

## EFFECT OF MAGNESIUM D - GLUCONATE FORTIFICATION ON HEAT STABILITY OF GOAT'S MILK AND PHYSICOCHEMICAL PROPERTIES, SENSORY CHARACTERISTIC AND TEXTURE PROFILE OF YOGHURTS DURING COLD STORAGE

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**ABSTRACT**

Average consumption of magnesium in Poland does not satisfy people's daily demand for this element; therefore it is necessary to supplement it. In the conducted experiment there was established the possibility of using magnesium D-gluconate for enriching yoghurts and goat's milk. The highest dose of magnesium, which did not cause protein precipitation during pasteurization, was the addition of 20 mg of magnesium for 100 g of goat's milk. Fortification with magnesium decreases pH and increases the hardness of yoghurts. Yoghurts enriched with magnesium during the whole storage period were better preferred by consumers than control yoghurts (without magnesium). Fortification with magnesium increases the intensity of milky-creamy taste and decreases the intensity of "goat" taste in goat's milk yoghurts. The amount of the introduced magnesium does not significantly change the cohesiveness and adhesiveness of yoghurts within 21-day-storage period.

**Keywords:** Magnesium, fortification, yoghurt, goat's milk

**INTRODUCTION**

Appropriate balance between particular elements in diet is necessary to correct functioning of a human body and maintain its homeostasis. More and more often you can come across the problem of biological deficiency of such an important element as magnesium. Magnesium is better assimilated as an ingredient of food products than pharmaceutical products. Milk is considered an average source of magnesium. In case of consumption of food, which is rich in phytates or proteins there might occur an interaction and decrease of the assimilation of magnesium. It is believed, that calcium disrupts assimilation of magnesium. However, the majority of research did not prove the influence of calcium on the assimilation of magnesium under the condition, that the daily dose of 2000 mg Ca is not exceeded, which may in fact decrease the absorption of magnesium (Bancerz *et al.*, 2012; Ziarno 2004). Assimilation of magnesium is lower when the consumption of protein in the diet is lower than 30 g daily. Significant increase in consumption of proteins can also influence the decrease of the concentration of magnesium, connected with the increased kidney secretion (Ziarno, 2004). Research of bioavailability of magnesium in 10 organic and non-organic magnesium salts was made by Coudray *et al.* (2005) and there was proved that magnesium D-gluconate has the highest bioavailability of magnesium.

It is forecasted that the consumption of yoghurts will be higher and higher and the properties of yoghurt qualify this product as a good carrier for magnesium in order to decrease the deficiencies of this element in diet. Currently a phenomenon of hypomagnesaemia is more and more often observed, especially in highly industrialised countries, also in Poland (Kocot, 2014). Scientists claim, that average consumption of magnesium by Poles does not correspond with a daily demand for this element (Jarosz and Bulhak – Jachymczuk, 2008). In such situations it is recommended to use supplementation of diet in magnesium, which is provided to the body with food products (Kruk – Słomka, 2012).

Goat's milk is counted as easily digestible and well-assimilated food for a human body and it is often used as a substitute in a diet of people who may be allergic to cow's milk proteins (Danków – Kubisz, 2007; Hekmat and Reid, 2006; Pieczonka, 2008; Danków and Pikul, 2011; Pandya, Ghodke, 2007). Goat milk contains a little of magnesium, from 12 mg to 16 mg Mg/100g (Park *et al.*, 2007; Ceballos *et al.*, 2009; Brendehaug and Abrahamsen, 1986). Good assimilation of the ingredients of goat's milk and optimum contents of protein make goat's products good carriers of magnesium. Moreover, thermic processing used in the production of fermented milk drinks cause significant changes in the

composition of mineral compounds of milk, including magnesium. Precipitation of insoluble magnesium compounds may cause as much as 50% of loss of this element. These technological losses caused by pasteurisation may be balanced by means of enriching milk in magnesium compounds.

The aim of the paper was to determine the possibility of using magnesium D-gluconate to enrich goat's milk before pasteurisation and to establish the dose of the introduced magnesium on acidity and heat stability of proteins. Moreover, there was determined the influence of applied dose of magnesium on the physicochemical and organoleptic properties and texture of yoghurts during 21-day period of storage.

**MATERIAL AND METHODS**

**Materials**

The research material was cumulative goat's milk collected three times in the middle of lactation (June-September). For milk and yoghurts enrichment magnesium D - gluconate hydrate  $\geq 98\%$  ( $C_{12}H_{22}MgO_{14} \cdot xH_2O$ , pure for analysis, Sigma – Aldrich, USA) was used.

**Milk analysis**

In raw milk there were determined physicochemical and microbiological parameters (Tab 1) and then fat was spun and the content of dry matter was normalized. The general number of micro-organisms and the number of somatic cells were determined in IBC M/SCC (Bentley) semi-automatic counter, and the chemical composition was determined in Bentley B-150 milk composition analyser. The chemical composition of milk used for production of yoghurts is presented in table 2.

**Table 1** Quality of raw goat's milk

Properties	Average ± standard deviation
General number of micro-organisms (CFU/ml)	359 000±51 000
Number of somatic cells (1 ml)	400 000±30 000
pH	6.570±0.022
General acidity (°SH)	6.400±0.045
Freezing point (°C)	-0.569±-0.002
Protein (%)	2.580±0.032
Fat (%)	3.440±0.500
Lactose (%)	4.200±0.025
Dry matter (%)	10.920±0.600

**Table 2** Chemical composition of normalized milk for production of yoghurts

Properties	Average ± standard deviation
Protein (%)	3.88±0.06
Fat (%)	2.06±0.26
Lactose (%)	6.45±0.04
Dry matter (%)	13.90±0.31

**Heat stability of milk enriched in magnesium D - gluconate**

The experiment was conducted in two stages. The scope of tests of the first stage included determining the quantity of addition of magnesium D - gluconate hydrate ≥ 98% (C<sub>12</sub>H<sub>22</sub>MgO<sub>14</sub>·xH<sub>2</sub>O, pure for analysis, Sigma – Aldrich, USA) not causing thermal denaturation of proteins of milk during its pasteurization in temperature of 72°C for 15 seconds. The doses of magnesium presented in tables were calculated based on molecular weight of magnesium gluconate. The experiment started with the dose of 1 mg of magnesium for 100 g of milk and continued until denaturation occurred during pasteurization. There was also made a test sample without addition of magnesium. After cooling milk samples pH was determined.

**Preparation of yoghurts**

The scope of the second stage of tests included production of yoghurt with the thermostatic method of various levels of enrichment with magnesium (0 mg, 5 mg, 10 mg, 15 mg and 20 mg) with the use of the vaccine FD-DVS YC-X16 (Chr. Hansen). Fermentation was conducted for 4.5 hours in disposable containers with lids (100 ml) in temperature of 43°C.

**Yoghurts analysis**

The assessment of the influence of addition of magnesium gluconate on acidity, texture and sensory characteristics (1-9 points) was conducted at four fixed dates, i.e. after 1 day, 7 days, 14 days and 21 days of storage. Preferences were determined by ranking method (9 - the most preferred yoghurt, 1 - the least preferred yoghurt). Determining potential acidity was performed by titration of 0.25N samples with standard solution of sodium hydroxide in presence of phenolphthalein as an indicator. Determining active acidity (pH) was performed with the electrometric method by measurement of activity of hydrogen ions with the use of pH/conductivity meter CPC – 505 (Elmetron) equipped with the combination electrode OSH 12 – 00. The texture was determined with the analyser Brookfield CT3 equipped with Brookfield Texture Pro CT software. For determination there was selected the TPA test with the following settings: sample – cylinder 66.00 mm x 33.86 mm, force 0.1 N, head speed 1 mm/s, table TA-BT-KIT, probe TA3/100.

**Statistical analysis**

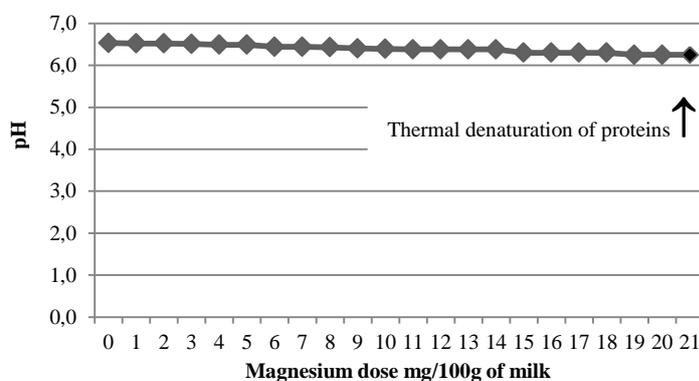
The obtained results were worked out statistically in the software Statistica v.10 with the use of one-way analysis of variance, and significance of differences between the averages was estimated with Tukey's test.

**RESULTS AND DISCUSSION**

**Effect of pasteurization on enriched goat's milk**

Magnesium D-gluconate belongs to the water-soluble compounds that cause the appearance of considerable amounts of ionic forms of magnesium. 70 - 75% of magnesium in the fresh milk is in the form of soluble salts, the remaining part of magnesium occurs as a colloidal compounds (phosphate and citrate). Only 15% of the magnesium in fresh milk is in the free ionic form. Increasing the amount of magnesium ions reduces the stability of milk proteins which can cause the thermal coagulation (Ścibisz et al., 2012; Zaręba et al., 2012).

The conducted tests have proven that the highest dose of magnesium which does not caused the precipitation of proteins after pasteurization was 20 mg of magnesium for 100 g of goat milk. The dose of fortification with magnesium causing precipitation of proteins after pasteurization in 75°C was 21 mg of magnesium for 100 g of milk. It was also observed that putting of higher and higher doses of magnesium D-gluconate caused a reduction of pH of milk (Fig 1). Enriching milk with the dose of 20 mg of magnesium (for 100 mg of milk) caused a reduction of active acidity from 6.530 (milk without addition of magnesium D-gluconate) to 6.250.



**Figure 1** Influence of applied dose of magnesium in the form of D-gluconate on pH of milk after pasteurization

**Effect of fortification on acidity of yoghurts**

Yoghurts enriched in 5, 10, 15, 20 mg of magnesium (for 100 g of processed milk) were characterized during the 21 days of storage by higher values of pH in comparison to test yoghurts, without addition of magnesium D-gluconate. On the first day of storage the highest pH = 4.541 were determined in yoghurts enriched with the dose of 20 mg of magnesium (for 100 g of milk for production) and the lowest values of pH (4.335) were determined in test yoghurts. There were found significant differences in active acidity between samples enriched in 20 mg of magnesium and test samples without addition of magnesium D-gluconate. Moreover, in all groups of yoghurts during successive weeks of cold storage, it was observed a reduction of pH and there were found statistically significant differences (Tab 3). According to Mituniewicz-Malek et al. (2013) the active acidity of goat's yoghurts (produced with the use of *Lb. casei* 01 inoculant) on first day of storage was 5.330 and it decreased to 4.410 after 21 days of cold storage.

**Table 3** The influence of dose of enrichment with magnesium on active acidity of goat's milk yoghurts during storage

Characteristic – fixed date of determination	Dose of enrichment with magnesium (mg of magnesium for 100 g of milk)				
	0	5	10	15	20
pH - 1 day	4.335 ± 0.017 <sup>aA</sup>	4.396 ± 0.027 <sup>aA</sup>	4.455 ± 0.065 <sup>aA</sup>	4.451 ± 0.066 <sup>aA</sup>	4.541 ± 0.190 <sup>bA</sup>
pH - 7 days	4.198 ± 0.093 <sup>aAB</sup>	4.242 ± 0.055 <sup>aB</sup>	4.242 ± 0.047 <sup>aB</sup>	4.258 ± 0.048 <sup>aB</sup>	4.270 ± 0.048 <sup>aB</sup>
pH - 14 days	4.271 ± 0.003 <sup>aAB</sup>	4.231 ± 0.039 <sup>aB</sup>	4.230 ± 0.066 <sup>aB</sup>	4.212 ± 0.051 <sup>aB</sup>	4.235 ± 0.045 <sup>aB</sup>
pH - 21 days	4.151 ± 0.068 <sup>aB</sup>	4.189 ± 0.043 <sup>aB</sup>	4.186 ± 0.051 <sup>aB</sup>	4.187 ± 0.032 <sup>aB</sup>	4.200 ± 0.042 <sup>aB</sup>

**Legend:** <sup>a-c</sup> – statistically significant differences (p < 0.05) analysed in row  
<sup>A-C</sup> – statistically significant differences (p < 0.05) analysed in column

**Effect of fortification on sensory and textural properties of yoghurts**

Non – fortified goat's milk yoghurts were the least preferred by the sensory panel during whole period of cold storage. The sensory panel preferred yoghurts enriched in magnesium on 7th, 14th and 21st day of sensory assessment and yoghurts enriched with a dose of 15 mg of magnesium (for 100 g of milk for production) were chosen as the best. Yoghurts enriched in 5 mg of magnesium

were preferably chosen on 1st day of storage. Mituniewicz - Malek et al. (2013) found that goat's milk fermented beverages containing a new generation of probiotic single strains *Lactobacillus sp.* (*Lb. paracasei AD 400*, *Lb. casei O1 oraz Lb. acidophilus 3*) also showed very good sensory characteristics during cold storage.

**Table 4** The influence of dose of enrichment yoghurts with magnesium on preference of sensory panel during storage (1 – 5 points)

Characteristic – fixed date of determination	Dose of enrichment with magnesium (mg of magnesium for 100 g of milk)				
	0	5	10	15	20
Preference – 1 day	4.556±2.068 <sup>abA</sup>	2.000±1.118 <sup>abA</sup>	4.555±2.550 <sup>abA</sup>	3.889 ±2.205 <sup>abA</sup>	3.444±1.810 <sup>abA</sup>
Preference – 7 days	4.556±2.128 <sup>abA</sup>	3.333±1.732 <sup>abA</sup>	3.667±2.000 <sup>abA</sup>	3.000±1.500 <sup>abA</sup>	3.778±1.986 <sup>abA</sup>
Preference – 14 days	4.375±2.560 <sup>abA</sup>	4.375±1.847 <sup>abA</sup>	3.875±2.357 <sup>abA</sup>	2.375±1.188 <sup>abA</sup>	3.000±2.000 <sup>abA</sup>
Preference – 21 days	4.111±2.522 <sup>abA</sup>	3.778±1.922 <sup>abA</sup>	3.111±1.764 <sup>abA</sup>	2.222±1.093 <sup>abA</sup>	3.889±1.900 <sup>abA</sup>

**Legend:** <sup>ab</sup> – statistically significant differences (p < 0.05) analysed in row  
<sup>A</sup> – statistically significant differences (p < 0.05) analysed in column

Goat's yoghurts of all experimental groups were characterized by a white colour assessed by the team in the range of 8.556 points to 9.000 points (Tab 5).

Moreover, there was no significant differences in colour of yoghurts depending upon fortification with magnesium and storage time.

**Table 5** The influence of dose of enrichment with magnesium on colour of goat's milk yoghurts during storage (1-9 points)

Characteristic – fixed date of determination	Dose of enrichment with magnesium (mg of magnesium for 100 g of milk)				
	0	5	10	15	20
Colour – 1 day	8.556±0.726 <sup>abA</sup>	8.556±0.726 <sup>abA</sup>	8.556±0.726 <sup>abA</sup>	8.556±0.726 <sup>abA</sup>	8.556±0.726 <sup>abA</sup>
Colour – 7 days	8.556±0.882 <sup>abA</sup>	8.556±0.882 <sup>abA</sup>	8.556±0.882 <sup>abA</sup>	8.556±0.882 <sup>abA</sup>	8.556±0.882 <sup>abA</sup>
Colour – 14 days	8.875±0.354 <sup>abA</sup>	8.875±0.354 <sup>abA</sup>	8.875±0.354 <sup>abA</sup>	8.875±0.354 <sup>abA</sup>	8.875±0.354 <sup>abA</sup>
Colour – 21 days	9.000±0.000 <sup>abA</sup>	9.000±0.000 <sup>abA</sup>	9.000±0.000 <sup>abA</sup>	9.000±0.000 <sup>abA</sup>	9.000±0.000 <sup>abA</sup>

**Legend:** <sup>ab</sup> – statistically significant differences (p < 0.05) analysed in row  
<sup>A</sup> – statistically significant differences (p < 0.05) analysed in column

Goat's milk products are particularly exposed to occurrence of defects in texture - lower consistence of curd produced by the thermostatic method, too liquid consistence and low viscosity of curd produced by a tank method (Szczepanik and Libudzisz, 2000). In the experiment there was observed positive effect of enrichment on the consistency, especially in yoghurts fortified with 20 mg of

magnesium (for 100 g of processed milk) in comparison to non-fortified yoghurts (Tab 6). According to Znamirowska et al. (2015) fortification of goat's yoghurt with magnesium chloride (20 mg of magnesium for 100 g of milk for production) has a positive effect on consistency.

**Table 6** The influence of dose of enrichment with magnesium on consistency of goat's milk yoghurts during storage (1-9 points)

Characteristic – fixed date of determination	Dose of enrichment with magnesium (mg of magnesium for 100 g of milk)				
	0	5	10	15	20
Consistency – 1 day	7.111±1.616 <sup>abA</sup>	7.889±0.928 <sup>abA</sup>	7.000±1.936 <sup>abA</sup>	7.333±1.236 <sup>abA</sup>	7.089±0.928 <sup>abA</sup>
Consistency – 7 days	7.222±1.416 <sup>abA</sup>	7.667±0.866 <sup>abA</sup>	7.222±1.716 <sup>abA</sup>	7.778±1.092 <sup>abA</sup>	8.111±0.928 <sup>abA</sup>
Consistency – 14 days	7.625±1.302 <sup>abA</sup>	7.875±0.991 <sup>abA</sup>	7.000±2.619 <sup>abA</sup>	7.725±1.588 <sup>abA</sup>	8.000±1.069 <sup>abA</sup>
Consistency – 21 days	7.889±1.167 <sup>abA</sup>	8.222±1.302 <sup>abA</sup>	7.889±1.167 <sup>abA</sup>	8.222±1.302 <sup>abA</sup>	8.222±1.302 <sup>abA</sup>

**Legend:** <sup>ab</sup> – statistically significant differences (p < 0.05) analysed in row  
<sup>A</sup> – statistically significant differences (p < 0.05) analysed in column

Table 7 presents the results of the assessment of intensity of milky - creamy taste in all groups of yoghurts. In control yoghurts, non-fortified with magnesium D-gluconate, there was found less intense milky-creamy taste. The sensory panel

found that fortification with magnesium increases perceptibility of milky-creamy taste in goat's yoghurts.

**Table 7** The influence of doses of enrichment with magnesium on perceptibility of milky-creamy taste of goat's milk yoghurts during storage (1-9 points)

Characteristic – fixed date of determination	Dose of enrichment with magnesium (mg of magnesium for 100 g of milk)				
	0	5	10	15	20
Milky-creamy taste – 1 day	4.556±1.046 <sup>abA</sup>	5.111±1.551 <sup>abA</sup>	5.333±1.606 <sup>abA</sup>	4.889 ±1.804 <sup>abA</sup>	4.667±1.240 <sup>abA</sup>
Milky-creamy taste – 7 days	4.778±1.949 <sup>abA</sup>	5.556±1.046 <sup>abA</sup>	5.222 ±1.949 <sup>abA</sup>	5.667±1.041 <sup>abA</sup>	5.778±1.032 <sup>abA</sup>
Milky-creamy taste – 14 days	3.750±1.412 <sup>abA</sup>	4.125 ±1.357 <sup>abA</sup>	4.375±1.021 <sup>abA</sup>	4.500±1.295 <sup>abA</sup>	4.375±1.378 <sup>abA</sup>
Milky-creamy taste – 21 days	4.000±1.041 <sup>abA</sup>	4.889 ±1.180 <sup>abA</sup>	5.111±1.759 <sup>abA</sup>	4.778 ±1.949 <sup>abA</sup>	4.892±1.892 <sup>abA</sup>

**Legend:** <sup>ab</sup> – statistically significant differences (p < 0.05) analysed in row  
<sup>A</sup> – statistically significant differences (p < 0.05) analysed in column

The carried-out experiment shows that the fortification with magnesium decreases sourness of the yoghurt's taste in comparison to non-fortified ones (Tab 8). Moreover, in all groups of yoghurts there were found an increase of

perceptibility of sour taste during the 21 days of cold storage. Confirmation of this trend is an increase of active acidity during successive weeks of cold storage.

**Table 8** The influence of dose of enrichment with magnesium on perceptibility of sour taste of goat's milk yoghurts (1-9 points) during storage

Characteristic – fixed date of determination	Dose of enrichment with magnesium (mg of magnesium for 100 g of milk)				
	0	5	10	15	20
Sour taste – 1 day	5.167±1.871 <sup>aA</sup>	4.667±1.323 <sup>aA</sup>	4.444±1.944 <sup>aA</sup>	4.111±1.261 <sup>aA</sup>	4.222±1.438 <sup>aA</sup>
Sour taste – 7 days	5.000±1.936 <sup>aA</sup>	4.667±1.803 <sup>aA</sup>	4.333±1.121 <sup>aA</sup>	4.444±1.236 <sup>aA</sup>	4.444±1.068 <sup>aA</sup>
Sour taste – 14 days	5.250±1.435 <sup>aA</sup>	4.375±1.768 <sup>aA</sup>	4.125±1.167 <sup>aA</sup>	4.875±1.357 <sup>aA</sup>	4.375±1.134 <sup>aA</sup>
Sour taste – 21 days	6.222±1.986 <sup>aA</sup>	5.111±1.205 <sup>aA</sup>	5.000±1.646 <sup>aA</sup>	5.000±1.398 <sup>aA</sup>	5.222±1.224 <sup>aA</sup>

**Legend:** <sup>a-c</sup> – statistically significant differences (p < 0.05) analysed in row  
<sup>A-C</sup> – statistically significant differences (p < 0.05) analysed in column

Unfavorable "goat" taste is caused by lipolytic processes, because in goat milk lipoprotein lipase is arranged on the surface of the fat globules in 46%, in milk's serum in 46%, while on the surface of casein micelles in 8%, which decides on a "goat" smell of milk (Danków – Kubisz, 2007). Furthermore, in goat's milk fat there is shown a high proportion of short- and medium-chain fatty acids (15%), which are responsible for the specific "goat" taste and smell of milk (Danków and Pikul, 2011). With extension of storage time the intensity of "goat" taste increased in yoghurts enriched with 5 mg, 10 mg, 15 mg of magnesium and in a non-fortified ones (Tab 9). The most intensive "goat" taste was determined in yoghurts not enriched in magnesium on 21st day of storage. The least intense "goat" taste was determined in yoghurts fortified with 20 mg of Mg on 14th and 21st day of storage. In these yoghurts there was not observed goat smell (1,000 pts.), abnormal taste (1,000 pts.) and smell (1,000 pts.). According to

Znamirowska et al. (2015) the use of enrichments with magnesium and production of goat yoghurt which, as a result of fortification, does not take sour and goat taste together with extension of storage time and has a nice smell, is a good prospect for promotion of goat's milk functional beverages. The most favorable solution for the industrial technology is production of yoghurt enriched with a dose of at least 10 mg of magnesium for 100 g of milk. It is highly probable that this kind of yoghurt will be most eagerly purchased by consumers. The most intensive sour smell was found in control yoghurts on 7th, 14th and 21st day of cold storage (Tab 10). In yoghurts fortified with magnesium there was found less intense sour smell, however the results of assessment do not showed significant differences between the dose of enrichment and intensity of sour smell. Also there was not observed a significant effect of storage time on the intensity of sour smell of yoghurt.

**Table 9** The influence of dose of enrichment with magnesium on perceptibility of goat taste of goat's milk yoghurts during storage (1-9 points)

Characteristic – fixed date of determination	Dose of enrichment with magnesium (mg of magnesium for 100 g of milk)				
	0	5	10	15	20
"Goat" taste – 1 day	1.200±1.200 <sup>aA</sup>	1.200±0.447 <sup>aA</sup>	1.200±0.447 <sup>aA</sup>	1.200±0.447 <sup>aA</sup>	1.800±0.836 <sup>aA</sup>
"Goat" taste – 7 days	1.500±0.836 <sup>aAB</sup>	1.500±0.836 <sup>aAB</sup>	1.333±0.516 <sup>aAB</sup>	1.400±0.547 <sup>aAB</sup>	1.800±0.836 <sup>aA</sup>
"Goat" taste – 14 days	1.750±0.500 <sup>aAB</sup>	1.750±0.447 <sup>aAB</sup>	1.500±0.516 <sup>aAB</sup>	1.500±0.500 <sup>aAB</sup>	1.400±0.447 <sup>aAB</sup>
"Goat" taste – 21 days	2.333±0.266 <sup>aB</sup>	2.333±0.805 <sup>aB</sup>	2.167±0.858 <sup>aB</sup>	2.000±0.449 <sup>aB</sup>	1.200±0.447 <sup>aB</sup>

**Legend:** <sup>a-c</sup> – statistically significant differences (p < 0.05) analysed in row  
<sup>A-C</sup> – statistically significant differences (p < 0.05) analysed in column

**Table 10** The influence of dose of enrichment with magnesium on perceptibility of sour smell of goat's milk yoghurts during storage (1-9 points)

Characteristic – fixed date of determination	Dose of enrichment with magnesium (mg of magnesium for 100 g of milk)				
	0	5	10	15	20
Sour smell – 1 day	3.222±1.922 <sup>aA</sup>	3.444±1.506 <sup>aA</sup>	3.000±1.500 <sup>aA</sup>	2.444±1.590 <sup>aA</sup>	2.444±1.333 <sup>aA</sup>
Sour smell – 7 days	4.000±1.550 <sup>aA</sup>	3.449±1.616 <sup>abA</sup>	2.189±1.364 <sup>bA</sup>	2.667±1.871 <sup>abA</sup>	2.333±1.936 <sup>abA</sup>
Sour smell – 14 days	4.050±1.435 <sup>aA</sup>	3.125±1.808 <sup>aA</sup>	2.125±0.835 <sup>aA</sup>	2.500±1.604 <sup>aA</sup>	2.750±1.832 <sup>aA</sup>
Sour smell – 21 days	4.000±1.500 <sup>aA</sup>	3.444±1.068 <sup>aA</sup>	3.111±1.261 <sup>aA</sup>	3.444±1.509 <sup>aA</sup>	3.444±1.667 <sup>aA</sup>

**Legend:** <sup>a-c</sup> – statistically significant differences (p < 0.05) analysed in row  
<sup>A-C</sup> – statistically significant differences (p < 0.05) analysed in column

Goat's milk yoghurts are particularly exposed to occurrence of defects in texture - the most important characteristics of quality of milk fermented beverages (Lankes et al., 1998; Szczepanik and Libudzisz, 2000; Wszolek, 1997). Defects in texture, besides defects in taste and smell, are the cause of lower consumer acceptance of this group of dairy products. The acid curd from goat's milk is characterized by lower conciseness and viscosity than the curd from cow's milk (Szczepanik and Libudzisz, 2000; Wszolek, 1997). The conducted tests proved that the highest hardness of curd was observed in yoghurts enriched in 15 mg and 20 mg of magnesium during whole period of storage (Tab 11). The lowest hardness was observed in non-fortified yogurts (0 mg of magnesium) for the whole period of the experiment. Enrichment with magnesium increases the

hardness of yoghurts. There were found significant differences in hardness of curd in yoghurts enriched with 0 mg, 5 mg of magnesium and hardness of yoghurts fortified in 15 mg and 20 mg of magnesium (p≤0.05). According to Mituniewicz – Malek et al. (2013) hardness of drink produced with the use of *Lb. acidophilus* 3 inoculant on 21st day of cold storage was 0.466 N. The effect of the applied dose of magnesium on the cohesiveness of yoghurt from goat's milk is shown in table 12. Enrichment with magnesium does not significantly affect on the cohesiveness of yoghurt and the obtained values were in the range from 0.537 to 0.723. There was not observed a significant difference in adhesiveness of yoghurts during whole period of storage.

**Table 11** The influence of dose of enrichment with magnesium on hardness of curds in goat's milk yoghurts during storage (N)

Characteristic – fixed date of determination	Dose of enrichment with magnesium (mg of magnesium for 100 g of milk)				
	0	5	10	15	20
Hardness – 1 day	0.890±0.112 <sup>aA</sup>	0.766±0.065 <sup>aA</sup>	0.895±0.073 <sup>bA</sup>	1.222±0.361 <sup>cA</sup>	1.138±0.345 <sup>cA</sup>
Hardness – 7 days	0.860±0.042 <sup>aA</sup>	0.750±0.110 <sup>aA</sup>	0.873±0.094 <sup>aA</sup>	1.190±0.362 <sup>bA</sup>	1.308±0.287 <sup>cA</sup>
Hardness – 14 days	0.673±0.085 <sup>aA</sup>	0.760±0.090 <sup>aA</sup>	0.895±0.110 <sup>aA</sup>	1.180±0.420 <sup>bA</sup>	1.281±0.227 <sup>cA</sup>
Hardness – 21 days	0.691±0.091 <sup>aA</sup>	0.810±0.060 <sup>aA</sup>	0.880±0.112 <sup>bA</sup>	1.152±0.308 <sup>bA</sup>	1.506±0.103 <sup>cB</sup>

**Legend** <sup>a-c</sup> – statistically significant differences (p < 0.05) analysed in row  
<sup>A-C</sup> – statistically significant differences (p < 0.05) analysed in column

**Table 12** The influence of dose of enrichment with magnesium on cohesiveness of curds in goat's milk yoghurts during storage (mm)

Characteristic – fixed date of determination	Dose of enrichment with magnesium (mg of magnesium for 100 g of milk)				
	0	5	10	15	20
Cohesiveness – 1 day	0.605±0.089 <sup>abA</sup>	0.602±0.178 <sup>abA</sup>	0.643±0.040 <sup>abA</sup>	0.545±0.140 <sup>abA</sup>	0.625±0.098 <sup>abA</sup>
Cohesiveness – 7 days	0.640±0.065 <sup>abA</sup>	0.598±0.183 <sup>abA</sup>	0.655±0.028 <sup>abA</sup>	0.494±0.248 <sup>abA</sup>	0.587±0.100 <sup>abA</sup>
Cohesiveness – 14 days	0.642±0.107 <sup>abA</sup>	0.566±0.177 <sup>abA</sup>	0.723±0.058 <sup>abA</sup>	0.537±0.319 <sup>abA</sup>	0.625±0.163 <sup>abA</sup>
Cohesiveness – 21 days	0.672±0.166 <sup>abA</sup>	0.595±0.175 <sup>abA</sup>	0.713±0.045 <sup>abA</sup>	0.645±0.218 <sup>abA</sup>	0.645±0.194 <sup>abA</sup>

**Legend:** <sup>ab</sup> – statistically significant differences (p < 0.05) analysed in row  
<sup>A-C</sup> – statistically significant differences (p < 0.05) analysed in column

**Table 13** The influence of dose of enrichment with magnesium on adhesiveness of curds in goat's milk yoghurts during storage (N)

Characteristic – fixed date of determination	Dose of enrichment with magnesium (mg of magnesium for 100 g of milk)				
	0	5	10	15	20
Adhesiveness – 1 day	0.072±0.010 <sup>abA</sup>	0.133±0.041 <sup>abA</sup>	0.096±0.005 <sup>abA</sup>	0.599±0.450 <sup>abA</sup>	0.318±0.551 <sup>abA</sup>
Adhesiveness – 7 days	0.097±0.006 <sup>abB</sup>	0.023±0.005 <sup>abA</sup>	0.123±0.073 <sup>abA</sup>	0.034±0.038 <sup>abA</sup>	0.028±0.005 <sup>abA</sup>
Adhesiveness – 14 days	0.050±0.010 <sup>abA</sup>	0.020±0.000 <sup>abA</sup>	0.020±0.050 <sup>abA</sup>	0.062±0.077 <sup>abA</sup>	0.032±0.004 <sup>abA</sup>
Adhesiveness – 21 days	0.106±0.086 <sup>abA</sup>	0.036±0.036 <sup>abA</sup>	0.178±0.044 <sup>abA</sup>	0.083±0.090 <sup>abA</sup>	0.078±0.082 <sup>abA</sup>

**Legend:** <sup>ab</sup> – statistically significant differences (p < 0.05) analysed in row  
<sup>A-C</sup> – statistically significant differences (p < 0.05) analysed in column

## CONCLUSION

Goat's milk can be enriched with magnesium in the form of D-gluconate before pasteurization (75°C) with maximum dose 20 mg of magnesium for 100 g of milk. Higher doses of magnesium decreases pH and can lead to coagulation of proteins. Enrichment of goat's milk yoghurts with magnesium lowered the intensity of "goat" taste during cold storage. Moreover, enrichment with magnesium does not significantly affect on the cohesiveness and adhesiveness of yoghurts. Fortification with magnesium increases the hardness of yoghurts and this trend was continued throughout the whole period of cold storage.

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