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QUALITATIVE AND QUANTITATIVE CHANGES OF THIAMINE IN TURKEY MEATBALLS IN THE PRESENCE OF POTASSIUM IODIDE

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Abstract. The aim of the work was to determine the effect of potassium iodide on quantitative and qualitative changes of thiamine during thermal processing (cooking) and storage of turkey meatballs. It was found that cooking resulted in 50% loss of total thiamine. Cool storage increased the losses by about 18%, while the use of the –18°C temperature for 30 days caused about 10% loss of the total thiamine. Addition of salt iodinated with potassium iodide increased the losses of both free and bound thiamine during cooking and storage by about 6%. Application of a collagen preparation impregnated with potassium iodide, and a mixture of collagen preparation with iodinated salt limited the losses up to 2%.

Key words: meat, thiamine, iodine, collagen, cooking, storage

INTRODUCTION

Broad range of food processing, preservation and storage methods requires understanding of both functional parameters of food components and mechanisms of reactions occurring among them. Besides basic indices, such as product quality concerning sensory and microbiological usefulness, the meaning of nutritive – wholesome quality of food increases. Considering high degree of processing of food products, one of the factors determining a product quality and correctness of applied treatments, is the content of indispensable but unstable vitamins.

Measurement of the group B vitamins, and particularly of thiamine, is, besides amino acid composition, the main index of nutritive value of meat and its products. Besides cereals and seeds of leguminous plants, meat is the main source of thiamine in our diet. Taking into account attractiveness of poultry meat and its products, its role as one of the thiamine sources increases.

In order to achieve maximal retention of thiamine during storage and further distribution of meat products, it is important to understand the effect of potassium iodide, which is used to enrich food in iodine, on the vitamin content.

The aim of this work was to determine the effect of potassium iodide on quantitative and qualitative changes of thiamine during cooking and storage of turkey meatballs. In the work model, technological conditions resulting from the effect of potassium iodide and storage conditions were taken into account. Among the storage conditions both cool and freeze storage were considered. Variability of the potential effect of potassium iodide was investigated using sodium chloride and collagen preparation as iodine carriers.

MATERIAL AND METHODS

Turkey meat (breast muscles, thighs and drumsticks) bought from an anonymous producer was used in the research. To obtain tissue homogeneity of the material the meat was separated from the bones, minced and mixed in the 1:1 ratio of breast muscles to thigh and drumstick mass. In dish preparation "pure" sodium chloride, salt enriched with potassium iodide in the amount of 3 mg/100 g, and collagen preparation were used. The collagen preparation was made from epimysium m. longissimus dorsi with Kopp's method [Kopp 1971] and freeze dried. Part of the collagen preparation was impregnated with potassium iodide. The impregnation consisted in rehydration of the preparation in the potassium iodide solution at 7.5 μg KJ/100 g concentration, using the 1:4 (m/m) ratio of the preparation to the solution. The concentration of the added potassium iodide was adjusted according to the amount introduced with sodium chloride.

Four meatball variants differing with respect to the kind of introduced additives were prepared (% with respect to the meat mass):

– variant 1–2% of sodium chloride,
– variant 2–2% of salt iodinated with potassium iodide,
– variant 3–2% of collagen preparation and 2% of salt iodinated with potassium iodide,
– variant 4–2% of collagen preparation impregnated with potassium iodide.

Cooking of 50 g meatballs started in boiling water and took 15 minutes at 3:1 (m/m) ratio of water to the product. The samples prepared in this way were stored in cool storage (temp. 4°C) for 4 and 6 days, and in freeze storage (temp. –18°C) for 20 and 30 days.

Directly after production and after the storage time the quantitative and qualitative changes in thiamin were determined. Taking into account biological forms of thiamine occurrence, the content of total, free and bound thiamine were determined. The amount of total and free thiamine was determined with a thiochromium method [Rettenmaier et al. 1979, Janitz 1985]. The content of bound thiamine was calculated from the difference between the total and free ones. The results of thiamine content are given recalculated into dry fat free mass. Therefore, the water content was determined with a drier method [PN-ISO 1442], the fat one with extraction – weight method according to Soxhlet using petroleum ether as a solvent [PN-ISO 1444], and the protein content with the Kjeldahal method [PN-75/A-04018]. Total nitrogen was recalculated into protein using 6.25 multiplier.

The results of measurements of thiamine content were subjected to variance analysis at the significance level: $\alpha < 0.05$.

RESULTS AND DISCUSSION

The obtained results indicated unfavorable effect of thermal processing on both free and bound thiamine. During cooking of the meat the total thiamine content was reduced by 50% at greater susceptibility to decomposition revealed by the bound vitamin. Such large fall of contents of both thiamine forms, confirmed with earlier investigations [Feliciotti and Esselen 1957, Demby and Cunningham 1980], should be explained with opening of thiazole ring and losing of biological activity taking place according to first-order reaction. Significant decrease of thiamine content during cooking was favoured by previous milling meats, which influenced enlargement of diffusion of both thiamine forms [Demby and Cunningham 1980, Ang et al. 1986, Waszkowiak et al. 2000]. Comminute of raw material and connected with this greater efficiency of hitting factor penetration contributed to greater losses of thiamine, in particular the form bound with more sensitive proteins [Pinheiro-Sant'ana et al. 1999, Waszkowiak et al. 1999].

Table 1. Effect of potassium iodide on quantitative and qualitative changes in thiamine during cooking of turkey meatballs
Tabela 1. Wpływ jodku potasu na zmiany ilościowe i jakościowe tiaminy podczas gotowania pulpetów z mięsa indyczego

Technological way Wariant technologiczny	Thiamine content, mg/100 g free-fat d.m. Zawartość tiaminy, mg/100 g s.m.b.					
	total – ogólna		free form – wolna		bound form – związana	
	x_t	%	x_f	%	x_t-x_f	%
NaCl	0.30[a*]	50.00	0.23[a]	48.94	0.07	53.85
NaCl + KJ	0.27[b]	45.00	0.21[c.b.a]	44.68	0.06	46.15
Collagen preparation + NaCl + KJ Preparat kolagenu i NaCl + KJ	0.30[a]	50.00	0.23[a]	48.94	0.07	53.85
Collagen preparation impregnated with potassium iodide Preparat kolagenu impregnowany KJ	0.30[a]	50.00	0.22[b.a]	46.81	0.08	61.54

% – thiamine content as compared to its content in raw meat.
*The means marked with different letters in the same column are statistically significantly different at $p < 0.05$.
x – arithmetic mean.
% – zawartość tiaminy w odniesieniu do zawartości tiaminy w mięsie surowym.
*Średnie oznaczone różnymi literami w tej samej kolumnie różnią się w sposób statystyczny istotnie przy $p < 0,05$.
x – średnia arytmetyczna.

Presence of a mixture of sodium chloride with potassium iodide increased the loss by about 5%. Model study showed that in the presence of oxidizing compounds, thiamine transforms into biologically inactive thiochromium. It was proved, that heating of thiamine in environment about pH 5-7 in the presence of oxidizing compounds caused entire destruction of thiamine in 5 minutes [Dwivedi and Arnold 1972]. Therefore, it seems possible that iodine, which is formed from potassium iodide, having oxidizing properties can also affect the amount of thiamine.

Table 2. Effect of potassium iodide on quantitative and qualitative changes in thiamine during storage of turkey meatballs
Tabela 2. Wpływ jodku potasu na zmiany ilościowe i jakościowe tiaminy podczas przechowywania pulpetów z mięsa indyczego

Technological way Wariant technologiczny		Thiamine content, mg/100 g Zawartość tiaminy, mg/100 g s.m.b.					
		total ogólna		free form wolna		bound form związana	
		x	%	x	%	x	%
	Days Dni	storage 4°C – przechowywanie w temp. 4°C					
NaCl	4	0.26^{a*}	86.70	0.21^{a}	91.30	0.05	71.43
	6	$0.19^{e.d}$	63.33	$0.15^{d.c}$	65.22	0.04	57.14
NaCl + KJ	4	0.20^{d}	74.07	$0.16^{c.b}$	76.19	0.04	66.67
	6	0.14^{g}	51.85	$0.12^{f.e}$	57.14	0.02	33.33
Collagen preparation + NaCl + KJ Preparat kolagenu i NaCl + KJ	4	$0.24^{c.b.a}$	80.00	$0.20^{b.a}$	86.96	0.04	57.14
	6	$0.18^{f.e.d}$	60.00	$0.15^{d.c}$	65.22	0.03	42.86
Collagen preparation impregnated with potassium iodide Preparat kolagenu impregnowanego KJ	4	$0.25^{b.a}$	83.33	$0.20^{b.a}$	90.91	0.05	62.50
	6	$0.18^{f.e.d}$	60.00	$0.14^{e.d.c}$	63.64	0.04	50.00
	Days Dni	storage –18°C – przechowywanie w temp. –18°C					
NaCl	20	0.25^{a}	83.33	0.19^{a}	82.61	0.06	85.71
	30	$0.24^{b.a}$	80.00	$0.18^{b.a}$	78.26	0.03	42.86
NaCl + KJ	20	$0.18^{f.e}$	66.67	$0.15^{d.c.b}$	71.43	0.03	50.00
	30	0.13^{g}	48.15	0.11^{e}	52.38	0.02	33.33
Collagen preparation + NaCl + KJ Preparat kolagenu i NaCl + KJ	20	$0.23^{c.b.a}$	76.67	$0.18^{b.a}$	78.26	0.05	71.43
	30	$0.21^{e.d.c.b}$	70.00	$0.17^{c.b.a}$	73.91	0.04	57.14
Collagen preparation impregnated with potassium iodide Preparat kolagenu impregnowanego KJ	20	$0.24^{b.a}$	80.00	$0.18^{b.a}$	81.82	0.06	75.00
	30	$0.22^{d.c.b}$	73.33	$0.17^{c.b.a}$	77.27	0.05	62.50

% – thiamine content as compared to its content in cooked meat.
*The means marked with different letters in the same column are statistically significantly different at $p < 0.05$.
% – zawartość tiaminy w odniesieniu do zawartości tiaminy w mięsie gotowanym,
*Średnie oznaczone różnymi literami w tej samej kolumnie różnią się w sposób statystyczny istotnie przy $p < 0,05$.

Application of the collagen preparation impregnated with potassium iodide as an iodine carrier facilitated maintaining the thiamine losses on the level of 50%, what permitted lowering of total thiamine by losses about 5%. More intensive protective activity of collagen on bound thiamine was observed, where losses decreased by about 10%. It can probably be explained by surrounding potassium iodide by collagen molecules and

hence limiting its oxidation to free iodine [Waszkowiak et al. 2000]. The same reaction was observed in the presence of the mixture of collagen preparation and the salt iodinated with potassium iodide.

Following 4 days of cool storage of the cooked-meatballs with sodium chloride the total thiamine content lowered by 13% at higher susceptibility to decomposition revealed by the bound vitamin. Prolongation of storage time to 6 days brought about increase of the loss by further 13%. These losses should probably be connected with unprofitable influence of fat oxidation products, forming in due to lengthening of storage time [Pikul 1992]. Investigations, relating incubation of beef with addition peroxided oil, showed enlargement of total thiamine losses about 40% [Szymandera-Buszka 1998]. Decrease of thiamine content, caused by presence of fat oxidation products, resulted from large sensibilities of the vitamin on red-ox factors [Dwivedi and Arnold 1972].

The presence of iodinated salt addition caused an increase in statistically significant way losses of the total thiamine during 4-day-long cool storage up to 26%, and after 6 days to 48%. The use of collagen preparation and iodinated salt, or the collagen preparation impregnated with potassium iodide facilitated limiting thiamine losses after 4-day-long storage to about 20%. As a storage time was prolonged to 6 days, the total thiamine losses in the samples with the addition of preparations was amounted to 40%, what permitted on increases of thiamine losses about 8%. Limitation of thiamine losses, during storages in presences of collagen should be explained with protective proprieties of proteins for both thiamine forms. Protective activity for thiamine showed e.g. α and β amino-acids [Janitz and Czyżewska 1983].

Protective activity of collagen is related to functional properties of these proteins. Important properties, which could efficiently limit the thiamine losses, was thermohydrolise of collagen, which took place during cooking. The effect of thermohydrolise was creating of framework from soluble collagen. The collagenous framework could be barrier which protects thiamine against oxidizing factors and limits its losses.

Similar relationship was noted during storing the cooked-meatballs at –18°C for 20 and 30 days. In the meat with an addition of sodium chloride the total thiamine losses were 17% after 20 days, and the use of iodinated salt increased the losses by further 16% at greater susceptibility to decomposition revealed by the bound thiamine. Extending storage time to 30 days increased thiamine losses in the presence of iodinated salt to 52%. An addition of collagen preparation impregnated with potassium iodide, and the one with iodinated salt facilitated lowering thiamine loss as compared to the samples with iodinated salt only.

This model of research also permitted confirmation of protective influence of preparation of collagen on both thiamine forms. In the meatballs stored for 20 days the presence of the collagen preparation limited thiamine losses to about 23%, and after 30 days the losses amounted to 30%, at considerably more intensive protective activity for bound thiamine.

CONCLUSIONS

1. Application of cooking as thermal processing causes 50% losses of the total thiamine. Further cool and freeze storage of meat products results in an increase in thiamine losses with more unfavorable effect revealed by cool storage.

2. Bound thiamine reveals greater susceptibility to decomposition during cooking and storage of meat products.

3. Addition of iodinated salt increases susceptibility to decomposition of free and bound thiamine both during cooking and storage.

4. Application of collagen preparation as iodine carrier results in reduction of thiamine losses as compared to the losses in the presence of iodinated salt.

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ZMIANY ILOŚCIOWE I JAKOŚCIOWE TIAMINY W PULPETACH Z MIĘSA INDYCZEGO W OBECNOŚCI JODKU POTASU

Streszczenie. Celem pracy było określenie wpływu jodku potasu na zmiany ilościowe i jakościowe tiaminy podczas obróbki cieplnej (gotowania) i przechowywania pulpetów z mięsa indyczego. Stwierdzono, że gotowanie przyczyniło się do wystąpienia 50% ubytków tiaminy ogólnej. Przechowywanie chłodnicze zwiększyło ubytki o około 18%, podczas gdy zastosowanie temperatury –18°C przez 30 dni spowodowało straty tiaminy ogólnej rzędu 10%. Dodatek soli jodowanej jodkiem potasu przyczynił się do zwiększenia ubytków zarówno tiaminy wolnej, jak i związanej podczas obróbki cieplnej i przechowywania o około 6%. Zastosowanie zarówno preparatu kolagenu impregnowanego jodkiem potasu, jak i mieszaniny preparatu kolagenu z solą jodowaną spowodowało ograniczenie ubytków do 2%.

Słowa kluczowe: mięso, tiamina, jod, kolagen, gotowanie, przechowywanie

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