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Content of nitrates (V) and (III) in the meat tissue of different animal species

Zawartość azotanów(V) i azotanów(III) w tkankach mięsnych różnych gatunków zwierząt

Summary: The aim of the present study was to determine the content of nitrates (V) and nitrates (III) in the meat tissue of different animal species. The study revealed that the content of nitrates (V) and (III) in beef, pork and poultry differed, while the place of purchase influenced the content of nitrates (V) and (III). The samples of beef, pork and poultry contained very low quantities of the compounds, which were below norms. The nitrates (V) and (III) concentrations in raw meat was differentiated by its type and purchase place. The content of nitrogen compounds in the examined raw meat samples were within a lower range of permissible norms and met the EU food law.

Key words: nitrates (V), nitrates (III), poultry meat, pork, beef

INTRODUCTION

The human's health is determined by various factors, but mainly the composition and biological value of a food. Among a spectrum of different factors, food contamination is the most undesirable. At any time, they may penetrate into the environment, or from the environment through the food chain get to food and human's organism [Karłowski *et al.* 1988].

Experiments involving animals revealed that nitrates (V) and (III) contributed, among others, to the inhibition of body weight gains, decrease of reproduction indices, miscarriages, foetus resorption, as well as may cause a negative influences on thyroid functions and decrease of A, B, and E vitamins levels.

According to Litwińczuk *et al.* [2004], the main sources of nitrates (V) and (III) in animal-origin products are contaminated fodder, vegetables, green forage, and silage along with their high concentrations in water. Experiments carried out by Karłowski *et al*.

[1988], Kühne [2004], and Michalski [1996, 1997] revealed that nitrates (V) and (III) were quickly absorbed from alimentary tract, and part of them could be metabolized due to the microflora present in digestive tract. Depending on the specificity of microflora in digestive tract, pH, and nutrients availability, nitrates (V) may be converted onto nitrates (III), nitrogen oxides, hydroxylamine, or ammonia [Kühne 2004, Synowiecki 1996].

Applying various additives, functional sets in fodders, and procedures for raw meat processing such as pickling or smoking, regardless of the tastiness improvement, affects the increase in nitrogen compounds concentrations: nitrates (V) and (III) as well as nitrosamines in final meat products [Michalski 1997, PN-74/A82114, Tietze *et al.* 2007]. Rywotycki [1999] and Słowiński [2001] reported that usually sodium nitrate (III) is used to pickle meat. Due to its high chemical activity, it can enter the side-reactions that are not associated with pickling process, i.e. nitrose-producing with N-nitrosamines as main products, that may be a cause of many cancer diseases at animals and people. The smoking process, besides improvements in meat products taste, shows negative effects in a form of the decrease of amino acids profile, proteins, and contamination with toxic substances, and even carcinogenic.

The study aimed at evaluating the nitrates (V) and (III) contents in poultry, pork, and beef meat tissue from various meat processing works and the trade localized in Lublin region.

MATERIAL AND METHODS

Study was carried out in 2006. Material consisted of poultry fillet, pork loin and beef tenderloin originating from five selected meat processing works. Livestock, the examined meat samples were taken, was produced in middle-eastern regions of Poland, mainly in Lublin, Biała Podlaska, Radzyń and surrounding communes.

Due to the data protection requirements, names of processing works were encoded with following letters: W, C, R, K, and L. In total, 75 meat samples were examined – 25 from each animals species. Nitrates (V) and (III) contents were determined in accordance to PN-74/A-82114.

Ground meat samples of 1 g weight each with borax addition were warmed on a water bath, and then proteins were removed by adding potassium hexacyanoferrate and zinc acetate. The solution was filtered and Griess's reagent was added to measure the absorbance at λ=250 nm wavelength. The calibration curve allowed for reading out the amount of sodium nitrate (III) in $\mu g/1cm^3$ that corresponded to the absorbance of determined solution.

Results were subjected to statistical processing using STATISTICA ver. 6 software, and applying single-factor variance analysis (ANOVA) assuming the significance level for $p \leq 0.05$

RESULTS AND DISCUSSION

Presence of nitrogen compounds in food products is a serious threat for health, even life of consumers, due to their carcinogenic character [Rywotycki 1999, Słowiński

2001]. Monitoring of their contents in foodstuff provides with a current information and allows for learn how processing affects their final concentrations directly before consuming, while determining their quantities in raw materials proves a high culture of agricultural crops and high quality of fodders for animals [Traczyk 2000].

Results from assessing the raw meat contamination with nitrates (V) and (III) are presented in Tables 1 and 2 including muscle tissues of poultry, pork, and beef as well as purchase site, i.e. meat processing works W, C, R, K, and L.

Level of nitrates (V) in poultry meat was from 0.59 to 9.70 mg/kg FW. The highest value was recorded in samples from works R and K, while the lowest from L. Presence of nitrates (V) in samples from L was six times lower than maximum value found.

Assessment of pork revealed that nitrates (V) content was from 3.24 to 13.16 mg/kg FW with the lowest concentration in meat from works C, and four times higher value from L. Contents of nitrates (V) from three other meat processing works were similar.

Referring to beef, nitrate (V) level showed a statistically significant variations from 0.61 to 11.05 mg/kg FW. The smallest amounts of nitrates (V) were found in beef from L, whereas the largest – in samples from R (18 times more). Differences occurred in beef tissue samples from W, C, and K, but they were not highly significant.

Amongst three examined meat types (poultry, pork, and beef), the largest quantity of nitrates (V) was recorded in pork, then beef, while the smallest – in poultry.

When comparing the meat processing works, i.e. sample origin, meat from C and L contained the least nitrates (V) (from 3.3 to 4.8 mg/kg FW, on average), whereas the highest levels were recorded in meat from K, W, and R, regardless of the meat type.

Contents of nitrates (III) in assessed tissues of poultry, pork, and beef meat indicated statistically significant differences, but they were not highly significant. Recorded differentiation referred to meat type and its origin (Tab. 2).

It was found that amount of nitrates (III) in poultry fillet ranged from 0.55 in C and L to 3.80 mg/kg FW in W, and the differences were not so high as those for nitrates (V).

In pork samples, average nitrates (III) concentration oscillated from 0.24 to 3.60 mg/kg FW in W and K. And similarly as for nitrates (V), a differentiation referring to the purchase place was recorded, but it was apparently lower.

The content of nitrates (III) in beef was the lowest and ranged from 0.20 to 4.00 mg/kg FW. Their similar concentrations were found in beef originating from L and C. It is noteworthy that nitrates (III) accumulation in assessed meat samples was lower than that of nitrates (V), and the lowest differences between nitrates (V) and (III) were recorded for pork meat (Tab. 1 and 2).

Polish Norms (PN-74/A82114) permit the presence of nitrates (V) in raw meat at levels from 1.00 to 200 mg/kg FW, while requirements for nitrates (III) are slightly less restrictive: meat can contain by 50 mg/kg FW more nitrates (III). Examined samples of different-type meat tissues contained nitrates (III) and (V) at their lowest permissible norms levels, whereas 40% of them (referring to nitrates (V)) and 70% (referring to nitrates (III)) contained determined nitrogen compounds at levels below permissible values.

The study revealed that contents of nitrates (III) and (V) as nitrosamines precursors, varied in reference to the meat type and purchase place. Concentration of nitrates was very low and, as compared to obligatory norms, the maximum nitrates (V) quantity found (13.16 mg/kg FW) made up only 6.58%.

Table 1. Content of nitrates (V) in selected animal tissues originating from different meat processing works ($NaNO_3$ mg kg^{-1} FW)
Tabela 1. Zawartość azotanów(V) w wybranych tkankach zwierząt pochodzących z różnych zakładów mięsnych ($NaNO_3$ mg · kg^{-1} s.m.)

Tissue Rodzaj tkanki	Purchase place – Zakłady mięsne									
	W		C		R		K		L	
	mean średnia	SD	mean średnia	SD	mean średnia	SD	mean średnia	SD	mean średnia	SD
Poultry (fillet) Mięso drobiowe (filet)	7.00^{ab}	1.23	3.30^{b}	1.02	9.70^{a}	1.42	9.16^{a}	2.13	0.59^{c}	0.08
Pork (loin) Mięso wieprzowe (schab)	7.27^{b}	1.02	3.24^{c}	0.96	9.16^{ab}	1.35	7.27^{b}	1.14	13.16^{a}	3.24
Beef (tenderloin) Mięso wołowe (polędwiczki)	6.74^{b}	0.95	3.26^{bc}	1.04	11.05^{a}	2.26	10.24^{a}	2.63	0.61^{c}	0.09

a b, c – values in rows marked with different letters show statistically significant differences at $p \leq 0.05$ – wartości w wierszach oznaczone różnymi literami różnią się statystycznie istotnie, $p \leq 0,05$
W, C, R, K, and L – meat processing works, where raw meat was purchased (poultry fillet, pork loin, beef tenderloin) – zakłady mięsne w których zakupione zostało mięso surowe (filet drobiowy, schab wieprzowy i polędwiczka wołowa)

Table 2. Content of nitrates (III) in selected animal tissues originating from different meat processing works ($NaNO_2$ mg kg^{-1} FW)
Tabela 2. Zawartość azotanów(III) w wybranych tkankach zwierząt pochodzących z różnych zakładów mięsnych ($NaNO_2$ mg · kg^{-1} s.m.)

Tissue Rodzaj tkanki	Purchase place – Zakłady mięsne									
	W		C		R		K		L	
	mean średnia	SD	mean średnia	SD	mean średnia	SD	mean średnia	SD	mean średnia	SD
Poultry (fillet) Mięso drobiowe (filet)	3.80^{a}	1.21	0.55^{c}	0.09	1.80^{b}	0.05	2.20^{ab}	1.03	0.55^{c}	0.03
Pork (loin) Mięso wieprzowe (schab)	3.60^{a}	1.26	0.60^{c}	0.08	2.20^{b}	1.00	3.60^{a}	1.06	0.24^{c}	0.02
Beef (tenderloin) Mięso wołowe (polędwiczki)	4.00^{a}	1.03	0.58^{c}	0.02	0.20^{c}	0.006	2.0^{b}	0.07	0.55^{c}	0.04

a b, c – values in rows marked with different letters show statistically significant differences at $p \leq 0.05$ – wartości w wierszach oznaczone różnymi literami różnią się statystycznie istotnie, $p \leq 0,05$
W, C, R, K, and L – meat processing works, where raw meat was purchased (poultry fillet, pork loin, beef tenderloin) – zakłady mięsne, w których zakupione zostało mięso surowe (filet drobiowy, schab wieprzowy i polędwiczka wołowa)

There are many sources of nitrates (V) and (III) in a diet. They may be naturally present in drinking water, may originate from mineral fertilizers, as well as industrial wastewaters or processing procedures such as pickling and smoking may introduce them [Karłowski *et al*. 1988, Tietze *et al*. 2007].

Under natural conditions, their amount is determined by geological factors, extent of mineral fertilization, and the size of industrial emission. Natural surface waters do not contain more than 10 mg/dm^3 of nitrates (V) and 1 mg/dm^3 of nitrates (III). In opinion of Karłowski *et al*. [1988], Kühne [2004], as well as Synowiecki [1996], and Traczyk [2000], both nitrates types influence on human's health. However, nitrates (III) are more harmful for living organisms, because they may lead to the inhibition of body weight gains, decrease of reproductive indices, and first of all, decrease the vitamins and biologically active substances presence in an organism [Kühne 2004, Rywotycki 1999, Synowiecki 1996]. Studies carried out by many scientists [Kühne 2004, Michalski 1996, Synowiecki 1996, Traczyk 2000] revealed that both raw materials, and foodstuff are contaminated with nitrates that are highly toxic, mutagenic, and carcinogenic. Their presence is mainly determined by an environment along with a man responsible for technological processes accompanied by their precursors.

Nitrogen oxide that, regardless of an outer supply (ingestion by various systems, including in a form of xenobiotics), may be synthesized in different organs and tissues, is another source of nitrates in animal's organism. It play the role of a radical and may be oxidized to nitrates (V) and (III). According to Michalski [1996, 1997] and Rywotycki [1999], large amounts of these substances is produced during foodstuff processing, but the quantity and quality of additives are strictly determined by law regulations. Therefore, monitoring of nitrogen compounds contamination of materials for food production is advisable, because it allows for determining the level of pollution and, on the other hand, indicates the efficiency of such processes as conservation, pickling, or smoking that affect the antioxidation and bacteriostatic processes. The lower initial contamination of a raw material, the lower level of discussed substances in final products ready for consumption. Available literature contains small number of publications upon nitrates (V) and (III) contents in animal tissues. Hence, comparison of own results with other ones is difficult. Kühne [2004] reported that according to EU food law, the highest permissible $NaNO_3$ remains in meat products thermally not processed should not exceed 50 mg/kg FW. Here achieved results related to meat contamination with nitrosamine compounds can be considered as highly satisfactory, because they reveal their low contents that are not the threat for consumer's health.

CONCLUSIONS

1. The nitrates (V) and (III) concentrations in raw meat was differentiated by its type and purchase place.

2. Contents of nitrogen compounds in examined raw meat samples were within lower range of permissible norms and met the EU food law.

3. The highest nitrates (V) concentration was recorded in pork, while the lowest in poultry. Referring to nitrates (III), their lowest amounts were determined in beef, and the highest – in pork.

4. The lowest levels of nitrates (V) and (III) were determined in meat from meat processing work C, that purchased slaughtered livestock from surrounding communes of Lublin region.

5. Achieved results prove low level of meat contamination with nitrates (V) and (III) as well as its appropriate quality.

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Streszczenie. Celem pracy było określenie zawartości azotanów (V) i azotanów (III) w tkankach mięsnych różnych gatunków zwierząt. Koncentrację azotanów (V) i (III) w mięsie surowym różnicował jego gatunek oraz miejsce pochodzenia. Zawartość związków azotowych w ocenianych próbkach mięsa surowego mieściła się w dolnych granicach dopuszczalnych norm i odpowiadała wymogom prawa żywnościowego UE.

Słowa kluczowe: azotany (V), azotany (III), mięso wołowe, mięso wieprzowe, mięso drobiowe