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Research Article

Shelf life extension of Thai noodles

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Abstract: Noodles traditionally have a short shelf life. Extending the shelf life by refrigeration causes the texture of the cooked noodles to rapidly become tough and less sticky. This change is due to retrogradation. The objective of this research was to study the effect of storage time (0, 24, 48, 72, 96 and 120 hours) and storage temperature (9, 30 and 40^{o}C) on the retrogradation rate in noodles and to study the effect of surfactants on noodle quality using Texture Analyser, X-ray diffraction and DSC. It was found that breaking force increased with storage time but breaking distance decreased with storage time. Texture of noodles kept at low temperature changed more rapidly than those at high temperature. The endothermic peak of noodles kept at 9^{o}C was obvious under observation, while those kept at 40^{o}C was not. The enthalpy of retrogradation increased with duration of storage. Data from X-ray diffraction supported the observation that keeping noodles at low temperature accelerated the retrogradation rate. The addition of approved surfactants, SSL, MG and GMS, lowered the enthalpy of retrogradation and the relative crystallinity of the noodles, as well as retarding the retrogradation in noodles during storage. The addition of 0.5% SSL, 0.2% GMS and 0.5% MG minimized the breaking force and maximized the breaking distance of noodles and lowered the enthalpy of retrogradation. SSL lowered the enthalpy of retrogradation more than GMS or MG. V-type crystalline area of noodles with added 0.5% SSL was the highest. This finding supports the view that retardation of retrogradation in noodles by the addition of surfactants is the result of surfactant and amylose complex formation.

Keywords: food, storage, retrogradation, surfactant, additives, SSL, MG, GMS

Introduction

Refrigeration adversely affects the texture of cooked noodles. This change is due to retrogradation which occurs in gelatinized starch, from initially an amorphous to a more crystalline state. These processes influence texture properties of food rich in starch (Eliasson, 1996).

Emulsifiers and surfactants have been used in the food industry since the 1920s, mainly as dough conditioners, as crumb softeners in breads, buns and rolls and as amylose complexing agents in starch based food (Moorthy, 1985). The mechanism by which the surfactant retards the firming process of crumbs is based on their ability to form complexes with amylose. The abilities of various surfactants to form inclusion complexes with amylose vary and consequently their contributions to a reduction in the staling rate are different (Conde-petit and Escher, 1991). The effect of a lipid/surfactant on retrogradation as observed with DSC is a decreased melting endotherm of recrystallized amylopectin and an increased size of the endotherm associated with the amylose-lipid complex transition (Eliasson, 1983; Russell, 1983). Conde-petit and Escher (1991) demonstrated (with DSC) that complex forming surfactants had a strong efficiency to retard crumb firmness. Surfactants prevent dissolution and leaching of amylose molecules, which may be the factor responsible for the reduction in granule swelling. They also form a complex with amylopectin molecules and their anti-staling effect, which is correlated with a reduction in granule swelling, is likely due to a reduction in starch polymer mobility after complexation so that less crystallization can occur (Gray and Bemiller, 2003). The function of surfactants, as crumb softening agents, is closely related to their interaction or complex formation with starch, particularly the linear amylose fraction, to retard bread staling (Azizi and Rao, 2004). Surfactants may also slow the rate of bread firming by forming a complex with the amylopectin fraction within the starch granule (Kamel and Ponte, 1993). However, the effect of surfactants on retrogradation of rice flour in noodles is still not known. The objective of this research is to study the effect of storage time and storage temperature on retrogradation in noodles and effect of surfactants on noodle quality.

Materials and Methods

Cooked noodle preparation

Rice flour was purchased from Choheng Vermicelli Factory in Nakorn Pathom Province, Thailand. Cooked noodles were prepared by steaming 42% (w/v) flour suspension on a tray (20*30 cm^2) for 5 min. Cooked sheeted noodle, 0.5-0.7 mm thick, was cooled down before cutting to 2.5 cm x 5 cm size. The noodles were kept in a plastic box and stored at temperatures of 9, 30 and 40^{o}C for 0, 24, 48, 72, 96 and 120 hours.

Addition of surfactants

Food grade monoglyceride (MG), sodium steroyl-2-lactylate (SSL) and glecerol monostearate (GMS) were kindly supplied by Cognis Thai Limited. The surfactants were melted and mixed with water at a ratio 1:4 before being added to rice flour suspensions at various concentrations. MG was added at 0.1, 0.3 and 0.5%, SSL was added at 0.3, 0.5 and 0.7%, and GMS was added at 0.08, 0.2 and 0.4% of rice flour weight, dry basis.

Textural properties of noodles

Textural properties of noodles were determined using Texture Analyzer, TA-XT2 (Stable Micro Systems, England). The 10 sheets of noodles were compressed with a cylindrical probe (10 mm. dia.) to 80% strain. Break force and break distance were recorded.

Thermal properties of the noodles

Thermal properties of the noodles were determined using DSC-7 (Pyris I, Perkin Elmer, England) according to Perdon (1999) method. The sample in a DSC pan was heated from 30 to 100°C at a heating rate of 10°C/min, cooled down to 30°C at a cooling rate of 10°C/min and reheated to 100°C at the same rate. The enthalpy of retrogradation (ΔH) was recorded.

X-ray diffraction

Crystallinity of noodles kept at 9 °C for 0, 24, 48, 72, 96 and 120 hours were investigated using X-ray diffraction (Jeol, JDX-3530, Japan) according to Shi and Seib (1992) method. B-type and V-type mass crystallinity of samples were analysed. B-type mass crystallinity was calculated from the area of the B-type crystalline fraction divided by the crystalline fraction, plus the amorphous fraction. V-type mass crystallinity was calculated from the area of the V-type crystalline fraction divided by crystalline fraction, plus the amorphous fraction.

Results and Discussion

Effect of storage time and storage temperature on retrogradation in noodles

Effect of storage temperature and storage time on textural properties of noodles is shown in Table 1. During storage the breaking force increased with storage time, but breaking distance decreased with storage time. For the noodles stored for 24 hrs at 9°C, breaking distance decreased from 6.81 mm to 3.45 mm and tended to level off after a period of storage. Texture of noodles kept at 9°C changed more rapidly than those at 30°C and 40°C. After storage, noodle texture became less sticky and easy to break. Storage at low temperature accelerated this change.

Table1. Effect of storage time and storage temperature on textural properties of noodles.

Time (hrs)	**Breaking force** (g)			**Breaking distance** (mm)		
	9°C	30°C	40°C	9°C	30°C	40°C
0	3465.4^{aE}	3465.4^{aD}	3465.4^{aE}	6.81^{aA}	6.81^{aBC}	6.81^{aB}
24	6680.8^{aC}	3971.6^{bC}	3720.6^{cD}	3.45^{bB}	7.19^{aA}	7.47^{aA}
48	10388.7^{aD}	4512.5^{bB}	3954.7^{cC}	3.38^{cB}	7.01b^{AB}	7.50^{aA}
72	11385.4^{aB}	4667.2b^{BA}	4134.6^{cC}	3.13^{bB}	6.84a^{AB}	7.02^{aB}
96	11748.1^{aAB}	4712.4b^{BA}	4359.4^{bB}	3.20^{cB}	6.61b^{CD}	7.08^{aB}
120	12251.4^{aA}	4893.1^{bA}	4720.4^{bA}	3.20^{cB}	6.38^{bD}	7.09^{aB}

Values with similar letter superscripts in a same row did not differ significantly (p>0.05)
Values with similar capital superscripts in a same column did not differ significantly (p>0.05)

Effect of storage temperature and storage time on thermal properties of noodles is shown in Table 2. Storage temperature affected the enthalpy of retrogradation. The endothermic peak of noodles stored at 9°C was obvious, while that at 40°C was not. At 30°C, the endothermic peak was observed after storage for 96 hours. This indicated that retrogradation in noodles occurred more during storage at low temperature. The enthalpy of retrogradation also increased with duration of storage.

Table 2. Effect of storage time and storage temperature on the enthalpy of retrogradation.

Time (hrs)	ΔH(J/g)		
	9°C	30°C	40°C
0	ND	ND	ND
24	1.67±0.04	ND	ND
48	2.62±0.06	ND	ND
72	3.17±0.14	ND	ND
96	3.32±0.01	1.56±0.57	ND
120	3.43±0.01	1.81±0.61	ND

ND: Not detected.

Data from X-ray diffraction of noodles stored at 9°C for various times is shown in Figures 1 and 2. Figure 1 shows that the longer the time of storage, the more crystalline the structure of the noodles. The B-type crystal structure corresponding to the amylopectin retrogradation increased with storage time while the V-type crystal structure, indicative of amylose complexing with fatty acids to form helical clathrate, was virtually unchanged (Fig2). The B-type mass crystallinity showed a high correlation with noodle retrogradation and storage time.

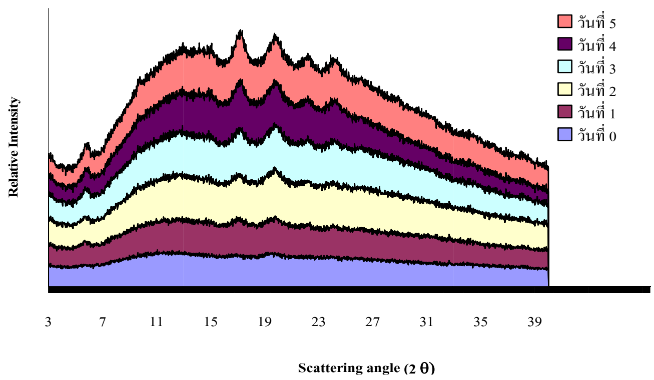

Fig.1. X-ray diffractogram of noodles stored at 9°C for various times.

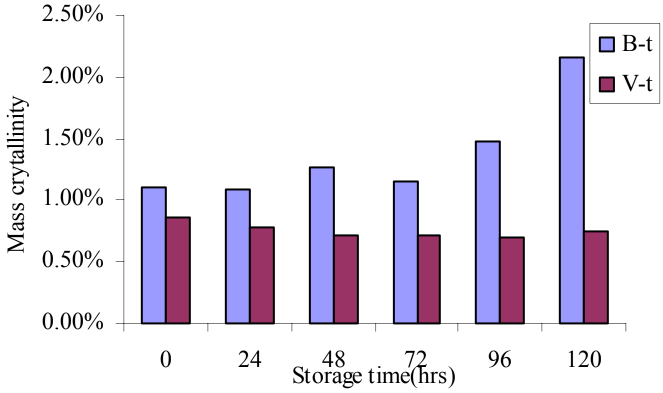

Fig. 2. B-type mass crystallinity and V-type mass crystallinity of noodles stored at 9°C for various times.

Effect of surfactants on retrogradation of noodles

The addition of SSL, MG and GMS resulted in a significant reduction in breaking force and breaking distance compared to the control (Table 3). It was found that the addition of SSL, MG and GMS at 0.5%, 0.5% and 0.2%, respectively, minimized breaking force and maximized breaking distance of the noodles. After storage, the noodles containing SSL, MG and GMS remained softer, more sticky and extensible than the control.

Table 3. Effect of surfactants on noodle textural properties during storage at 9°C.

Time (hrs)	Breaking force (g)				Breaking distance (mm)			
	control	SSL 0.5%	Mg 0.5%	GMS 0.2%	control	SSL 0.5%	Mg 0.5%	GMS 0.2%
0	3465.4^{E}	3107.1^{D}	3158.6^{D}	3055.6^{E}	6.81^{A}	6.98^{A}	6.92^{A}	7.16^{A}
24	6680.8^{C}	6433.7^{C}	6477.6^{C}	6378.3^{D}	3.45^{B}	3.37^{B}	3.24^{B}	3.24^{B}
48	10388.7^{D}	9727.3^{B}	9849.9^{B}	9367.9^{C}	3.38^{B}	3.18^{BC}	2.93^{B}	3.18^{B}
72	10571.1^{B}	9817.7^{B}	10307.0^{A}	9442.8^{C}	3.13^{B}	2.98^{BC}	3.16^{B}	3.22^{B}
96	11748.1^{AB}	9825.8^{B}	10401.3^{A}	9854.6^{B}	3.20^{B}	3.12^{BC}	3.13^{B}	3.06^{B}
120	12251.4^{A}	10104.4^{A}	10770.1^{A}	10335.0^{A}	3.2^{B}	2.95^{C}	3.180^{B}	3.23^{B}

Values with similar superscripts in a same column did not differ significantly (p>0.05)

The addition of SSL, MG and GMS lowered the enthalpy of retrogradation compared to the control in the order: SSL>GMS>MG (Table 4). It was found that the addition of SSL, MG and GMS at 0.5%, 0.5% and 0.2%, respectively minimized the enthalpy of retrogradation. The addition of surfactants showed a dramatic effect on the melting of the amylose-lipid complex.

Table 4. Effect of surfactants on the enthalpy of retrogradation during storage at 9°C.

Storage time	ΔH(J/g)			
	control	SSL0.5%	GMS 0.2%	MG 0.5%
0	ND	ND	ND	ND
24	1.67±0.04	1.28±0.12	1.29±0.38	1.90±0.13
48	2.62±0.06	1.47±0.06	1.79±0.05	2.36±0.11
72	3.17±0.14	2.19±0.19	2.58±0.02	2.76±0.23
96	3.32±0.01	2.77±0.04	2.79±0.11	3.04±0.41
120	3.43±0.01	3.06±0.17	3.09±0.19	3.22±0.21

ND: Not detected

Surfactants also lowered the crystallinity in noodles compared to the control as shown in Figure 3. SSL, MG and GMS could retard the crystalline formation in noodles during storage. B-type crystallinity in the control was the highest, while that in noodles with added SSL 0.5% was the lowest. The noodles with added surfactants apparently showed only the V-type structure. The V-type crystallinity in noodles with added SSL at 0.5% was higher than that with added GMS at 0.2% and MG at 0.5%, respectively. This supports the previous observation that the retardation of retrogradation in noodles by the addition of surfactants is the result from surfactant and amylose complex formation (Eliasson and Gudmundsson, 1996).

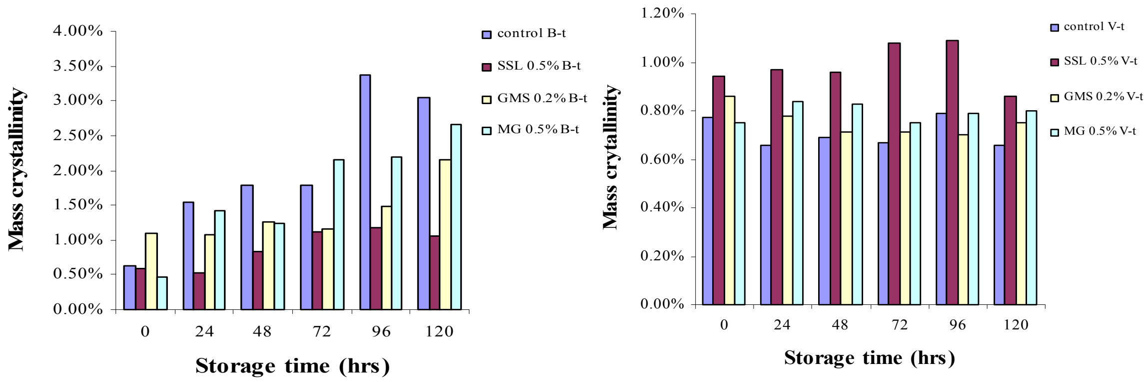

Fig. 3. Effect of surfactant on B-type crystallinity (a) and V-type crystallinity (b) in noodles.

Conclusion

The storage time and storage temperature affected the texture, the enthalpy of retrogradation and the relative crystallinity in noodles. The maximum retrogradation in noodles occurred at 9°C. The addition of surfactants decreased the surfactant and amylose complex formation. The result showed that maximum improvement of noodle quality was obtained with the addition of SSL 0.5% followed by GMS 0.2% and MG 0.5%.

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