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INFLUENCE OF SELECTED FACTORS ON THE VISCOSITY OF SET STYLE YOGURT AND ACID CASEIN GEL AT CONSTANT SPEED OF SPINDLE ROTATION*

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Abstract: The influence of milk dry matter (DM) content (8.20%, 9.27% and 10.28%) and applied heat treatments (untreated milk and milk heat-treated at 90°C/10') on the viscosity of set-style yogurt and acid casein gel gained by acidification with GDL (glucono-δ-lactone) has been investigated. Viscosity was measured during the time of 3 minutes at constant speed of spindle rotation of 20 rpm.

The results have shown that yogurt samples produced from untreated milk had higher viscosity values than samples produced from heat-treated milk.

An increase of dry matter content influenced the increase of viscosity of yogurt samples produced from both untreated milk and heat-treated milk. Samples with 10.28% DM had the highest viscosity values.

An increase of DM content in samples of acid casein gel produced by acidification with GDL had an opposite influence. The samples with smallest DM content had the highest viscosity values.

There is no linear relationship between the period of storage of set-style yogurt produced from heat-treated milk and viscosity value.

Key words: milk, heat treatment, set-style yogurt, viscosity.

Introduction

The majority of fermented products are produced by milk fermentation with lactic acid bacteria that convert lactose into lactic acid. The alternative ways of

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milk acidification include the addition of agents for acidification such as lemon acid, hydrochloric acid, anhydride of propionic acid and lactates. However, direct acidification with acids does not lead to gel formation but to the formation of precipitates. Slow- hydrolyzing agents such as glucono-δ-lactone (GDL) give a satisfying creamy and gelatinous structure of yogurt during a relatively short time (Amice-Quemeneur et al., 1995).

Two of the most important factors from microbiological viewpoint that determine the quality of final products are the type and character of starter culture used during yogurt production. The primary criteria for selection of suitable starter culture include the rate of acidification, aroma, flavor, stability and texture of final product (Bouzar et al., 1997). The special influence on the microstructure and viscosity of final products have exopolysaccharide producing bacteria (Eps^+), since they have a role of stabilizing agent (Hassan et al., 1996, Hess et al., 1997, Kalab et al., 1983, Tamime et al., 1984).

Since yogurt shows thixotropic behavior, it is assumed that the hysteresis loop formed between upward and downward viscosity curves represents the measure of structure destruction during applied shear stress. According to the investigations of Hassan et al. (1996), yogurt samples produced with Eps^+ strains have a considerably higher structure destruction during upward shearing, and the casein network of those samples have a higher number of polymer links than samples produced with Eps^- strains.

One of the factors influencing the formation and microstructure of acid casein gels is the temperature of acidification (Amice-Quemeneur et al., 1995, Guinee et al., 1993, Lucey et al., 1997). The time of gelatification is increased when the temperature of acidification is decreased, and the change from liquid to gel state can be followed by the change of tanδ. According to Kim and Kinsella (1989), gel formation starts earlier with an increase of acidification temperature, and gel shows more elastic than viscous properties. The value of tanδ is between 0.20 and 0.25 in the temperature range of 20-40ºC, showing lower values for gels formed at 20ºC and higher values for gels formed at 40ºC (Lucey et al., 1997a).

Lucey et al. (1997) gave an explanation for the decrease of the modulas of elasticity when the temperature of acidification is increased. An increase of temperature leads to the formation of a higher number of bonds as well as to the increase of hydrophobic bonds primarily inside of the casein micelles. As a result, casein micelles shrink (contract) and voluminosity of casein micelles is decreased, which leads to the decrease of contact region and lesser interaction among micelles. Since the conformation of protein molecules depends on the balance of inter- and intramolecular forces, it is logical that casein micelles have higher voluminosity at lower temperatures and that they are more susceptible to deformations than at higher temperatures due to a lesser number of hydrophobic interactions which usually allow micelles to form a higher number of protein-protein interactions (Lucey et al., 1997a, Lucey et al., 1997).

According to Amice-Quemeneur et al. (1995), the acidification temperature influences gel firmness. Those authors explain it by dimensions of casein aggregates. The dimensions of casein aggregates in acid casein gel formed by GDL are bigger when gel is formed at 20ºC than above 30ºC. When acidification is performed at temperatures below 30ºC, big casein aggregates are formed by the addition of casein particles to already formed small casein aggregates (floc-particle mechanism), whereas at higher temperatures big casein aggregates re formed by the connection of small casein aggregates (floc-floc mechanism) (Amice-Quemeneur et al., 1995).

Material and Methods

For these investigations, set-style yogurt produced from reconstituted skim milk powder has been used. Skim milk powder has been reconstituted up to the following dry matter (DM) contents:

1) Milk with 8.20% DM
2) Milk with 9.27% DM
3) Milk with 10.28% DM

For the investigation on the influence of heat treatment on the viscosity of set-style yogurt and acid casein gel, reconstituted skim milk has been heat treated at 90ºC/10'. Untreated milk has been used as a control sample.

Milk fermentation has been performed at 43ºC, using yogurt culture "Texel" France. Acid casein gel is produced by acidification with glucono-δ-lactone (GDL).

Viscometer *ViscoBasic Plus – FUNGILAB* has been used to measure the viscosity of set-style yogurt and acid casein gel during predetermined storage period. Spindle No 3 has been used. All investigations have been performed at 18±1ºC. Measurements of the viscosity of set-style yogurt have been performed after 1, 5 and 10 days of storage at 4ºC, while the viscosity of acid casein gel has been measured after the first day of storage.

The change of viscosity of set-style yogurt and acid casein gel at 20 rpm over time has been investigated by the method as described by Labropoulos et al., 1984. According to this method, viscosity values have been recorded during an estimated time period following the moment of first value shown at display, which is taken as time zero. Viscosity values were recorded after every 30 sec, during 3 min.

Results and Discussion

The influence of dry matter content, applied heat treatments and way of coagulation, as well as a storage period at low temperatures during 10 days, on

the change of viscosity of acid casein gel at constant shearing rate was investigated.

Chemical composition of milk and set-style yogurt

Chemical composition of milk and set-style yogurt is shown in Table 1.

T a b. 1. - Chemical composition of reconstituted skim milk and set-style yogurt

Milk sample	Heat treatment	DM (%)	Fat (%)	NFDM (%)	Nitrogen (%)	Proteins (%)
Milk with 8.20% DM	Untreated	8.20	0.10	8.10	0.4539	2.90
	90ºC/10'	8.29	0.10	8.19	0.4575	2.92
Yogurt	Untreated	8.07	0.10	7.97	0.4455	2.84
	90ºC/10'	8.35	0.10	8.25	0.4515	2.88
Milk with 9.27% DM	Untreated	9.27	0.15	9.12	0.5208	3.33
	90ºC/10'	9.38	0.15	9.23	0.5381	3.44
Yogurt	Untreated	8.81	0.15	8.67	0.5159	3.29
	90ºC/10'	8.92	0.15	8.77	0.4859	3.10
Milk with 10.28% DM	Untreated	10.28	0.20	10.08	0.5791	3.70
	90ºC/10'	10.87	0.25	10.62	0.6085	3.88
Yogurt	Untreated	10.21	0.20	10.01	0.5568	3.55
	90ºC/10'	10.24	0.20	10.04	0.5960	3.80

Legend: DM – dry matter content
NFDM – non-fat dry matter

As it can be seen from table 1., yogurt had a lower dry matter content than the milk it was produced from. Only yogurt samples produced from heat-treated milk with 8.20% DM didn't follow this pattern. These data agree with those of Djordjević et al. 1988a, 1988b and Denin-Djurdjević 2001. In addition, protein content of yogurt samples is lower than in milk, which indicates that lactic acid bacteria not only ferment lactose present in milk, but also do the casein proteolysis (Laws, 2001, Shah and Shihata, 1998). These findings agree with those of Denin-Djurdjević, 2001, Denin-Djurdjević et al., 2002 and Shah and Shihata, 1998.

The influence of dry matter content, way of acidification, applied heat treatments and storage period on the viscosity of acid casein gel at constant rate of spindle rotation

The data on viscosity change over time, depending of coagulation way, applied heat treatment and storage period for samples produced from milk with 8.20% DM are shown in Table 2.

T a b. 2.- The influence of investigated parameters on the viscosity change of acid casein gel and set-style yogurt produced from milk with 8.20% DM at spindle rotation of 20 rpm

Way of acidification	Applied heat treatment	Storage period	Calculated parameters	Time (min)					
				0.5	1.0	1.5	2.0	2.5	3.0
				Viscosity (mPas)					
GDL	Untreated	1 day	x_{sr}	4494.80	3715.70	3029.43	2844.47	2085.07	1923.73
			Sd	417.37	451.36	549.55	401.16	160.72	374.46
			Cv	9.29	12.15	18.14	14.10	7.71	19.47
	90ºC/10'	1 day	x_{sr}	2360.07	1913.90	1842.80	1561.50	1452.80	1490.30
			Sd	357.59	325.37	315.70	151.98	194.43	468.64
			Cv	15.15	17.00	17.13	9.73	13.38	31.45
Fermentation by yogurt culture	Untreated	1 day	x_{sr}	4021.20	3726.73	3050.77	2504.00	2106.93	1793.87
			Sd	585.25	586.92	264.20	889.11	993.12	487.18
			Cv	14.55	15.75	8.66	35.51	47.14	27.16
	90ºC/10'	1 day	x_{sr}	2778.54	2114.64	1863.88	1568.60	1491.18	1395.52
			Sd	228.37	371.05	261.41	233.32	263.86	240.69
			Cv	8.22	17.55	14.03	14.87	17.69	17.25
	90ºC/10'	5 days	x_{sr}	3790.37	3075.60	2392.93	2197.13	2048.33	1739.77
			Sd	110.89	459.74	168.75	243.46	168.16	268.12
			Cv	2.93	14.95	7.05	11.08	8.21	15.41
	90ºC/10'	10 days	x_{sr}	3387.60	2668.20	2388.70	2101.53	2354.93	1930.87
			Sd	739.14	1027.79	609.49	868.21	1188.99	763.71
			Cv	21.82	38.52	25.52	41.31	50.49	39.55

As it can be seen from Table 2. samples of acid casein gel produced by GDL from heat untreated milk with 8.20% DM had higher viscosity values at the beginning than samples of set-style yogurt. The viscosity values after 0.5 min were 4494.80 mPas and 4021.20 mPas, respectively, for samples of acid casein gel and set-style yogurt. The viscosity decrease during time of shearing was more pronounced for samples of acid casein gel produced by GDL, namely, the decrease was 2571.07 mPas, so the viscosity value after 3.0 min was 1923.73 mPas. The viscosity decrease during time of shearing for set-style yogurt samples was 2227.33 mPas, and final viscosity value was 1793.87 mPas after 3.0 min. However, although there were noticeable differences in the viscosity values at the beginning and end of measurement, these samples had similar viscosity values after 1.0, 1.5 and 2.5 min, as can be seen from Table 2. and Figure 1.

The viscosity value of acid casein gel samples produced by GDL from heat-treated milk was 2360.07 mPas after 0.5 min and was lower than for set-style yogurt (2778.54 mPas). Since the viscosity decrease during time of shearing was less pronounced for samples of acid casein gel produced by GDL (869.77 mPas) than the one of set-style yogurt samples (1383.02 mPas), after 3.0 min of shearing the samples of acid casein gel produced by GDL had higher viscosity value (1490.30 mPas) than set-style yogurt samples (1395.52 mPas). However, since the difference of the viscosity values was small, it can be concluded that the way of acidification didn't have noticeable influence on the viscosity values of

samples produced from heat-treated milk, measured at constant rate of spindle rotation.

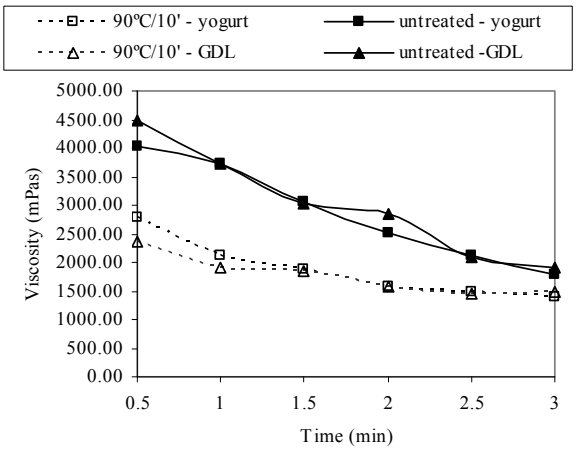

Fig. 1. - The influence of way of acidification and applied heat treatment on the viscosity change of the acid casein gel produced from milk with 8.20% DM, at spindle rotation of 20 rpm

The influence of storage period on the viscosity change of set-style yogurt produced from milk with 8.20% DM is shown in Figure 2. and in Figure 3. as Index of viscosity change.

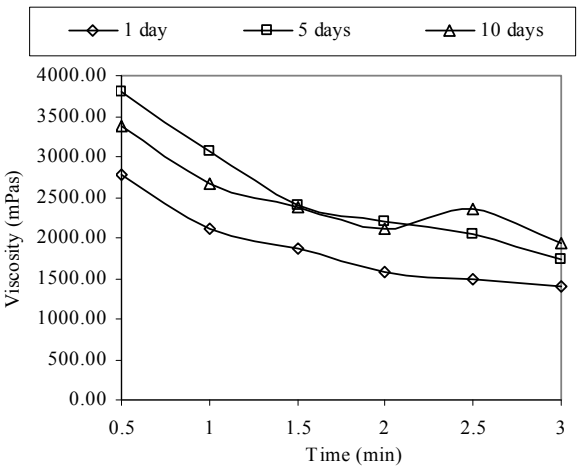

Fig. 2. - The influence of storage period on the viscosity change of set-style yogurt produced from milk with 8.20% DM heat-treated 90ºC/10', at spindle rotation of 20 rpm

As it can be seen from Table 2. and Figure 2., yogurt samples after one day of storage had the smallest viscosity values. Yogurt samples stored for 5 days had the highest viscosity values after 0.5 min of shearing, while yogurt samples stored for 10 days had the highest viscosity values after 3.0 min of shearing. As shown in Figure 3. , yogurt samples stored for 5 and 10 days had similar viscosity values after 1.5 and 2.0 min of shearing, whereas after 2.5 and 3.0 min the influence of storage period on the viscosity is the most obvious. These results indicate the rearrangement and hardening of protein matrix as well as the formation of bigger number of bonds that are resistant to flow.

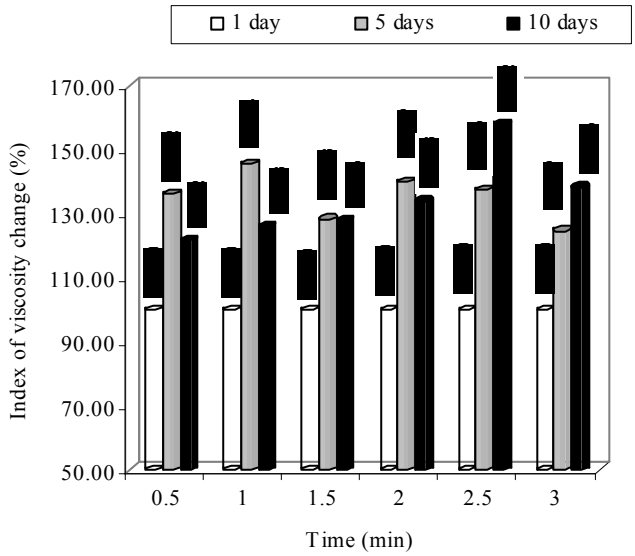

Fig. 3. - The influence of storage period on the viscosity change of set-style yogurt produced from milk with 8.20% DM heat-treated 90ºC/10', shown as Index of viscosity change (%)
Values after 1 day of storage are taken as index value 100%

The data on viscosity change over time, depending of coagulation way, applied heat treatment and storage period of acid casein gel and set-style yogurt for samples produced from milk with 9.27% DM are shown in Table 3.

The samples of acid casein gel produced by GDL from heat-untreated milk with 9.27% had lower viscosity values during the investigated time of shearing than the samples of set-style yogurt, as shown in Table 3. and Figure 4. The viscosity values after 0.5 min were 2288.90 mPas and 4399.47 mPas, respectively, for samples of acid casein gel produced by GDL and set-style yogurt. The viscosity decrease during shearing was less pronounced for acid

casein gel (1020.50 mPas) than for set-style yogurt (2378.77 mPas). The viscosity values after 3.0 min were 1268.40 mPas and 2020.70 mPas, respectively, for samples of acid casein gel produced by GDL and set-style yogurt.

T a b. 3. - The influence of investigated parameters on the viscosity change of acid casein gel and set-style yogurt produced from milk with 9.27% DM at spindle rotation of 20 rpm

Way of acidification	Applied heat treatment	Storage period	Calculated parameters	Time (min)					
				0.5	1.0	1.5	2.0	2.5	3.0
				Viscosity (mPas)					
GDL	Untreated	1 day	x_{sr}	2288.90	1976.07	1519.30	1574.47	1402.50	1268.40
			Sd	684.53	582.21	299.93	295.76	533.60	439.60
			Cv	29.91	29.46	19.74	18.78	38.05	34.66
	90ºC/10’	1 day	x_{sr}	1579.33	1373.37	1060.57	875.43	901.93	830.00
			Sd	333.36	341.92	112.40	125.53	161.94	243.37
			Cv	21.11	24.90	10.60	14.34	17.95	29.32
Fermentation by yogurt culture	Untreated	1 day	x_{sr}	4399.47	3862.87	3360.37	2516.63	2375.23	2020.70
			Sd	975.64	855.58	709.18	506.62	1147.85	644.94
			Cv	22.18	22.15	21.10	20.13	48.33	31.92
	90ºC/10’	1 day	x_{sr}	3574.43	2859.57	2514.53	1862.90	2123.57	1947.67
			Sd	584.22	736.96	582.15	325.02	256.60	233.76
			Cv	16.34	25.77	23.15	17.45	12.08	12.00
	90ºC/10’	5 days	x_{sr}	3373.27	2670.77	3258.10	2307.40	1993.40	1728.80
			Sd	354.79	222.68	857.73	509.13	245.93	707.93
			Cv	10.52	8.34	26.33	22.07	12.34	40.95
	90ºC/10’	10 days	x_{sr}	4830.90	3479.77	2737.10	2618.20	2434.37	2635.60
			Sd	330.00	646.97	769.75	833.91	775.41	51.72
			Cv	6.83	18.59	28.12	31.85	31.85	1.96

The influence of the way of acidification was more pronounced for samples produced from heat-treated milk, so after 0.5 min of shearing, the samples of acid casein gel had the viscosity of 1579.33 mPas, and samples of set-style yogurt had the viscosity of 3574.43 mPas.

The viscosity decrease during time of shearing was 749.33 mPas for samples of acid casein gel produced by GDL, giving the final viscosity of 830.00 mPas after 3.0 min of shearing. The viscosity decrease of set-style yogurt samples produced from heat-treated milk with 9.27% DM was 1626.76 mPas and viscosity after 3.0 min was 1947.67 mPas. However, these samples showed a deviation from a thixotropic behavior, since the smallest viscosity value of 1862.90 mPas was recorded after 2.0 min of shearing.

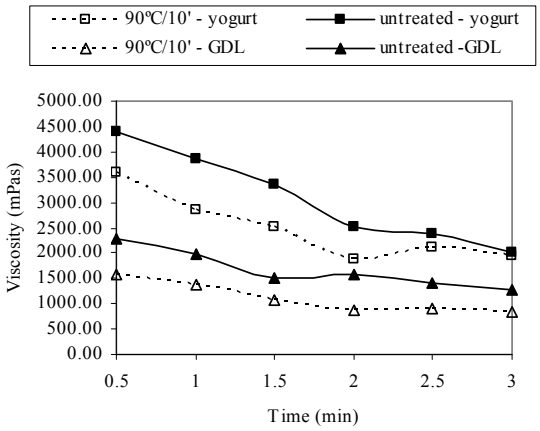

Fig. 4. - The influence of way of acidification and applied heat treatment on the viscosity change of the acid casein gel produced from milk with 9.27% DM, at spindle rotation of 20 rpm

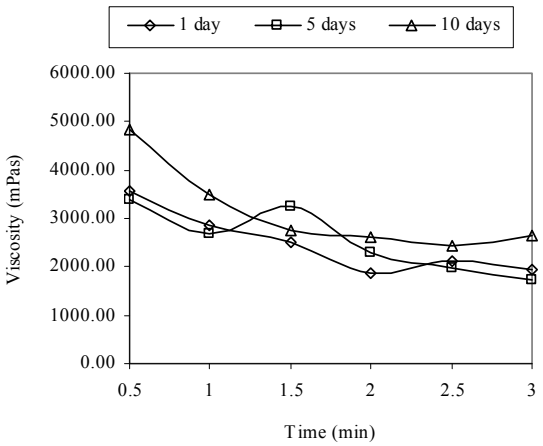

Fig. 5. - The influence of storage period on the viscosity change of set-style yogurt produced from milk with 9.27% DM heat-treated 90ºC/10', at spindle rotation of 20 rpm

The influence of storage period on the viscosity change of set-style yogurt produced from heat-treated milk with 9.27% DM is shown in Figure 5. and Figure 6.

As it can be seen from presented data, samples stored for 10 days had the highest viscosity values after 0.5, 1.0, 2.0, 2.5 and 3.0 min. The viscosity values after 0.5 min were 3574.43 mPas, 3373.27 mPas and 4830.90 mPas, respectively, for samples stored 1, 5 and 10 days. From data shown in Table 4. and Figure 6. it

can be seen that viscosity value of samples stored for 10 days were by 35.15% and 35.32%, respectively, higher after 0.5 and 3.0 min, than those of samples stored for 1 day.

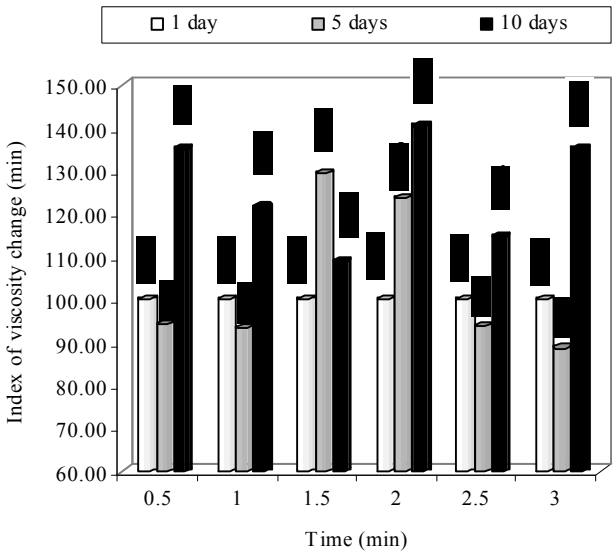

Fig. 6. - The influence of storage period on the viscosity change of set-style yogurt produced from milk with 9.27% DM heat-treated 90ºC/10', shown as Index of viscosity change (%)
Values after 1 day of storage are taken as index value 100%

As it can be seen from Figure 5. set-style yogurt samples stored for 5 days had a significant deviation from thixotropic behavior after 1.5 min of shearing.

The viscosity decrease during shearing was 1626.76 mPas, 1644.47 mPas and 2195.30 mPas, respectively, for samples stored for 1, 5 and 10 days, indicating that higher starting viscosity values lead to more pronounced viscosity decrease during the time of shearing.

The data on viscosity change over time, depending of coagulation way, applied heat treatment and storage period of acid casein gel and set-style yogurt for samples produced from milk with 10.28% DM are shown in Table 4. and Figures 7., 8. and 9.

T a b. 4. - The influence of investigated parameters on the viscosity change of acid casein gel and set-style yogurt produced from milk with 10.28% DM at spindle rotation of 20 rpm

Way of acidification	Applied heat treatment	Storage period	Calculated parameters	Time (min) 0.5	1.0	1.5	2.0	2.5	3.0
				Viscosity (mPas)					
GDL	Untreated	1 day	x_{sr}	2639.10	2408.83	1791.93	1540.07	1223.07	1057.93
			Sd	695.07	633.84	571.67	635.02	275.60	327.51
			Cv	26.34	26.31	31.90	41.23	22.53	30.96
	90ºC/10'	1 day	x_{sr}	1785.90	1489.90	1057.23	879.17	758.37	708.70
			Sd	370.02	193.25	153.19	166.15	289.26	207.50
			Cv	20.72	12.97	14.49	18.90	38.14	29.28
Fermentation by yogurt culture	Untreated	1 day	x_{sr}	5192.93	5292.97	4425.00	3913.50	3537.80	3041.70
			Sd	206.26	73.29	744.41	1046.80	985.05	558.91
			Cv	3.97	1.38	16.82	26.75	27.84	18.37
	90ºC/10'	1 day	x_{sr}	4150.60	3306.90	3268.97	2971.60	2605.13	2416.57
			Sd	167.86	69.41	194.31	254.24	157.20	122.83
			Cv	4.04	2.10	5.94	8.56	6.03	5.08
	90ºC/10'	5 days	x_{sr}	4383.03	3162.40	2874.10	2638.87	2474.13	2305.50
			Sd	615.64	351.54	179.19	267.05	381.30	276.96
			Cv	14.05	11.12	6.23	10.12	15.41	12.01
	90ºC/10'	10 days	x_{sr}	3732.00	3854.77	3479.53	3131.40	2745.17	2564.93
			Sd	299.93	396.39	178.42	343.96	459.91	571.14
			Cv	8.04	10.28	5.13	10.98	16.75	22.27

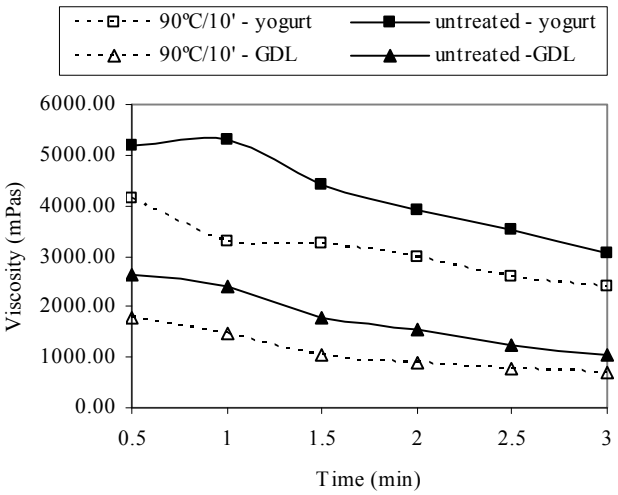

Fig. 7. - The influence of way of acidification and applied heat treatment on the viscosity change of the acid casein gel produced from milk with 10.28% DM, at spindle rotation of 20 rpm

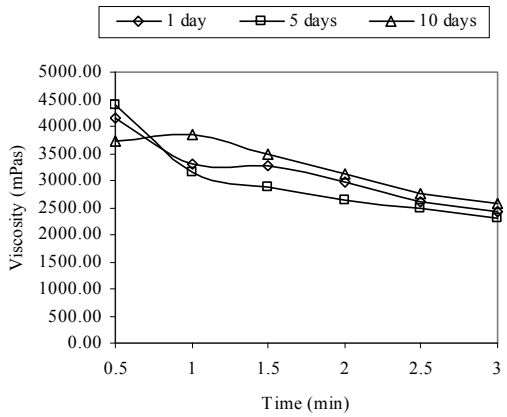

Fig. 8. - The influence of storage period on the viscosity change of set-style yogurt produced from milk with 10.28% DM heat-treated 90ºC/10', at spindle rotation of 20 rpm

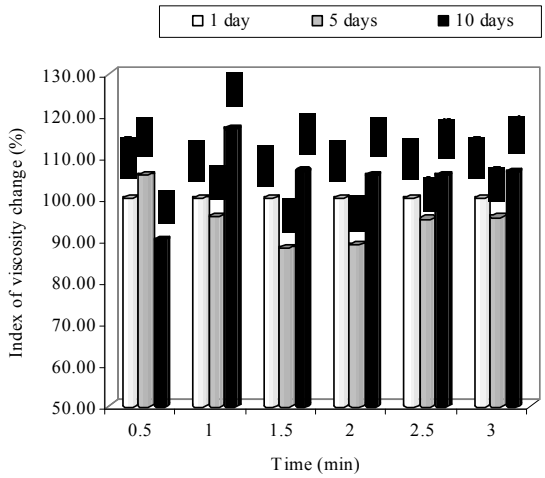

Fig. 9. - The influence of storage period on the viscosity change of set-style yogurt produced from milk with 10.28% DM heat-treated 90ºC/10', shown as Index of viscosity change (%)
Values after 1 day of storage are taken as index value 100%

It can be seen from Table 4. and Figure 7. that the way of acidification had even more pronounced influence on the viscosity value of samples produced from milk with 10.28% DM. The viscosity values after 0.5 min were 2639.10 mPas and 5192.93 mPas, respectively, for acid casein gel produced by acidification of heat-untreated milk with GDL and set-style yogurt. The decrease of viscosity during shearing was more pronounced for samples of set-style yogurt (2151.23 mPas) than for acid casein gel produced by GDL (1581.17 mPas), gaining the final viscosity values of 1057.93 mPas and 3041.70 mPas, respectively, for samples produced by acid casein gel and yogurt culture.

The difference in viscosity value was more pronounced for samples produced from heat-treated milk samples, indicating that the way of acidification has a great influence on the viscosity values. The viscosity values after 0.5 min were 1785.90 mPas and 4150.60 mPas, respectively, for samples produced with GDL and yogurt culture. The decreases of viscosity values during investigated time of shearing were 1077.20 mPas and 1734.03 mPas, and viscosity values after 3.0 min were 708.70 mPas and 2416.57 mPas, respectively, for samples produced with GDL and yogurt culture.

The influence of storage period on the change of viscosity value of set-style yogurt produced from heat-treated milk with 10.28% DM is shown at Figure 8. and Figure 9.

The results presented in Table 4., Figure 8. and Figure 9. show that storage period had insignificant influence on the change of viscosity values for samples produced from heat-treated milk with 10.28% DM. After 0.5 min, samples stored for 10 days had the smallest viscosity value (3732.00 mPas), while samples stored for 5 days had the highest (4383.03 mPas). However, the decrease of viscosity value was the smallest (1167.06 mPas) for samples stored for 10 days, giving the highest final viscosity of 2564.93 mPas after 3.0 min. Samples stored for 5 days had the most pronounced decrease of viscosity (2077.53 mPas), giving the smallest viscosity value after 3.0 min 2305.50 mPas. Additionally, as it can be seen from Figure 8. and Figure 9. samples stored for 10 days do not follow a thixotropic pattern after 1.0 min of shearing, so the viscosity value of these samples was by 16.57% higher than for samples after 1 day of storage.

Figures 10., 11., 12. and 13. have been formed on the basis of Tables 2., 3. and 4. These figures show the influence of dry matter content on the viscosity values at contant rate of spindle rotation.

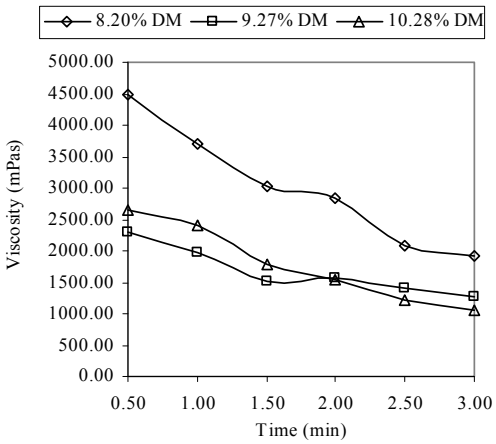

Fig. 10. - The influence of dry matter content on the viscosity change during time for samples of acid casein gel produced from heat-untreated milk by GDL

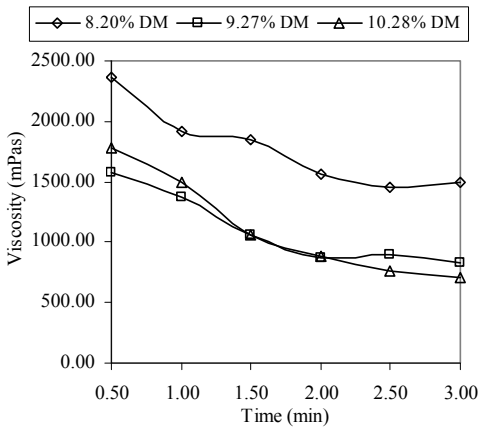

Fig. 11. - The influence of dry matter content on the viscosity change during time for samples of acid casein gel produced from heat-treated milk by GDL

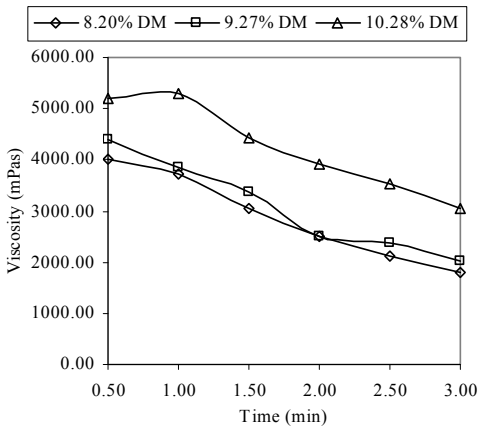

Fig. 12. - The influence of dry matter content on the viscosity change during time for samples of set-style yogurt produced from heat-untreated milk

The influence of dry matter content on the change of viscosity value of acid casein gel samples produced from heat-untreated milk by acidification with GDL is shown in Figure 10. As Figure 10. shows, samples produced from milk with 8.20% DM had the highest viscosity values during the investigated period of shearing. Samples produced from milk with 9.27% SM and 10.28% DM had similar viscosity values, showing considerably lower values after 0.5 min than samples produced from milk with 8.20% DM.

The influence of dry matter content on the change of viscosity value of acid casein gel samples produced from heat-treated milk by acidification with GDL is shown at Figure 11. As it can be seen from the given figure, once again the

highest viscosity values were recorded for samples with 8.20% DM. These data indicate the different pattern of acid casein gel formation with an increase of dry matter content.

The influence of dry matter content on the viscosity of set-style yogurt samples produced from heat-untreated milk is shown in Figure 12. Opposite to the samples of acid casein gel formed with GDL, the viscosity values of set-style yogurt increased with an increase of dry matter content. The samples produced from milk with 10.28% DM had the highest viscosity values, while the samples produced from milk with 8.20% DM had the smallest viscosity values.

The influence of dry matter content on the viscosity change of set-style yogurt samples produced from heat-treated milk is shown in Figure 13. As it can be seen from Figure 13. the viscosity of yogurt samples produced from heat-treated milk has increased with an increase of dry matter content.

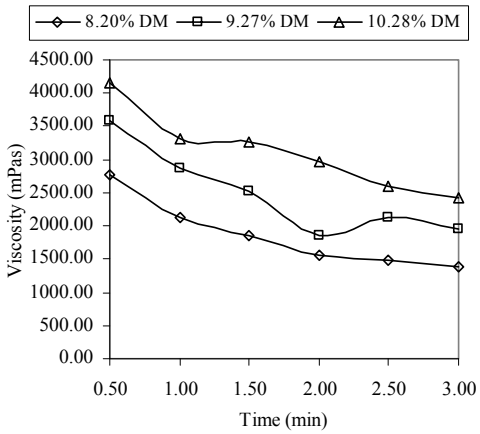

Fig. 13. - The influence of dry matter content on the viscosity change during time for samples of set-style yogurt produced from heat-treated milk

Conclusion

The following conclusions can be drawn on the basis of gained results:

During the viscosity measurement of acid casein gel at constant rate of spindle rotation, the viscosity values decreases over time, indicating a thixotropic behavior.

Samples of set-style yogurt produced from heat-untreated milk have higher viscosity values during the investigated time of shearing than samples produced from heat-treated milk.

Samples of acid casein gel produced from heat-untreated milk by GDL have higher viscosity values than samples produced from heat-treated milk. With an

increase of dry matter content of milk, namely, with an increase of casein content, the difference in viscosity value of samples produced from heat-treated and heat-untreated milk become less pronounced.

The influence of way of acidification on the viscosity value is negligible for samples with low DM content (8.20% DM), which had similar values of viscosity for both acid casein gel and set-style yogurt. With an increase of dry matter content (9.27% and 10.20% DM), samples produced by fermentation with yogurt culture had considerably higher viscosity values than samples produced by GDL.

An increase of dry matter content induced the increase of viscosity values in samples of set-style yogurt produced from both heat-treated and heat-untreated milk. The highest viscosity values are recorded for samples of set-style yogurt with 10.28% DM, and smallest for samples with 8.20% DM.

The influence of dry matter content increase was opposite for samples of acid casein gel produced by GDL, whereas the samples with the smallest DM content had the highest viscosity values, regardless of the applied heat treatment of milk.

The linear relationship between storage period and viscosity values was not established for samples produced from heat-treated milk. For samples with 8.20% DM the highest viscosity values were after 1 day of storage. For samples with 9.27% DM, the samples stored for 10 days had the highest, while samples stored for 5 days had the smallest viscosity values at the beginning and at the end of shearing. Samples with 10.28% DM stored for 10 days had at the beginning of measurement the smallest, but at the end the highest viscosity values. Samples stored for 5 days had the highest viscosity values at the beginning and the smallest at the end of shearing.

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UTICAJ ODABRANIH FAKTORA NA VISKOZITET ČVRSTOG JOGURTA I KISELOG KAZEINSKOG GELA PRI KONSTANTNOJ BRZINI ROTACIJE VRETENA*

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R e z i m e

Istraživanja su obuhvatila uticaj suve materije mleka (8.20%, 9.27% i 10.28%) i primenjenih termičkih tretmana (termički netretirano mleko i termički tretirano mleko na 90°C/10 min.) na viskozitet čvrstog jogurta i kiselog kazeinskog gela dobijenog acidifikacijom pomoću glukono-δ-laktona (GDL-a). Viskozitet je određivan tokom vremena pri brzini rotacije vretena od 20 o/min u toku 3 minuta.

Rezultati su pokazali da su uzorci čvrstog jogurta proizvedeni od termički netretiranog mleka imali veće vrednosti viskoziteta od uzoraka proizvedenih od termički tretiranog mleka.

Povećanje sadržaja suve materije mleka utiče na povećanje viskoziteta uzoraka čvrstog jogurta proizvedenih od termički netretiranog mleka i termički tretiranog mleka. Najveće vrednosti viskoziteta imali su uzorci sa 10.28% suve materije.

Kod uzoraka kiselog kazeinskog gela proizvedenih acidifikacijom pomoću GDL-a uticaj povećanja suve materije mleka je suprotan. Uzorci sa najmanjim sadržajem suve materije imaju najveće vrednosti viskoziteta.

Nije utvrđena linearna zavisnost između dužine perioda skladištenja i vrednosti viskoziteta čvrstog jogurta proizvedenog od termički tretiranog mleka.

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