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The Effect of Various Humectants on Equilibrium Moisture Content and Storage Stability of Seasoned Squid

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Abstract

This study was, firstly, to investigate water holding capacity in terms of variation of moisture sorption isotherms of seasoned squid treated with sodium lactate, glycerol, propylene glycol, sorbitol, mannitol, sodium benzoate, potassium sorbate and calcium propionate, and secondly, the effect of humectant treatments on storage stability was studied. The criteria for storage stability was based on three quality factors, namely, lipid oxiations, color development by non-enzymatic browning reactions and lipid oxidation, and mold growth. The effect of humectants on equilibrium moisture content was in the following increasing order; mannitol < sorbitol < sodium lactate < propylene glycol < glycerol. The experimental data indicated that sodium lactate has, in practice, potentially positive effect on processing of seasoned squid. During the storage period of 60 days, TBA values increased in all samples tested as humectants concentrations increased up to 10%. However, in the range of 1-7% sodium lactate treatment, the degree of lipid oxidation, browning reactions and mold growth were not high enough to affect the quality of seasoned squid, when compared with conventionally manufactured ones.

Key words: humectants, intermediate moisture food, seasoned squid.

Introduction

Among some of traditional intermediate moisture foods, fishery products are of significance in Korean food industries with respect to the annual production and consumption. In recent years, the annual production of traditional intermediate foods made from fishes reached 5 billion US dollar level and this marks approximately 45% of the processed fishery products.

With the recent technological development of intermediate moisture food, current research is now focused on the modification of semi-dried products, utilizing a number of humectants in an effective and safe manner. The manufacture of traditional intermediate moisture fishery products has the following technological principles; depression of water activity by addition of sugars and salts, and retardation of microbial growth by antimicrobial agents.

Glycerol and several other polyhydric alcohols have received consideration as most effective humectants in processing of intermediate moisture foods. However, many of these compounds produce a significant water activity depression only at concentrations above their flavor threshold, an outcome that restricts their usefulness in foods[1].

It has been reported that sodium lactate shows remarkable behavior and is further particularly effective in synergistic combinations with sodium chloride[2]. In addition, it was demonstrated that sorbitol and mannitol in intermediate moisture foods was effective in antimicrobial and water binding action with resultant reduction in moisture content[3].

This study was, therefore, to investigate the effects of sodium lactate, sobritol and mannitol on equilibrium moisture content of the traditional intermediate moisture foods prepared with squid on the one hand, and to determine the quality changes of the product during storage on the other

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hand.

Materials and Methods

Sample preparation

To prepare the model system of intermediate moisture squid, the peeled squid was sliced (2.0×2.0×0.5cm) and freeze-dried. The freeze-dried squid was then immersed in various concentrations of humectant solutions at 20℃ for 12 hours. The model system was based on the following basic composition; 10% (w/w) sucrose, 3% sodium chloride and 0.3% monosodium glutamate, plus such humectants as: 1-7% of sodium lactate, propylene glycol and glycerol, and 2-10% of sorbitol and mannitol. The concentrations of sodium benzoate, potassium sorbate and calcium propionate were adjusted to 0.05%, 0.20% and 0.10% by weight percent, respectively.

Once the immersion was completed, squid was to be re-dried in a batch type air dehydrator at 30℃ and the residual moisture content was conditioned at constant relative humidity of 79%. Fig. 1 shows the flow sheet of the manufacture of intermediate moistrue squid. The finished products were individually subjected to the determination of adsorption isotherms and the storage storage stability test.

Determination of sorption isotherms

For the equilibration of moisture content with relative humidity, gravimetric method was used, using relative humidity over saturated salt solutions described by Rockland[4]. The actual equilibrium relative humidity was determined by an electric hygrometer (Hygroskop, DT, Switzerland).

Storage stability

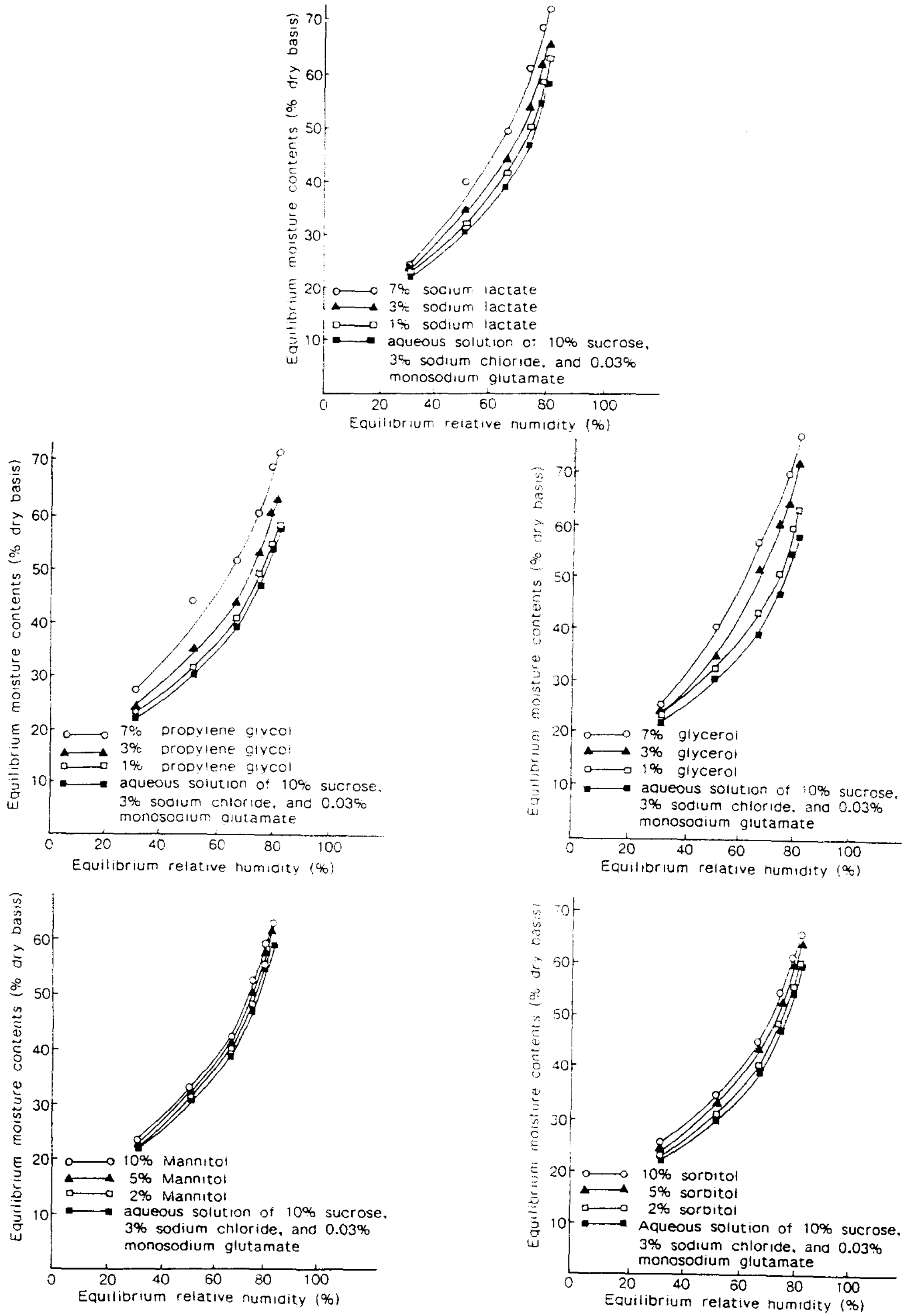
For chemical determination of rancidity and non-enzymatic browning reactions, the samples with and without humectant treatment were stored at 30℃ for 60 days. During the storage period, duplicate samples were taken for chemical analysis at an interval of 15 days. Thiobarbituric acid (TBA) was determined by the method reported by Taradgis et al[5]. Color development of samples was determined by the procedure of Han et al[6] and mold growth was detected visually for 60 days of storage.

Results and discussion

Fig. 2 through 5 show the adsorption isotherms for samples treated with various humectants. As expected, the differences in equilibrium moisture content with and without humectant treatment were obviously observed. At the equilibrium relative humidity of 79%, the effect of humectants on equilibrium moisture content was in the following increasing order; mannitol < sorbitol < sodium lactate < propylene glycol < glycerol. The differences in equilibrium moisture content between sorbitol and mannitol appeared to be negligible, whereas the effect of sodium lactate on the increase of equilibrium moisture content was compatible with that of glycerol and propylene glycol.

Frozen squid
↓
Thawing
↓
Dismantling and skinning
↓
Heat treatment(80°C, 5min.)
↓
cooling with tap water
↓
Draining
↓
Slicing
↓
Freeze-drying(-36°C, 24hrs.)
↓
Seasoning(10°C, 12hrs.)
↓
Draining
↓
Drying at 30°C for 8hrs.
↓
Humidifying at 79%RH(30°C, 5days)
↓
Intermediate moisture squid

Fig. 1. Flow sheet of manufacture of intermediate moisture squid.



Figs. 2-5. Adsorption isotherms for dried squid soaked with various humectants solutions at 30°C.

The data presented in Fig. 2 through 5 indicate that sodium lactate may be substituted for glycerol and propylene glycol. The magnitude of the effect of this compound became greater as the concentration increased. In addition, the effect of sodium lactate on the adsorption isotherms was remarkably observed in the range of 50-80% RH. Equilibrium moisture content of all samples tested was, in general, affected by increasing the humectant concentrations and the effect of concentrations on water holding capacity was found to be additive, that agreed with the results previously reported[7].

During the storage period of 60 days, TBA values increased in all samples as humectant concentration increased up to 10% as shown in Table 1. However, it appeared that TBA values were not significantly affected by humectant concentrations in the range of 1-7%. The slight difference in TBA value of all samples treated with different concentration was assumed to be due to the change of the moisture content.

One of the negative effects of humectant treatment in intermediat mositure foods is color change either by non-enzymatic browning reactions or by lipid oxidation. As shown in Table 2, the rate of color change from golden brown to a dark color increased as the concentrations of various humectants increased from 1 to 10% during storage. The increase in color with concentration was expected, since the browning of intermediate moisture squid was due to the non-enzymatic browning reaction, an interaction between amino group and reducing sugars. In addition, the intermediate moisture squid was maintained at constant relative humidity of 79.0% during the storage period, which is very close to the maximum browning reaction.

The color change of samples due to lipid oxidation was also observed during storage as shown in Table 3. The increase in browning reaction was affected by increasing the humctant concentra-

Table 1. Variation of TBA value vs. storage time

Humectant concentration % (w/w)		Storage time in days				
		0	15	30	45	60
Control		0.053*	0.059	0.063	0.070	0.081
Sodium lactate	1%	0.060	0.063	0.070	0.077	0.082
	3%	0.061	0.064	0.072	0.079	0.085
	7%	0.063	0.070	0.078	0.083	0.092
Propylene glycol	1%	0.057	0.063	0.070	0.074	0.087
	3%	0.060	0.065	0.077	0.081	0.089
	7%	0.062	0.071	0.080	0.087	0.093
Glycerol	1%	0.055	0.060	0.065	0.070	0.082
	3%	0.055	0.062	0.068	0.074	0.083
	7%	0.056	0.065	0.074	0.080	0.085
Sorbitol	2%	0.059	0.062	0.070	0.076	0.082
	5%	0.061	0.064	0.072	0.079	0.083
	10%	0.063	0.055	0.073	0.082	0.089
Mannitol	2%	0.054	0.060	0.069	0.074	0.082
	5%	0.055	0.061	0.071	0.076	0.083
	10%	0.055	0.062	0.073	0.075	0.085
Sodium benzoate	0.05%	0.054	0.062	0.067	0.074	0.082
Potassium sorbate	0.2 %	0.054	0.060	0.064	0.070	0.082
Calcium propionate	0.1 %	0.053	0.061	0.065	0.072	0.083

* Optical density at 535 *nm*

Table 2. Brown color densitv of water dialyzed fraction

Humectant concentration % (w/w)		Storage time in days				
		0	15	30	45	60
Control		0.014 *	0.028	0.034	0.038	0.042
Sodium lactate	1%	0.015	0.029	0.035	0.039	0.044
	3%	0.016	0.030	0.036	0.040	0.045
	7%	0.019	0.033	0.039	0.042	0.047
Propylene glycol	1%	0.015	0.029	0.035	0.039	0.041
	3%	0.017	0.031	0.036	0.040	0.043
	7%	0.019	0.034	0.038	0.043	0.045
Glycerol	1%	0.014	0.029	0.035	0.038	0.043
	3%	0.015	0.031	0.036	0.039	0.044
	7%	0.018	0.034	0.030	0.042	0.047
Sorbitol	2%	0.015	0.028	0.034	0.039	0.041
	5%	0.016	0.029	0.035	0.040	0.042
	10%	0.017	0.031	0.037	0.041	0.043
Mannitol	2%	0.014	0.028	0.035	0.038	0.042
	5%	0.015	0.028	0.036	0.039	0.041
	10%	0.016	0.029	0.037	0.040	0.044
Sodium benzoate	0.05%	0.014	0.027	0.035	0.038	0.043
Potassium sorbate	0.2 %	0.012	0.028	0.036	0.039	0.042
Calcium propionate	0.1 %	0.014	0.028	0.037	0.039	0.041

* Optical density at 460nm

Table 3. Brown color density of chloroform-methanol fraction

Humectant concentration % (w/w)		Storage time in days				
		0	15	30	45	60
Control		0.012*	0.014	0.016	0.018	0.021
Sodium lactate	1%	0.013	0.015	0.018	0.019	0.023
	3%	0.014	0.015	0.018	0.020	0.023
	7%	0.015	0.017	0.019	0.021	0.024
Propylene glycol	1%	0.012	0.015	0.017	0.019	0.022
	3%	0.013	0.016	0.017	0.020	0.023
	7%	0.015	0.018	0.019	0.022	0.024
Glycerol	1%	0.014	0.015	0.018	0.019	0.021
	3%	0.015	0.017	0.019	0.021	0.020
	7%	0.016	0.018	0.020	0.022	0.021
Sortitol	2%	0.012	0.015	0.016	0.017	0.019
	5%	0.013	0.015	0.016	0.018	0.020
	10%	0.014	0.016	0.018	0.020	0.021
Mannitol	2%	0.013	0.015	0.016	0.017	0.018
	5%	0.013	0.014	0.017	0.018	0.019
	10%	0.014	0.015	0.018	0.019	0.020
Sodium benzoate	0.05%	0.013	0.014	0.015	0.019	0.022
Protassium sorbate	0.2 %	0.014	0.014	0.015	0.019	0.021
Calcium propionate	0.1 %	0.014	0.014	0.016	0.018	0.023

* Optical density at 460nm

tions. However, it was found that the degree of lipd oxidation was not closely related to the humectant concentration. When compared with the samples treated with 0.05% benzoate, 0.2% potassium sorbate and 0.1% calcium propionate, brown color density of the samples treated with different humectant concentration did not change markedly after 60 days of storage as shown in Table 2 and 3.

According to the visual observation of mold growth, it was found that 0.2% potassium sorbate and 0.1% calcium propionate were most effective in the inhibition of mold growth, whereas the sample treated with 2% sorbitol had no effect on shelf-life. The experimental results shown in Table 4 indicate that sodium lactate and propylene glycol at the concentration level of 3.0% affected fungal growth in the intermediate moisture squid.

Table 4. Effect of humectant concentration on mold growth

Humectant concentration % (w/w)		Storage time in days				
		0	15	30	45	60
Control		-		+	+	+
Sodium lactate	1%	-			+	+
	3%	-		-	-	
	7%	-		-	-	-
Propylene glycol	1%	-				+
	3%	-				
	7%			-	-	
Glycerol	1%	-			+	+
	3%			-	-	+
	7%	-		-	-	-
Sorioitol	2%	-		+	+	+
	5%	-			+	+
	10%	-		-		-
Mannitol	2%	-		-	+	+
	5%	-			+	+
	10%	-		-	-	-
Sodium benzoate	0.05%	-		-	+	+
Potassium sorbate	0.2%	-		-	-	-
Calcium propionate	0.1%	-		-	-	-

* —: None

+: Appearence of mold

**: All samples were adjusted to pH 5.5

It may be concluded that in the range of 1-7% sodium lactate treatment the level of lipid oxidation, browning reactions and mold growth was not high enough to affect the quality of the intermediate moisture squid during the storage period of 60 days.

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여러가지 보습제가 조미오징어 평형수분함량에 미치는 영향

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본 실험은 여러가지 보습제 및 방부제(Sodium lactate, Glycerol, Propylene glycol, Sorbitol, Mannitol, Sodium benzoate, Potassium sorbate 및 Calcium propionate)처리를 한 중간수분식품 모델의 보수력을 등온흡습 곡선으로 측정하였다. 중간수분식품의 모델은 오징어를 재료로 사용하였고, 제조된 모델식품의 저장성도 검토하였다. 저장요인으로서는 지질산패, 색깔변화 및 곰팡이 번식을 관찰하였다. 보습제의 보수력은 mannitol < sorbitol < sodium lactate < propylene glycol < glcerol의 순서로 높았으며, 특히 1-7% sodium lactate는 모델식품의 보수력 증가에 기여도가 높게 나타났으며, 실제로 조미오징어 제조에 긍정적 효과를 보였다. 저장기간 60일 동안 sodium lactate 처리구의 TBA價, 갈변반응 및 지질산패의 정도는 재래적 방법에 의한 糖 처리구에 비해 큰 차이를 보이지 않았다.