EFFECT OF ADDITION OF TREHALOSE, MALTOSE AND TWO MODIFIED STARCHES ON COLOUR AND TEXTURAL ATTRIBUTES OF CHICKEN SURIMI GELS DURING FROZEN STORAGE

ORIGINAL SCIENTIFIC PAPER

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ABSTRACT

Texture profile analysis (TPA) and instrumental colour parameters of chicken surimi gels after frozen storage were investigated. Chicken surimi gels were prepared from mechanically deboned chicken meat, mixed with trehalose (w = 8%), maltose (w = 8%), tapioca modified starch (MTS) (w = 8%) and barley modified starch (MBS) (w = 8%), quickly frozen and stored for 90 days s on -30°C. Instrumental colour parameters (Lightness (L*), redness (a*), yellowness (b*) and whiteness (L* − 3b*) of chicken surimi gels were significantly ($P < 0,05$) affected by addition of trehalose, maltose and modified starches. Highest values of lightness (L*) and whiteness showed sample mixed with MBS. Textural profile analysis (TPA) parameters, hardness and chewiness increased significantly ($P < 0,05$) by addition of trehalose, maltose, MBS and MTS. Cohesiveness and springiness of chicken surimi gels were also significantly ($P < 0,05$) affected by addition of trehalose, maltose MBS and MTS. Increase in colour and textural attributes of chicken surimi gels after frozen storage indicates possible interactions between chicken myofibrillar proteins and trehalose, maltose and modified starches.

Key words: Chicken surimi, Texture, Colour, Modified starch, Trehalose, Maltose, Frozen storage.

INTRODUCTION

Chicken myofibrillar protein concentrate, produced with modified technology used for fish surimi[1,2], is characterized by very good technological properties, such as a high water holding capacity and a high ability to form strong gels after being heated[3]. Freezing has become the most frequently used preservation method for meat and meat products. To protect myofibrillar proteins from denaturation during frozen storage and maintain its possible high processability, some cryoprotectants (i. e. disaccharides, polysaccharides, polyalcohol's, organic acids and polyphosphates) are generally added[4,5].

Trehalose (D-glucopyranosyl-α (1→1)-D-glucopyranoside) is a non-reducing disaccharide with low caloric value and low sweetness, which is only 45% of that of sucrose[6]. Because of its ability to form strong hydrogen bonds with the polar group of the biomolecules and higher glass transition temperature, trehalose has superior preservation properties as compared to other sugars[7]. Trehalose has been found to have a protective effect against thermal inactivation of enzymes and freeze-draying of microorganisms[8]. Osako et al.[9] investigated gel forming ability, unfrozen water content, Ca^{2+} ATPase activity of horse mackerel surimi, during freezing and frozen storage, upon addition of trehalose, sucrose, glucose and sorbitol and concluded that trehalose had similar cryoprotective effect as sucrose and sorbitol.

Colour and texture are the major factors responsible for the final acceptance of surimi-based products by consumers[10]. To better suit the textural preferences of consumers, ingredients must be added to surimi that modify the textural and water mobility properties of the surimi[11]. In composite food such as surimi the additives can modify the texture. Protein additives, such as egg white, are used to increase the gel strength and to give a whiter and glossier appearance to the gel[12]. The final surimi-based product can assume almost any desired texture through its gel forming capacity.

Starch is usually added to surimi to improve gelling properties and final textural properties [13].

Gelation of starch is thought to arise from the formation of a three dimensional network which binds the swollen granules. Factors involved in the gelatinization of starch are mainly type, size and previous history of starch granules[14], concentration, temperature, cooking time, agitation, types, and amounts of added ingredients. Starch gelatinization is accompanied by melting of crystallites, loss of birefringence, granule swelling, and increase in viscosity[11].
The objective of this study was to determine influence of trehalose, maltose, MTS and MBS on instrumental colour and texture parameters of chicken surimi gels after frozen storage.

MATERIAL AND METHODS

Sample preparation

Chicken surimi samples were prepared in the laboratory from mechanically deboned chicken meat using the modified procedure of Yang and Froning[15] where washing and leaching was performed with distilled water, instead of with tap water. The samples were mixed with trehalose, maltose, modified tapioca starch (MTS) and barley starch (MBS) in mass fractions 8%. Mass fractions were determined as percent of total mass. MBS modification procedure: 0,145 g glutaric acid was suspended in 4,35 g acetic anhydride. 100 g of starch (d.m.) was suspended in 145 ml distilled water by agitating at magnetic agitator (300 rpm), during agitating the solution of glutaric acid and acetic anhydride was added. pH of suspension was kept at 9 with 1M NaOH. After addition of modified agents the stirring was continued for another 30 min. The reaction of starch with glutaric acid and acetic anhydride was terminated by reduction of pH to 5 with addition of 1M HCl. Suspension was than centrifuged (300 rpm/5min) to separate starch. Starch pellet was resuspended in water and centrifuged again. This step was repeated until supernatant became colourless. Starch suspension was then neutralized, centrifuged once more and modified starch was finally air dried. MTS was prepared according to the method by Wurzburg[16]. The samples were packed in plastic test tubes with an inside diameter of 10 mm, frozen, and stored at -30 °C. Texture profile analysis and colour parameters were evaluated after 90 days. Water activity (a_w) was determined using a Rotronic Hygrolab 3 (Rotronic AG, Bassersdorf, Switzerland) at a room temperature (20 ± 2°C). The Food Scan Meat Analyser was used to determine moisture, total protein share, total fat share and collagen content according to the AOAC 2007. 04[17].

Texture profile analysis (TPA)

After defrosting, test tubes with their content were heated for 25 min in a water bath at 80°C. The test tubes with produced gels were cooled in ice water until the temperature of approx. 20°C was obtained inside the sample. After that, they were stored at 4 - 6°C until the next day. Texture profile analysis (TPA) tests were performed using a TA.XT2i SMS Stable Micro Systems Texture Analyzer (Stable Microsystems Ltd., Surrey, England) equipped with a cylindrical probe P/75. This involved cutting samples into 1,5 cm thick slices and compressed twice to 60% of their thickness. Force-time curves were recorded at across-head speed of 5 mm/s and the recording speed was also 5 mm/s. The following parameters were quantified [18]: hardness (g), maximum force required to compress the sample, springiness (ratio), the ability of the sample to recover its original form after the deforming force was removed, cohesiveness, extent to which the sample could be deformed prior to rupture (ratio) and chewiness (g), which is calculated hardness · cohesiveness · springiness, was measured.

Determination of colour

Colour measurements (L*, a*, and b* values) were preformed using a Hunter-Lab Mini ScanXE (A60-1010-615 Model Colorimeter, Hunter-Lab, Reston, VA, USA). The instrument was standardized each time with a white and black ceramic plate (L*0 = 93,01, a*0 = -1,11, and b*0 = 1,30). The Hunter L*, a*, and b* values correspond to lightness, greenness (-a*) or

redness (+a*), and blueness (-b*) or yellowness (+b*), respectively. The whiteness (W) was calculated using the formula: L* - 3 b*. The colour measurements were performed on chicken surimi at a room temperature (20 ± 2 ºC).

Statistical analysis

Three determinations for basic chemical composition, seven for TPA and colour parameters were measured from each sample. Experimental data were analysed by the analysis of variance (ANOVA) and Fisher's least significant difference (LSD), with significance defined at P< 0,05. Statistical analysis was carried out using the Statistica ver. 12.7.StatSoft Inc. Tulsa, 2015. OK. USA.

RESULTS AND DISCUSSION

The mean basic chemical composition, pH and a_w values of chicken surimi samples before mixing with sugars or modified starches are presented in Table 1. The mass fraction of water, protein and fat in chicken surimi were similar to the results reported by Stangierski and Kijowski[19] for myofibril concentrate prepared from mechanically recovered poultry.

The TPA parameters of chicken surimi mixed trehalose, maltose, MTS, and MBS after 90 days of frozen storage are shown in Table 2. Four parameters were obtained: hardness, springiness, cohesiveness and chewiness. The chicken surimi samples frozen for 90 days had higher values for TPA parameters then fish surimi reported by Tablio-Munizaga and Barbosa-Canovas[20]. This can be attributed to the different nature of samples (chicken and fish meat).

Table 1. Basic chemical composition, a_w and pH of chicken surimi samples

Water *w* (%)	Proteins *w* (%)	Fat *w* (%)	Collagen *w* (%)	pH	a_w
84,75± 0,28	13,06± 0,58	0,73± 0,07	0,79± 0,01	6,95± 0,04	0,98± 0,01

Values are means ± Standard deviation of triplicate.

The sample of chicken surimi without addition of additives showed lowest values of hardness and chewiness. The hardness of chicken surimi gels increased significantly (P< 0,05) with the addition of 8% trehalose, 8% maltose, 8% MBS and8% MTS. The chicken surimi hardness and chewiness were more influenced by addition of sugars then by the addition of modified starches.

Table 2. Texture profile analysis parametrs of chicken surimi mixed with 8% trehalose, 8% maltose, 8% MBS and 8% MTS after 90 days of frozen storage

	Hardness	Springiness	Cohesiveness	Chewiness
No additive	105,04d ± 12,72	0,89ab ± 0,02	0,74b ± 0,04	69,86 ± 12,92
Trehalose	274,61a ± 27,32	0,87ab ± 0,01	0,77a ± 0,01	184,10a ± 14,48
Maltose	221,98b ± 28,17	0,85b ± 0,01	0,77a ± 0,03	146,41b ± 8,37
MTS	201,13b ± 20,52	0,93a ± 0,05	0,72b ± 0,01	135,81b ± 11,26
MBS	135,60c ± 9,32	0,88ab ± 0,01	0,79a ± 0,01	94,85c ± 14,51

Values are means ± SD seven measurements. Values in the same row with different superscripts (a-c) are significantly different (P<0,05).

The springiness of chicken surimi samples were in the range from 0,85 to 0,93. The highest values of springiness showed the sample mixed with 8% MTS. Chicken surimi samples cohesiveness was significantly (P<0,05) affected with addition of sugars and modified starches (Table 3). The

main differences in TPA among different additives added were obtained in hardness and chewiness. The increase of texture profile analysis parameters with the addition of sugars and modified starchesare was in agreement with the result reported by Alakhrash et al.[21], for fish surimi with addition of oat bran.

Instrumental colour parameters of chicken surimi with addition of sugars and modified starches are presented in Table 3. Generally, the demand is higher for surimi gels with high lightness (L*), low yellowness (b*) and high whiteness (W). The colour parameters of chicken surimi were different then the colour parameters of fish surimi[20, 22]. This can be related to the nature of sample (higher myoglobin content in chicken meat). Similar, higher values for L*, a*, b* for pork and chicken surimi in comparison with Alaska Pollock surimi were reported by Jin et al.[23]. The addition of trehalose, maltose, MBS and MTS significantly increased (P< 0,05) lightness and whiteness of chicken surimi samples. This is in agreement with the studies that investigated the addition of potato starch and egg white and oat bran to Alaska Pollock surimi[20, 21]. The addition oftrehalose, maltose, MBS and MTS to chicken surimi, resulted in decreased of a* values, indicating a slightly greater green hue in these treatments. Yellowness (+b*) decreased with the addition of oats 8% trehalose, maltose, MBS and MTS. This decrease was higher in samples of chicken surimi mixed with sugars then modified starches.

Since the most important quality parameter in surimi is whiteness, and in order to better predict the behaviour of additives, whiteness was calculated according to the formula W = L* - 3b*. The whiteness of chicken surimi samples varied from 20,62 to 33,45. The similar increase in lightness and whiteness for the heat induced fish surimi gels mixed with potato starch and egg were reported by Tabilo-Munizaga and Barbosa-Canovas[20]. The addition of sugars and modified starches significantly increased whiteness (P< 0,05) of chicken surimi samples.

CONCLUSIONS

The results of this study showed statistically significant (P < 0,05) increase of lightness (L*) and whiteness (W), decrease of greenness (+a) and yellowness (+b) of chicken surimi samples with addition of trehalose, maltose and two modified starches. Also, the increase of TPA parameters of chicken surimi samples after frozen storage with the addition of trehalose, maltose and two modified starches were observed. This can indicate possible interaction of trehalose, maltose, MBS AND MTS with the chicken myofibrillar proteins and its stabilisation.

Table 3. Instrumental colour parameters of chicken surimi mixed with 8% trehalose, 8% maltose, 8% MBS and 8% MTS after 90 days of frozen storage.

No additive	L*	a*	b*	Whitness L* – 3b*
No additive	75,70e ± 0,28	2,38a ± 0,12	18,36a ± 0,39	20,62c ± 1,03
Trehalose 8%	79,58c ± 0,20	1,91ab ± 0,15	15,66ab ± 0,31	30,62b ± 1,11
Maltose 8%	77,22d ± 0,89	1,63b ± 0,26	15,53b ± 0,36	31,51ab ± 1,90
MTS 8%	80,70b ± 0,23	2,21a ± 0,16	16,41b ± 0,59	32,59ab ± 1,57
MBS 8%	82,49a ± 0,44	1,72b ± 0,07	16,35b ± 0,29	33,45a ± 0.50

Values are means ±SD of seven measurements. Values in the same row with different letters (a-b) are significantly different (P< 0,05)

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