PREDICTION OF BIOGENIC AMINES AND POLYAMINES FORMATION BY VOLATILE BASIC NITROGEN (VBN) DURING STORAGE OF MEAT AND POULTRY

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Background

Biogenic amines are formed in various foods during storage through the decarboxylation of amino acids. This process involves the amino acid decarboxylase of microorganisms or tissue (Halasz et al., 1994; Hernandez-Jover et al., 1997). The consumption of food containing high amounts may have toxicological effects (Silla Santos, 1996). In contrast, polyamines arise in food through two sources: the biosynthesis from amino acids and the synthesis by bacterial flora (Bardocz, 1995). Amines include cadaverine, putrescine, histamine, tyramine, serotonin, β-phenylethylamine, spermine, and spermidine. Cadaverine is formed from lysine; putrescine from ornithine; histamine from histidine; tyramine from tyrosine; serotonine from tryptophan; β-phenylethylamine from phenylalanine; spermine from putrescine, and spermidine from spermine (Halasz et al., 1994). For meat, attempts have been made to utilize biogenic amines content as an index for the freshness of muscle food (Mietz and Karmas, 1977; Veciana-Nogues et al., 1997). Because the production of ammonia due to the deamination of amino acids increases in meat and poultry during storage, the total level of volatile basic nitrogen (VBN) was found to be one of the best indices of the decomposition of fresh meat and poultry (Byun, 2000).

Objectives

Since VBN has been used as an index of freshness for meat and poultry, the relationship between VBN and biogenic amines was examined. The goal was to explore the possibility of predicting the formation of biogenic amines during the storage of meat and poultry based on the level of VBN.

Methods

Samples of beef and pork were purchased from a slaughterhouse one day after the slaughter. The samples of chicken were obtained the day after slaughter from a local market. Only lean flesh was taken from the samples, then ground, and made into patties of about 100 g. The latter were packaged in HDPE film. They were stored in a refrigerator at 4 ± 2^{o} C. To measure the VBN and amines, the samples of beef and pork were removed from storage at 1, 4, 7, and 15 days. The chicken samples were tested at 1, 3, 5, and 9 days. The amines were determined by the method of Eerola et al. (1993), while VBN relied on approach of the Pharmacology Society of Japan (1986). The Statistical Analysis System Computer Programmed Method (2000) was used for data analysis and interpretation. A simple linear regression model was used to compare the Pearson correlation coefficients between VBN and each amine in samples of meat and poultry.

Results and Discussion

In the samples of beef, serotonin, spermidine, and spermine did not differe significantly as a function of storage time. On the other hand, changes were observed in β-phenylethylamine, putrescine, cadaverine, histamine, and tyramine. The level of the VBN increased with time of storage. When biogenic amines and polyamines were analyzed in relation to VBN, their formation in beef could be predicted over time, with the exception of serotonin and spermine (Table 1). The formation of β-phenylethylamine was highly correlated to the level of VBN. In pork the trends were similar to those in beef except for the fact that serotonin decreased significantly with time during storage, while histamine did not change significantly over time. For the regression equations based on VBN, histamine was the only amine which could not be predicted (Table 2). Putrescine gave the highest coefficient of determination (r^2). As for chicken, the situation was different from that of red meat. With chicken breast, all the biogenic amines increased significantly with storage time. In the case of polyamines, spermine increased significantly with time. It has been reported that putrescine, spermidine and spermine are ubiquitous components of meat; most bacteria contain putrescine, cadaverine and spermidine but no spermine (Tabor and Tabor, 1984). The regression on VBN during storage was highly significant for most of the amines except histamine and spermidine (Table 3). In chicken leg, β-phenylethylamine, serotonin, spermidine, and spermine did not change significantly with storage time. The regression models based on VBN could predict the formation of putrescine, cadaverine, histamine, and tyramine (Table 4). In general, the regressions for putrescine, cadaverine and tyramine exhibited highly significant dependence on VBN for both meat and poultry. The differences among the biogenic amines and polyamines in the regression models of VBN during storage might be due in part to differences in the dominant microbial flora within the samples of meat and poultry.

Conclusions

The level of biogenic amines and polyamines in meat and poultry changed during storage. The extent of change differed among the different amines. VBN, which is a good index of microbial spoilage, could serve as a predictor for the formation of biogenic amines and polyamines during storage. However, the kind amines to be predicted using VBN differed among meats and poultry. It may be due to the differences in the dominant microbial flora among meats and poultry.

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Table 1. Linear regression of Biogenic amines on VBN during storage of beef loins

	X	Y^a	Regression equation	R^2
Beef loins	VBN	PHE^{***}	Y = 0.08X - 0.76	0.9210
		PUT^{***}	Y = 6.22X - 57.93	0.8835
		CAD^{***}	Y = 5.22X - 29.89	0.6372
		HIS^{**}	Y = 0.15X + 1.40	0.5059
		SER	Y = -0.14X + 14.79	0.1196
		TYR^{***}	Y = 0.43X - 2.54	0.6817
		SPD^{**}	Y = 0.09X + 2.81	0.4349
		SPM	Y = 0.01X + 33.04	0.0009

** P<0.01 ; *** P<0.001, [a] PHE:ç-phenylethylamine; PUT: putrescine; CAD: cadaverine; HIS: histamine; SER: serotonin; TYR: tyramine; SPD: spermidine; SPM: spermine

Table 2. Linear regression of Biogenic amines on VBN during storage of pork loins

	X	Y^a	Regression equation	R^2
Pork loins	VBN	PHE^{***}	Y = 0.26X - 2.76	0.8010
		PUT^{***}	Y = 2.24X - 26.71	0.8982
		CAD^{***}	Y = 4.19X - 37.71	0.7864
		HIS	Y = 0.02X + 1.01	0.1045
		SER^{***}	Y = -0.52X + 25.89	0.5843
		TYR^{***}	Y = 0.81X - 8.95	0.7455
		SPD^{**}	Y = 0.20X - 0.15	0.5124
		SPM^{**}	Y = 0.34X + 26.93	0.4154

** P<0.01 ; *** P<0.001, [a] same as in Table 1.

Table 3. Linear regression of Biogenic amines on VBN during storage of chicken breasts

	X	Y^a	Regression equation	R^2
Chicken breasts	VBN	PHE^{**}	Y = 0.19X - 1.21	0.5197
		PUT^{***}	Y = 7.37X - 77.47	0.6614
		CAD^{**}	Y = 2.82X - 30.59	0.4261
		HIS	Y = 0.21X + 4.24	0.1013
		SER^{*}	Y = 0.30X + 5.18	0.3857
		TYR^{**}	Y = 4.08X - 43.16	0.4593
		SPD	Y = 0.02X + 6.60	0.0321
		SPM^{**}	Y = 0.99X + 41.05	0.4456

*P<0.05 ; ** P<0.01 ; *** P<0.001, [a] same as in Table 1.

Table 4. Linear regression of Biogenic amines on VBN during storage of chicken legs

	X	Y^a	Regression equation	R^2
Chicken legs	VBN	PHE	Y = 0.50X + 2.98	0.0155
		PUT^{***}	Y = 5.70X - 56.70	0.6755
		CAD^{***}	Y = 1.35X - 11.29	0.6743
		HIS^{**}	Y = 0.32X + 0.67	0.5243
		SER	Y = 0.08X + 13.01	0.0079
		TYR^{***}	Y = 1.46X - 10.40	0.5882
		SPD	Y = -0.08X + 11.04	0.0321
		SPM	Y = 0.24X + 68.71	0.0097

** P<0.01 ; *** P<0.001, , [a] same as in Table 1