KINETICS OF YOGHURT COAGULUM SYNERESIS

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Abstract

Yoghurt coagulums were prepared from buffaloe's milk standardized to 3% fat and heated to 70, 80 and 90°C. The yoghurt samples were stored at 4 and 12°C for 2,4 and 6 days. Syneresis was measured throughout 60 min. with interval periods of 10 min. Data of whey drainage from yoghurt coagulums were evaluated using Arrhenius equation to determine the activation energy (Ea), velocity constant of process (k), temperature coefficient (Q10), decimal reduction time (Du) and lethal thermal coefficient (Z). Results revealed a great variations according to the heat treatments of yoghurt milk and the storage temperatures.

INTRODUCTION

Reactions that occur in milk are accelerated to different extents by increasing the temperature. Many chemical reactions are accelerated two to three folds by raising the temperature 10°C (Walstra and Jenness, 1984).

The effect of different factors such as acidity, cooking temperature, size of curd granules, agitation and time of treatment on the drainage of whey from cheese curd were studied by Kiermeier and Wullerstoff (1963). El-Shobery and Shalaby (1992) studied the effect of rennet, acid and acid/rennet coagulation of milk at different temperatures named 20, 30, 40 and 50°C on curd syneresis. depend on the size of curd granules, temperature and time. There was no syneresis below 18°C and at temperature above 45°C (Walstra and Jenness, 1984).

Gels formed from milk by renneting or acidification under quiescent conditions may subsequently show syneresis, i.e. expel liquid (Whey), because the gel (curd) contracts. Often, syneresis is undesirable, e.g. during storage of products like yoghurt, sour cream, cheese or quark (Walstra, 1993).

One of the problems in yoghurt during processing and storage is whey expelling. It is useful to know under what conditions syneresis can be largely prevented (Walstra, 1993).

In this study kinetics of syneresis for yoghurt produced under different heat treatments of yoghurt milk and different storage temperatures are not known, therefore this study concerns with this aspect.

MATERIALS AND METHODS

Materials :

Evening fresh buffaloe's milk obtained from Faculty of Agriculture's farm at Fayoum was used.

Lactic culture (CHR Hansen's, Denmark, Dri-VAC) consisted of Str. thermophilus and L.delbrueckii ssp. bulgaricus was used after being activated in fresh sterilized skim milk.

Methods :

The milk was standardized to 3% fat and divided into three equal portions. The first was heated to 70^{o}C, the second to 80^{o}C, while the third portion was heated to 90oC, all milks were heated for 5 min and cooled to 40oC. Each of the three portions was inoculated with 5% of starter culture, then incubated at 40^{o}C for 3 hrs till coagulation. Yoghurt samples were kept at 4^{o}C and 18^{o}C for 2, 4, and 6 days. The syneresis of yoghurt samples was carried out at zero, 2, 4 and 6 days of storage by placing the curd on a wire mesh without scattering. The drained whey were collected in a graduated cylinder through musline cheese-cloth during 60 min with 10 min intervals and used as a measure of syneresis (Kammerlehner and Kessler, 1980).

RESULTS AND DISCUSSION

Whey exuded from yoghurt coagulum stored at 4 and 12^{o}C and made from milk heated to 70, 80 and 90oC was collected at 10, 20, 30, 40, 50 and 60 minutes. Rate of syneresis was not constant but depended on yoghurt milk heating temperature and yoghurt storage temperature. The present results agree with the findings of Kirchmeier (1972) and EL Shobery and Shalaby (1992).

Data were analyzed graphically to determine the order of reaction by means of the method described by Morris (1970). In all treatments, a linear relationship was found through the points of measurement, only the plot on the ordinate was chosen to be according to the equation for first order process, where log N's were plotted against time (t).

The velocity constants (k') of syneresis process for the different yoghurt coagulums made from milk heated to 70, 80 and 90oC and stored at 4 and 12oC for 0,2,4 and 6 days, could be calculated from the slope lines (Table 1). The results show that the syneresis rate was heghly affected according to the yoghurt milk heat treatment, storage temperature, and storage period. This could be due to the increase interaction as the heating temperature increased and bacterial activity during yoghurt storage, while increases up to the 4th day of storage, and decreased after 6 days.

Table 1. Velocity constants of yoghurt coagulums stored at 4 and 12°C and made from milk heated to 70, 80 and 90°C.

Storage temp. (°C)	Storage period (day)	Heating temp. (°C) 70	80	90
			k' (sec^{-1})	
4	0	12.50	16.50	17.70
	2	15.60	13.90	6.30
	4	18.60	10.00	4.00
	6	3.33	3.27	10.00
12	0	12.50	16.50	17.70
	2	18.00	12.65	5.70
	4	23.10	14.10	8.00
	6	3.07	5.30	10.00

Results presented in Table 2 show clear differences in the activation energy of syneresis between yoghurt coagulums stored at jefferen temperatures for certain periods. The activation energy of yoghurt increased with the increase of storage period. The increase was high at the end of storage period of yoghurt stored at 4oC, and was higher in the yoghurt stored at 12°C after 4 days of storage. This trend is in agreement with the findings of El-Shobery and Shalaby, 1992. They stey stated that higher energy of activation was associated with a slower syneresis process. The lower activation energy might reflect the association of the coagulated caseins.

Table 2. Activation energy values of yoghurt coagulums made from milk heated to 70-90 °C (avarage) and stored at 4 and 12°C.

Storage period (day)	Storage temp. (°C) 4	12
	E_a ($J.mol^{-1}$)	
0	16254	16254
2	54689	21799
4	21034	26771
6	76488	49171

The temperature coefficient (Q10) denotes how much faster a reaction takes place when the temperature is raised by 10°C. This value was calculated from the rate of velocity constant (K) of the process at given temperature (u) and at 10°C higher (Ku+10). (El-Shobery and Shalaby, 1992). As presented in Table 3, the high values of temperature coefficient (Q10) indicate the higher rate of syneresis through the increase of both heating temperature of milk and storage temperature of yoghurt.

The results presented in Table 3 show that the temperature coefficient (Q10) of syneresis was affected due to the heat treatment of yoghurt milk and the storage period. The temperature coefficient values of yoghurt stored at 4°C were lower than those stored at 12°C till the second day of storage. On the other hand Q10 of yoghurt coagulum made from milk heated from 80 to g°0C was higher than coagulum of milk made from milk heated from 70 to 80°C in both storage temperatures. Our results agree with the findings of El-Shobery and Shalaby (1992).

Table 3. Temperature coefficient (Q10) of yoghurt coagulum stored at 4 and 12°C and made from milk heated at the range of 70-90°C.

Storage temp. (°C)	Storage period (day)	Heating range. (°C) 70-80	80-90
		(Q_{10})	
4	0	0.78	0.91
	2	1.12	2.21
	4	1.86	2.50
	6	1.20	0.33
12	0	0.78	0.91
	2	1.42	2.26
	4	0.93	1.76
	6	0.58	0.53

To calculated representation coefficient (Z-value), a clear, practical and easily manipulated representation of the logarithm of time (t) plotted against temperature (u) at constant N/N0, is done. Hence a linear relationship is derscribed by Arrhenius equation after some modification.

log t = - (Ea/2.3RT) u + log t0.

Where T : Absolute temperature ($^{o}C + 273$)

R : Gas constant (8.314 J. mol-1)

From plot slope, the lethal thermal coefficient (Z-value: The increase in temperature necessary for obtaining the same effect in one tenth of time) was calculated using the equation:

$$Z = \frac{2.3\ RT}{E_a}$$

Data presented in Table 4 show the lethal thermal coefficient (Z-value) for syneresis of yoghurt coagulum from milk heated at the temperature range of 70-90oC were higher in samples stored at 12oC than those at 4oC along the storage period. This may be attributed to the microbial activity during storage.

Table 4. Lethal thermal coefficient (Z-value) of yoghurt coagulums stored at 4 and 12^{o}C and made from milk heated at the temperature range of 70-90^{o}C.

Storage period (day)	Storage temp. (°C) 4	12
	Z-value (°C)	
0	1.120	1.120
2	1.350	0.400
4	0.434	0.500
6	0.353	0.750

To calculate the decimal reduction time (Du-value) expressed, as the time required at a given temperature (u) to reduce syneresis rate to one tenth of the original value, the following equation was used:

Dυ = 2.3 /k

Data presented at Table 5 show that Du was highly affected by the heating temperature of yoghurt milk, storage temperature and storage temperature and storage period. Values of Du was increased by the increase of heating temperature of yoghurt milk. Also, these values decreased as storage period was increased.

Table 5. Decimal reduction time (Du) of yoghurt coagulums stored at 4 and 12°C and made from milk heated to 70, 80, and 90°C.

Storage temp. (°C)	Storage period (day)	Heating temp. (°C) 70	80	90
			Dυ (min)	
4	0	3.10	2.40	2.20
	2	2.43	3.83	6.08
	4	2.06	2.76	8.33
	6	0.01	0.01	3.83
12	0	3.10	2.40	2.20
	2	2.13	3.03	6.73
	4	1.66	2.72	4.79
	6	0.24	7.23	3.83

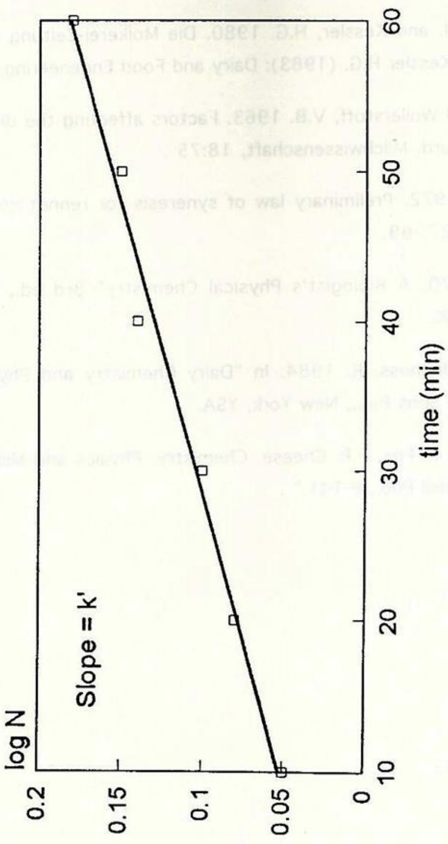

Fig. 1: Plot of syneresis of yoghurt coagulum according to the first order reaction (k' = velocity constant).

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حركية الشرش في خثرة الزبادى

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تم تحضير الزبادي من لبن الجاموس المعدل الي ٣٪ دهن مع تسخينه الي درجة حرارة ٧٠، ٨٠ ،٩٠°م لمده ٥ دقائق وقد تم تخزين خثرات الزبادي علي درجتي حرارة ٤ ، ١٢ °م لمدة ٢ ، ٤، ٦ أيام. وقد تم قياس كمية الشرش المنفصل من هذه الخثرات خلال فترة ساعة وأخذت قراءات الشرش المنفصل كل ١٠ دقائق. وقد أمكن تقييم عملية خروج الشرش عن طريق الرسم البياني وقوانين حركية التفاعلات، واتضح أن عملية خروج الشرش تتبع تفاعلات الرتبة الأولي. وقد تم في هذا البحث تقديم قيم ثوابت معادلة أرهينيوس مثل طاقة التنشيط للتفاعلات Ea وثابت سرعة التفاعل k و المعامل الحراري العشري Q10 ووقت الخفض العشري Du والمعامل الحراري الليثالي Z لكل نوع من خثرات الزبادي حسب المعاملة الحرارية التي أجريت علي اللبن المصنع منه ، ودرجة حرارة وزمن التخزين. وقد لوحظ بوضوح أن النتائج تعتمد علي شدة المعاملة الحرارية للبن وكذا درجة حرارة تخزين الزبادي.