

Results and Discussion

- *Physical properties of fermented milk powder*

The moisture content of dried powder has a significant effect on the physicochemical stability of the powder during storage and transportation. The oxidative stability is changed depending on the moisture content (Reh *et al*., 2004). The technological properties such as water solubility wetting capability of the powder are affected by the amount of moisture (Mathlauth, 2001). The requirement of moisture content of a food powder is between 4 % and 6 %. Particle size and shape are very important during particle formation and processing because they can directly affect the quality of the final products (Ma *et al*., 2000). Particle size also influences the flowability and segregation of powders (Fitzpatrick, 2007). The physical properties of yoghurt powder are presented in Table 1. According to the results of the compressibility index formula and as shown in Table 2, it was concluded that yogurt powder flows well. Different ranges for Carr Index and HR were defined by Lebrun *et al.* (2012). According to Tables 1 and 2 HR and Carr index of yogurt powder are 1.16 and 15.37 respectively. Assessment of HR is important to understand the impact of relative humidity on powder compression during its shelf-life. Thereupon, HR can serve as a criterion for measurement of state transition from free flow to cohesion (Lumy *et al.*, 2012).

- Physical properties of fermented milk tablets

- Weight of fermented dairy tablets

Uniformity of weight of any tablet is a critical physical characteristic. Different percentages of effervescent agent (citric acid, tartaric acid and sodium bicarbonate) did not have significant effect on the weight of fermented milk tablets ($P<0.05$) (Table 3). Saifullah *et al.* (2014) showed that the combination of citric acid and sodium carbonate powder in four kinds of fruit juices (pineapple, pitaya, guava and mango) during the production of effervescent fruit tablets did not have significant effect on the weight of tablets. Weight uniformity of tablets is important due to direct relationship between the content and the chemical ingredients. Therefore, standard deviation of tablets has to be less than 5% (Zaid *et al.*, 2013).

Table 1. Physical properties of yogurt powder

Physical properties	Yogurt Powder
Moisture content (%)	4.4±0.002
Bulk density (kg/m^3)	0.67±0.003
Absolute density (kg/m^3)	0.66±0.002
Tapped density (kg/m^3)	0.78±0.002
Carr index, CI (%) Carr	15.37±0.016
Hausner ratio, HR Hausner	1.12±0.022
Mean particle size diameter, D50 (µm)	51.99± 0.009

Table 2. Ranges for compressibility index and Hausner ratio (Lebrun *et al.*, 2012)

Carr Index (CI), %	Hausner Ratio (HR)	Flowability
0-10	1.00-1.11	Excellent
11-15	1.12-1.18	Good
16-20	1.19-1.25	Fair
21-25	1.26-1.34	Passable
26-31	1.35-1.45	Poor
32-37	1.46-1.59	Very poor

Table 3. The effect of effervescent agent on physical characteristics of fermented milk tablet

Effervescent agent (%)	Weight (g)	Hardness (N)	Erosion (%)	Dencity (g.cm^{-1})
0	2.000 ± 0.007^a	14.69± 0.47^a	0.003±0.004 ^{d}	1.05 ± 0.112 ^{e}
20	1.999 ± 0.006^a	9.67± 0.33^b	0.015± 0.006^d	1.24 ± 0.018^d
40	1.998 ± 0.007^a	8.08± 0.35^c	0.068±0.024^c	1.33 ± 0.043^c
50	1.998 ± 0.009^a	3.91± 0.24^d	0.147± 0.021 ^{b}	1.53 ± 0.027^b
60	2.000 ± 0.006^a	2.37± 0.23^d	0.230 ± 0.032^a	1.66 ± 0.025 ^{a}

Within the same column, the values with different letters are significantly different ($P< 0.05$).

- *Density of fermented milk tablets*

To assess the effect of different percentages of effervescent agents content (citric acid, tartaric acid and sodium bicarbonate), the density of all fermented milk tablets were measured in chloroform. The results indicated that the lowest and the highest densities (1.05 and 1.66 $g.cm^{-2}$ respectively) were related to the content of effervescent agents (0 and 60 % respectively). As shown in Table 3, bulk density of fermented milk tablets are increased significantly due to the increase in added effervescent agent content from 0 % to 60 % ($P<0.05$). Podczeck and Sharma (1996) have suggested that small particles of effervescent powder fill the space between large particles of the tablet, and increase the density of the effervescent binary powder mixtures. Ong *et al.* (2014) reported that tablets (ripe and green mango powder) with effervescent agent have higher density than ripe and green mango without any effervescent agent. The density of the mixture tablets elevates when both powders are contained in the tablet, while its volume declines in this process. This is because; green mango powder particles fill the voids between larger particles of ripe mango. As a result, the bonding between particles is much stronger than effervescent tablets made of ripe or green mango. This compactness lowers the volume of the tablet.

- *Hardness of fermented milk tablets*

As shown in Table 3, changes in effervescent agent content of the fermented milk significantly change its hardness, i.e. the higher the effervescent agent content of the fermented milk tablet, the less hard will the resulting tablet be ($P<0.05$). The physical properties of effervescent agents such as particle size and density has caused lower tensile strength in fermented milk tables in comparison to the control tablets. Therefore, hardness of fermented milk tablets decreased significantly due to the increased effervescent agents content (Yosef *et al.*, 2009).

- *Friability value of fermented milk tablets*

The results of the statistical analysis suggest that different contents of effervescent agents affect the friability of fermented milk tablets significantly ($P<0.05$). By increasing the content of effervescent agents from 0 % to 60 %, friability of tablets changed from 0.003 % to 0.23 % because of the tensile strength reduction of the tablet (Aslan and Jahangiri, 2013).

- *Dissolution time of fermented milk tablets*

Table 4 shows the results of dissolution time in five fermented milk tablets. The dissolution time was decreased by higher content of effervescent agents and the effervescence is higher because of the reaction of water with effervescent agents and CO_2. By increasing the effervescent agents content from 0 to 60 %, the dissolution time drops from 2700 to 350 seconds.

The numerous tiny gas bubbles rapidly produced (i.e. effervescence) speeds up the tablet particles disintegration rate (Jagdal *et al*., 2009; Bolhuis *et al.*, 1997). The tablet solvency in water depends on the durability of the bond between the particles and the resultant strength of the structure. When the tablet is loosely structured, water can more readily penetrate into its structure and disintegrate it. The tablets with more effervescent agent, expand (swell) faster and more rapidly weakens the bond between the particles and disintegrate faster in water. Thereupon, it will collapse faster (Bolhuis *et al.*, 1997).

- *Phase separation time of the fermented milk*

Table 4 shows the results of the phase separation (in minutes) of fermented milk produced by effervescent fermented milk tablets. By increasing the content of effervescent agents in tablets from 0 to 60 %, the phase separation time of the resulting fermented milk dropped from 120.5 to

34.5 min. The impact of high acidity of the fermented milk brings the casein to its iso-electric point, whereby sedimentation of the protein occurs in the bottle resulting in phase separation (Tamime, 2006). This research is consistent with our results, because by increasing the percentage of the effervescent agent, the pH drops following the earlier phases.

- Sensory evaluation of fermented milk tablets

This study showed that the addition of effervescent agents (citric acid and sodium bicarbonate) to a kind of fermented dairy drink (like doogh) produced by adding effervescent fermented milk tablets in water has a positive effect on the acceptability of the product by panelists (P<0.05) (products of these treatments on, the fermented milk tablet produced with 40 % effervescent agents content has the highest acceptability in terms of appearance, mouth feel and flavor (P<0.05) (Table 5).

Conclusion

This study showed that effervescent agents (e.g. citric acid, tartaric acid and sodium bicarbonate) did not have significant effects on the weights and diameters, but the increase in the effervescent agent content caused increased density, friability value and decreased in hardness and dissolution time in fermented milk tablets. Sensory evaluation of the fermented milk produced by dissolving fermented milk tablets in water showed that 40 % content of the effervescent agent resulted in highest score of acceptability in terms of appearance, mouth feel and flavor of final product by the panelists.

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Table 4. The effect of effervescent agent on physical characteristic of fermented milk produced using fermented milk tablet

Effervescent agent (%)	Dissolution time (S)	Phase separation (min)
0	2705±252[a]	120.5 ± 3.64[a]
20	939± 21[b]	77.5 ± 3.64[b]
40	601± 9 [c]	55.2 ± 2.94[c]
50	454± 13[d]	45 ± 3.08[d]
60	349± 15[d]	34.5 ± 3.64[e]

Within the same column, the values with different letters are significantly different (P< 0.05).

Table 5. The effect of effervescent agent on sensory evaluation; appearance, mouth feel and flavor acceptability of fermented milk produced using fermented milk tablet

Effervescent agent (%)	Acceptability		
	Appearance	Mouth feel	Flavor
0	4±0.02[c]	2.7±0.02[c]	2±0.20[c]
20	4.5±0.03[b]	3.4±0.06[b]	2.6±0.4[b]
40	4.8±0.05[a]	4±0.03[a]	3.8±0.3[a]
50	5±0.05[a]	3.8±0.03[a]	3.4±0.3[a]
60	5±0.05[a]	3.8±0.06[b]	3.6±0.3[a]

Within the same column, the values with different letters are significantly different (P< 0.05).

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