Nauka Przyroda Technologie

2011
Tom 5
Zeszyt 1

ISSN 1897-7820 http://www.npt.up-poznan.net
Dział: Nauki o Żywności i Żywieniu

KRYSTYNA SZYMANDERA-BUSZKA, KATARZYNA WASZKOWIAK, MARZANNA HĘŚ, ANNA JĘDRUSEK-GOLIŃSKA

Department of Food Service and Catering
Poznań University of Life Sciences

THE EFFECT OF THE APPLICATION OF PROTEIN AND CELLULOSE PREPARATIONS AS IODINE CARRIERS ON STABILITY OF THIAMINE IN PROCESSED MEATS*

Summary. Fortification of processed meat with iodised table salt was shown to increase thiamine losses, both during thermal processing and storage. Taking into consideration the fact, as well as the recommendation for reduction of consumption of table salt, alternative iodine carriers need to be searched for. Thus the aim of the study was to determine the effect of soy protein isolate (SPI) and wheat fibre (WF) as iodine salts' (potassium iodide and iodate) carriers on thiamine stability in selected processed meats (steamed meatballs and burgers). The results were compared to the effect of iodised table salt. The highest thiamine losses were found in the presence of iodised table salt, both in the form of iodide and iodate. The application of iodised WF and SPI significantly limited thiamine losses in the course of steaming. It also made possible to reduce thiamine losses during storage in relation to iodised table salt. It was found that the application of WF and SPI as iodine carriers facilitates increased stability of thiamine in relation to table salt during processing and storage of the meat dishes.

Key words: thiamine retention, potassium iodide, potassium iodate, iodine carriers, soy protein isolate, wheat fibre

Introduction

Vitamin B_1, as a component of enzymatic systems, plays important role in human metabolism, i.e. in lipid and carbohydrates metabolism, as well as energy production. Primary sources of thiamine are cereals, pulses and pork. However, food processing

*This research has been supported by the Ministry of Scientific Research and Information Technology (Ministerstwo Nauki i Informatyzacji) in Poland under the project no. N31202731/ /2058.

cause considerable losses of thiamine, both in the free and bound form (DWIVEDI and ARNOLD 1972, SZYMANDERA-BUSZKA and WASZKOWIAK 2003, SEIDLER et AL. 2004, KONG et AL. 2008). Some technological additives may significantly affect the vitamin B_1 stability (DWIVEDI and ARNOLD 1972, BUI and SMALL 1990). It was shown in model studies that thiamine in the presence of oxidizing compounds (e.g. $KMnO_3$) is transformed into a biologically inactive form – thiochromium. Food fortification with iodine salts also increases thiamine losses. The application of table salt iodised with potassium iodide into meat dishes (meatballs and burgers and dumplings stuffed with meat – perogies) was shown to increase losses of total thiamine, both during thermal processing and storage. Taking into consideration the adverse action of iodised table salt on the vitamin stability, as well as the recommendation for of reduction consumption of the salt, alternative iodine carriers need to be searched for. The connective tissue proteins (collagen and elastin) were shown to be effectively applied for the purpose (WASZKOWIAK et AL. 2000, WASZKOWIAK and SZYMANDERA-BUSZKA 2007, 2008). Collagen was the most efficient and the effect was connected with its functional properties, especially its high water holding capacity. It was also found that the application of the proteins reduced thiamine losses in comparison to iodised table salt both during cooking and storage of fortified meatballs (WASZKOWIAK and SZYMANDERA-BUSZKA 2007).

Therefore, it was decided to apply other food additives which possessed similar functional properties as iodine salt carriers. Soy protein isolate and wheat fibre were selected and both carriers were shown to limit the dynamic of iodine changes in meat products in comparison with the dynamics when iodised table salt was used (WASZKOWIAK and SZYMANDERA-BUSZKA 2008).

The aim of the study was to determine the effect of soy protein isolate (SPI) and wheat fibre (WF) caring iodine salts (potassium iodide – KI and potassium iodate – KIO_3) on thiamine stability in selected processed meats.

Materials and methods

Iodine carriers

A soy protein isolate (Kulinaria S.A., Poland; composition: 89-91% protein; water holding capacity: 6 g of water per 1 g of isolate) and a wheat fiber Vitacel WF 400 (Kulinaria S.A., Poland; composition: 74% cellulose, 24% hemicellulose, water holding capacity: 10.5 g of water per 1 g of fibre) were used in the study as alternative carriers of iodine salt.

For the purpose of comparison a traditional iodine salt carrier, i.e. evaporated table salt (Salt Mine "Solino", Inowrocław, Poland) was also used in the study.

Carriers' iodination

Iodination process of WF and SPI was performed according to Waszkowiak and Szymandera-Buszka method (WASZKOWIAK and SZYMANDERA-BUSZKA 2008). Briefly, it consisted in soaking of the carriers with a KI or KIO_3 solution at ratio 1:4 (w/v) for approx. 30 min at room temperature and freeze-drying. The solutions of KI and KIO_3 were applied at a concentration of 7.5 mg/l and 9.75 mg/l, respectively.

Table salt was iodinated with potassium iodide or iodate by spray mixing (DIOSADY et AL. 1997). A total of 10 ml solution at a concentration of 3 g KI per 1 l or 3.9 g KIO_3 per 1 l, respectively, was sprayed per 1 kg table salt while it was constantly mixed in a homogenizer (Homogenizer 2094, Fos Tecator, Sweden) and the iodised table salt was freeze-dried.

Parameters of carrier iodination (concentrations of KI and KIO_3 solutions) were selected so that iodine content on carriers met the guidelines of the Polish government (ROZPORZĄDZENIE... 2003) concerning table salt iodination, i.e. 23 mg iodine per 1 kg carrier (which is equivalent to 30 mg KI per 1 kg or 39 mg KIO_3 per 1 kg, respectively).

Meat products production and storage

Meat pork was ground (mesh size diameter 3 mm) and mixed with components according to the formulation (minced meat – 70%, breadcrumbs – 7.5%, water – 14.8%, onion – 7.5%, pepper – 0.2%). The meat batter was divided into six portions and the following additives (% of meat batter) were blended in:

1) table salt iodised with KI (2%),
2) WF iodised with KI (2%) and non-iodised table salt (2%),
3) SPI iodised with KI (2%) and non-iodised table salt (2%),
4) table salt iodised with KIO_3 (2%),
5) WF iodised with KIO_3 (2%) and non-iodised table salt (2%),
6) SPI iodised with KIO_3 (2%) and non-iodised table salt (2%).

Carriers iodised with KI or KIO_3 were added to the batter in the hydrated form (WF at the 1:6 ratios, SPI at 1:3). The hydration rate of carriers was selected by results of sensory analysis of the products (JĘDRUSEK-GOLIŃSKA and SZYMANDERA-BUSZKA 2007) and was connected with their water holding capacity.

In order to maintain identical conditions determining the kinetics of thermal processing, balls of similar weight (50 ±1 g) were formed. Next they were roasted (230°C/16 min) or steamed (100°C/16 min) in a convection oven (Rational, Germany). Steamed meatballs and roasted meatballs (burgers) were freezer stored (–18°C) for five months.

Determination of thiamine content

The quantitative changes in thiamine were determined with a thiochromium method (AOAC... 1995) with some modifications.

Statistical analysis

The statistical analyses of data were performed with STATISTICA version 7.0 programme (StatSoft). To compare mean values of the thiamine content the analysis of variance (ANOVA) was applied. The data were compared for statistically significant differences by the Tukey's multiple range test ($p = 0.05$).

For analyses of thiamine changes during storage the correlations between variables were investigated by the regression analysis (PIKE 1986). The thiamine changes during storage time were found to be described well by exponential decay (correlation coefficient R^2 was always higher than 0.92). Thus, it was decided to apply half-life $t_{½}$ for comparison dynamics of the changes.

Results

Changes in thiamine content during cooking

The results showed a statistically significant ($p < 0.05$) changes in thiamine content after thermal processing (Table 1). The thiamine retention amounted of 81% and 78% in the products fortified with table salt iodised with KI and KIO_3, respectively, and the effect of thermal process (steaming or roasting) was not observed.

Table 1. Thiamine content in raw pork meatballs and after roasting or steaming (mean values, n = 7)
Tabela 1. Zawartość tiaminy w kotlecikach wieprzowych surowych oraz pieczonych i gotowanych (wartości średnie, n = 7)

Technology variant	Carrier					
	soy protein isolate		wheat fibre		table salt	
	content (mg per 100 g)	retention (%)	content (mg per 100 g)	retention (%)	content (mg per 100 g)	retention (%)
Fortified with KI						
Raw meatballs	1.100 a	100	1.170 a	100	1.120 a	100
Burgers (roasted)	0.904 b	82	0.945 b	81	0.900 b	81
Steamed meatballs	0.850 c	72	0.909 b	78	0.900 b	81
Fortified with KIO_3						
Raw meatballs	0.963 a	100	0.960 a	100	0.897 a	100
Burgers (roasted)	0.792 c	82	0.783 b	82	0.699 b	78
Steamed meatballs	0.871 b	90	0.755 b	79	0.700 b	78

Values with different letters in the same column are significantly different (one-way ANOVA and Tukey's test, $p < 0.05$).

The effect of alternative carriers on thiamine losses was found after steaming of meatballs (Table 1). The application of SPI as a carrier of KIO_3 was observed to increase the thiamine retention up to 90%. However, an adverse effect was shown after steaming of the balls fortified with KI. The losses of thiamine after roasting were similar for burgers irrespective of an applied carrier of KI and KIO_3.

Changes in thiamine during storage

The effect of freezer storage on the thiamine stability was also found to be significant (Tables 2 and 3). A statistically significant ($p < 0.05$) relationship was observed between storage time and thiamine content in meat products irrespective of thermal processing, as well as carrier and iodine form.

Table 2. Changes in thiamine content in pork dishes fortified with KI during freezer storage (mean values, n = 7)
Tabela 2. Zmiany zawartości tiaminy w daniach z wieprzowiny z dodatkiem KI podczas przechowywania zamrażalniczego (wartości średnie, n = 7)

Storage time (days)	Carrier					
	soy protein isolate		wheat fibre		table salt	
	content (mg per 100 g)	retention (%)	content (mg per 100 g)	retention (%)	content (mg per 100 g)	retention (%)
Burgers						
1	0.904 a	100	0.945 a	100	0.900 a	100
60	0.687 b	76	0.630 b	67	0.608 b	67
105	0.614 c	68	0.536 c	57	0.527 c	58
150	0.530 d	59	0.482 d	51	0.455 d	51
$t_{1/2}$	203		159		159	
Steamed meatballs						
1	0.850 a	100	0.909 a	100	0.900 a	100
60	0.599 b	70	0.599 b	66	0.572 b	64
105	0.552 c	65	0.550 c	60	0.531 c	59
150	0.548 c	64	0.478 d	52	0.455 d	51
$t_{1/2}$	245		170		163	

Values with different letters in the same column are significantly different (one-way ANOVA and Tukey's test, $p < 0.05$).

During storage of steamed meatballs the highest stability of thiamine was recorded in the presence of iodised SPI. The application of SPI as a carrier of KI increased the thiamine retention up to 64% after five-month storage of the meatballs in comparison to about 50% of retention in the ones with iodised WP or iodised table salt. After five-month storage of steamed meatballs containing KIO_3, the thiamine retention in the ones with SPI was also the highest. It amounted of 46% in comparison 42% and 34% in meatballs with iodised WP and table salt, respectively. Analysis of the dynamics of the changes in freezer stored meatballs showed the application of SPI as a carrier of KI made it possible to extend half-life of thiamine by 51%, while it was 41% for KIO_3 in relation to iodised table salt.

For steamed meatballs containing WP iodised with KI similar losses of thiamine were recorded as for products with iodised table salt. However, taking into consideration the dynamics of changes in thiamine content it was found that half-life of thiamine was longer for samples with the carrier in relation to ones with iodised table salt (Table 2). The calculated half-life for thiamine was longer by 27% for the dishes fortified with KIO_3 and by 4% only for the ones with KI.

Table 3. Changes in thiamine content in pork dishes fortified with KIO_3 during freezer storage (mean values, n = 7)
Tabela 3. Zmiany zawartości tiaminy w daniach z wieprzowiny z dodatkiem KIO_3 podczas przechowywania zamrażalniczego (wartości średnie, n = 7)

Storage time (days)	Carrier					
	soy protein isolate		wheat fibre		table salt	
	content (mg per 100 g)	retention (%)	content (mg per 100 g)	retention (%)	content (mg per 100 g)	retention (%)
Burgers						
1	0.792 a	100	0.783 a	100	0.699 a	100
60	0.558 b	70	0.592 b	76	0.431 b	62
105	0.554 b	70	0.508 c	65	0.362 c	52
150	0.494 c	62	0.532 d	68	0.333 d	48
$t_{1/2}$	241		263		140	
Steamed meatballs						
1	0.871 a	100	0.755 a	100	0.700 a	100
60	0.465 b	53	0.391 b	52	0.305 b	44
105	0.425 c	49	0.350 c	46	0.267 c	38
150	0.401 c	46	0.321 c	42	0.235 d	34
$t_{1/2}$	142		128		101	

Values with different letters in the same column are significantly different (one-way ANOVA and Tukey's test, $p < 0.05$).

When analysing the effect of the iodine carriers on thiamine stability in burgers during freezer storage the significant role of the form of iodine salt (KI or KIO_3) was observed. In case of KI, a higher stability was observed in samples with SPI applied as its carrier (59% of retention) than in samples with iodised WP or table salt (about 50% of retention). Calculated half-life for thiamine in burgers with iodised SPI was longer by 28%.

When KIO_3 was spread in burgers by WP even more advantageous effect on thiamine stability was observed. It made possible to extend the half-life of thiamine and increase thiamine retention after five-month storage up to 68% in relation to 62% and 48% of thiamine retention in burgers with iodised SPI and table salt, respectively.

Analysing the effect of the thermal process on thiamine stability during storage a statistically significant effect of the form of iodine salt was observed ($p < 0.05$). When KIO_3 was applied higher dynamics of thiamine degradation were recorded in meatballs (steamed samples). In samples with KI on SPI as carrier, changes in thiamine content were observed to be more dynamic during the storage of burgers (roasted) than steamed meatballs. Calculated half-life of thiamine was by 21% shorter in roasted samples. In turn, the dynamics of thiamine degradation were almost the same in roasted and steamed samples with an addition of remaining carriers.

Discussion

The studies confirmed the previous results concerning the adverse effect of heating on the thiamine stability (WASZKOWIAK et AL. 1999, SZYMANDERA-BUSZKA and WASZKOWIAK 2003, SEIDLER et AL. 2004). The influence of the temperature of 100°C has a significant effect on the disruption of the thiazole ring to hydrogen sulfide, derivatives of furane and thiofene. The thermal processing was observed to affect thiamine stability mostly during processing itself, as well as during successive storage. Boiling generally increased thiamine losses in comparison to roasting or frying. In the course of roasting the so-called skin was formed, resulting in a reduction of thermal drip and thiamine losses (DAVIDEK et AL. 1990, SZYMANDERA-BUSZKA et AL. 2006).

The effect of two iodine salts on thiamine losses was compared and lower stability of thiamine was observed in the presence of KIO_3 than KI. It was found irrespective of the applied iodine salt carrier. A longer half-life of KIO_3 to free iodine probably results in the formation of larger amounts of the element in relation to KI, which reacts faster (WANG et AL. 1999).

When analysing the effect of the applied iodine carrier the highest thiamine losses were observed in meat products with iodised table salt. Performing a simultaneous study on iodine retention in the burgers and steamed meatballs with the carriers (WASZKOWIAK and SZYMANDERA-BUSZKA 2008) we also found the lowest stability of KI and KIO_3 in products fortified with iodised table salt (an exception was the burgers with KIO_3). It shows a connection between stability of iodine salts and rate of thiamine losses in fortified meat products and confirms the results of our pervious study on application of collagen and elastin as carriers (SZYMANDERA-BUSZKA and WASZKOWIAK 2003, WASZKOWIAK and SZYMANDERA-BUSZKA 2007). A lower stability of iodine salts and their higher dynamics of changes into elementary iodine probably increased thiamine degradation in meat.

The application of SPI or WP instead of table salt as iodine carriers makes it possible to reduce thiamine losses. The protective action is higher during storage. SPI was shown to be more effective in protection of thiamine against degradation. The study of iodine retention, mentioned above (WASZKOWIAK and SZYMANDERA-BUSZKA 2008), also recommended SPI as the best iodine carrier among the applied ones (the lowest losses of iodine during storage were recorded). It was explained with a high water holding capacity, as well as formation of gel structure during thermal processes, both could stabilise iodine salts (DAVIDEK et AL. 1990, WASZKOWIAK and SZYMANDERA-BUSZKA 2005). Cellulose (the main component of WP) may probably form sheaths around iodine or thiamine resulting in limited protective effect, too.

The protective action of soy isolate may also be explained by its antioxidant properties. The thiazole ring enters a reaction with protein and it might be protected against the adverse action of free iodine, as well as other oxidising agents. In earlier studies

(SZYMANDERA-BUSZKA 2003) the protective action towards thiamine in the presence of oxidizing agents was also found for casein hydrolysate.

Conclusions

The results showed the application of soy protein isolate (SPI) and wheat fibre (WF) as iodine carriers facilitates increased stability of thiamine in relation to table salt. The effect was stronger during storage of processed meat and with an extension of storage time an increasingly advantageous effect was observed.

The simultaneous study indicated the carriers limited the iodine losses in meat products in comparison with iodised table salt. Therefore, both could be a recommended alternative to table salt in fortification of processed meats, caring iodine salts and protecting against changes in nutrition quality of the products.

References

AOAC Official Method 942.23. Thiamine (vitamin B_1) in food. 1995. In: Association of Official Analytical Chemists official method of analysis. Ed. P. Cunniff. Vol. 2. AOAC International, Arlington, VA, USA: 6-7.

BUI L.T.T., SMALL D.M., 1990. The impact of flours and product storage on the thiamin content of Asian noodles. LWT – Food Sci. Techn. 41, 2: 262-269.

DAVIDEK J., VELISE J., POKORNY J., 1990. Chemical changes during food processing. Department of Food Chemistry and Analysis Institute of Chemical Technology, Prague.

DIOSADY L.L., ALBERTI J.O., MANNAR V.M.G., STONE T.G., 1997. Stability of iodine in iodized salt used for correction of iodine-deficiency disorders. Food Nutr. Bull. 18, 4: 388-397.

DIOSADY L.L., MANNAR V.M.G., 2000. Stability of iodine in iodized salt. In: 8th World Salt Symposium. Ed. R.M. Geertman. Elsevier, Amsterdam: 977-982.

DWIVEDI B.K., ARNOLD R.G., 1972. Chemistry of thiamine degradation 4-methyl-S(β-hydroxyethyl) thiazole from thermally degraded thiamine. J. Food Sci. 37: 689-692.

GAWĘCKI J., HRYNIEWIECKI L., 2000. Żywienie człowieka. Podstawy nauki o żywieniu. Wyd. Nauk. PWN, Warszawa.

JĘDRUSEK-GOLIŃSKA A., SZYMANDERA-BUSZKA K., 2007. Consumer desirability of pork meat products with an addition of preparations being carriers of iodine. Pol. J. Hum. Nutr. Metab. 34, 1/2: 779-782.

KONG F., OLIVEIRA A., TANG J., RASCO B., Crapo Ch., 2008. Salt effect on heat-induced physical and chemical changes of salmon fillet (*O. gorbuscha*). Food Chem. 106, 3: 957-966.

PIKE D.J., 1986. A practical approach to regression. In: Statistical procedures in food research. Ed. J.R. Piggott. Elsevier, London: 61-100.

ROZPORZĄDZENIE Ministra Zdrowia z dnia 19 grudnia 2002 r. w sprawie substancji wzbogacających dodawanych do żywności i warunków ich stosowania. 2003. Dz. U. 27, poz. 237.

SEIDLER T., CARNOVALE E., LUCARINI G., INCERTI I., 2004. Effect of conventional and HTST sterilization on thiamine and riboflavin content in salmon and hake canned products. Acta Sci. Pol. Technol. Aliment. 3, 2: 45-56.

SZYMANDERA-BUSZKA K., 2003. Quantitative and qualitative changes of thiamine in sterilized pork in the presence of selected technological additives. Pol. J. Food Nutr. Sci. 12, 53, 4: 59-62.

Szymandera-Buszka K., Górecka D., Hęś M., Waszkowiak K., 2006. Stability of thiamine during of barley groats' cooking. Pol. J. Environ. Stud. 15, 2B: 835-837.

Szymandera-Buszka K., Waszkowiak K., 2003. Qualitative and quantitative changes of thiamine in turkey meatballs in the presence of potassium iodide. Acta Sci. Pol. Technol. Aliment. 2, 2: 95-102.

Wang G.Y., Zhou R.H., Wang Z., Shi L., Sun M., 1999. Effects of storage and cooking on iodine content in iodized salt and study on monitoring iodine content in iodized salt. Biomed. Environ. Sci. 12: 1-9.

Waszkowiak K., Szymandera-Buszka K., 2005. Utilization preparations of connective tissue proteins as carriers of potassium iodide – studies of iodine retention during their storage. Pol. J. Hum. Nutr. Metab. 32, suppl. 1: 1130-1134.

Waszkowiak K., Szymandera-Buszka K., 2007. Effect of collagen preparations used as carriers of potassium iodide on retention of iodine and thiamine during cooking and storage of pork meatballs. J. Sci. Food Agric. 87, 8: 1473-1479.

Waszkowiak K., Szymandera-Buszka K., 2008. Effect of storage conditions on potassium iodide stability in iodised table salt and collagen preparations. Int. J. Food Sci. Technol. 43, 5: 895-899.

Waszkowiak K., Szymandera-Buszka K., Janitz W., 2000. Utilization of collagen isolate as a carrier of potassium iodide in production and storage of dishes from turkey meat. Electr. J. Pol. Agric. Univ. Ser. Food Sci. Technol. 3, 2, #05.

Waszkowiak K., Szymandera-Buszka K., Janitz W., Górecka D., 1999. Comparative evaluation of nutritive and sensory value of selected raw materials and dishes after thermal processing in a convection oven and with conventional methods. Electr. J. Pol. Agric. Univ. Ser. Food Sci. Technol. 2, 2, #08.

WPŁYW ZASTOSOWANIA PREPARATÓW BIAŁKOWYCH I CELULOZOWYCH JAKO NOŚNIKÓW SOLI JODU NA STABILNOŚĆ TIAMINY W POTRAWACH MIĘSNYCH

Streszczenie. Badania nad wykorzystaniem izolatu białka soi oraz błonnika pszennego dla wzbogacania produktów mięsnych w jod wykazały, iż oba te preparaty mogą być zastosowane jako alternatywne nośniki soli jodu, istotnie ograniczając straty jodu podczas produkcji oraz przechowywania. Postanowiono zatem ocenić wpływ powyższych nośników na zmiany zawartości tiaminy jako wskaźnika wartości odżywczej produktów mięsnych. Celem pracy było określenie wpływu izolatu białka soi oraz preparatu błonnika pszennego jako nośników soli jodu (jodku i jodanu potasu) na stabilność tiaminy w wybranych potrawach mięsnych (pulpety i kotlety). Stwierdzono, że wpływ nośnika na straty tiaminy podczas obróbki termicznej był determinowany rodzajem soli jodu użytej dla wzbogacania produktów. Ochronne działanie wobec tiaminy obu alternatywnych nośników zaobserwowano tylko w przypadku potraw wzbogacanych w jodek potasu. Stwierdzono mniejsze straty tiaminy podczas przechowywania potraw zawierających jodowany izolat białka soi oraz preparat błonnika pszennego w porównaniu z potrawami z dodatkiem jodowanej soli kuchennej.

Słowa kluczowe: retencja tiaminy, jodan potasu, jodek potasu, nośniki jodu, izolat białka soi, włókno pszenne

Corresponding address – Adres do korespondencji:
Krystyna Szymandera-Buszka, Katedra Technologii Żywienia Człowieka, Uniwersytet Przyrodniczy w Poznaniu, ul. Wojska Polskiego 31/33, 60-624 Poznań, Poland, e-mail: krbuszka@up.poznan.pl

Accepted for print – Zaakceptowano do druku:
19.10.2010

For citation – Do cytowania:
Szymandera-Buszka K., Waszkowiak K., Hęś M., Jędrusek-Golińska A., 2011. The effect of the application of protein and cellulose preparations as iodine carriers on stability of thiamine in processed meats. Nauka Przyr. Technol. 5, 1, #1.