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COMPARISON OF INDICATORS FOR MICROBIAL QUALITY OF MEAT DURING AEROBIC COLD STORAGE

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Background

Consumers' concern on the freshness of meat they purchase has been growing high. It would benefit both the consumers and the industry to have reliable methods of assessing the microbial quality/freshness of meat. As direct microbial analysis is costly and time-consuming, alternative methods associated with chemical changes due to microbial growth have been intensively studied(Dainty, 1996). Chemical methods of assessment relating to protein breakdown and fat spoilage, and some techniques measuring physical changes are suitable for spoilage indicators (Singhal et al., 1997). More than 40 chemical, physical and microbiological methods have been proposed for the detection and measurements of bacterial spoilage in meats (Jay, 1986; Sheridan, 1995). However, these methods have drawbacks of one kind or another, since the observed chemical changes are essentially an expression of the development of a food ecosystem (Nychas et al., 1998)

Objective

To evaluate the indicators of predicting the microbial quality of pork and beef loins during cold storage under aerobic condition.

Methods

Fresh loins of beef and pork shortly after the completion of rigor were purchased and backfats were removed aseptically before packaging with polyethylene film (Canaan Co., Ltd., Seoul, Korea). Packaged samples were stored at 0° C and 4° C until total plate count(TPC) reached over 10^8. During the storage time, samples were taken out periodically for measurements of electric conductivity, amines, D-glucose, L-lactate, TPC, psychrotrophic bacterial count, pH, volatile basic nitrogen(VBN), and TBA value. Triplicate experiments were carried out. Conductivity was measured in meat by using LT8K21 conductivity meter (NWK-Binar Gmbh, Germany). Amines analysis were according to Eerola et al.(1993) using HPLC(Model M930, Young-Lin Co., Seoul, Korea) on a Symmetry C 18 (3.9 X150cm) column (Waters, Co., Milford, USA). D-glucose and L-lactate were analyzed by using the enzyme analysis kit (Boehringer Mannheim, Ubinghen, Germany) with the method of Lambropoulou et al.(1996). TPC and psychrotrophic bacterial count were made by using Swab method (APHA, 1985) and Petrifilm(Microbiology Products 3M Health Care, USA) according to AOAC(1995). Measurements of TBA and VBN were by the method of Witte et al.(1970) and PSJ(1986). Statistical analysis was carried out for Pearson correlation coefficients by SAS(1995).

Results and discussions

As for beef, the result of Table 1 showed that bioamines were highly correlated with both TPC and psychrotrophic count at both storage temperatures. The increment of histamine and tyramine during the storage time were so small that it would be difficult for them to be used as a indicator of microbial quality. Dahr and Simard (1985) showed that in ground beef with TPC and psychrotrophic bacteria counts ranged from 10^2 to 10^9 /g, the bacterial counts were very significantly correlated with putrescine, tyramine, cadaverine and spermidine. They suggested that putrescine may be used as a direct bacterial count indicator. In this study the change of putrescine was the biggest in beef while in pork, that of cadaverine. They gave good correlation with microbial count during the storage time. Microbial counts of beef and pork samples were $10^{2.5}$ /cm^2 and $10^{2.8}$ /cm^2 at the beginning and 10^8 /cm^2 and $10^{8.5}$ /cm^2 at the end of the experiment, respectively. Because the ammonia production due to deamination of amino acids increases during spoilage, total volatile basic nitrogen(VBN) has been used as an index of decomposition of fresh meat in Korea and Japan. A maximum acceptability limit of 20 mg volatile nitrogen for 100g of fat free meat has been recommended for beef (Pearson, 1967). VBN increased with storage time, showing higher value at higher storage temperature. The level of VBN surpassed 20 mg, the recommended limit for palatability, in the middle of the storage period. It increased to around 30 mg when TPC reached 10^8. The trend was similar in beef and pork. Singhal et al.(1997) suggested that on storage, the meat is not necessarily unpalatable until the value reaches 30 mg. It gave the highest correlation coefficient with microbial counts in beef and pork at 0^0 C and 4^0 C. Animal fats contain various components including triglyceride, phospholipids, carotenoid pigments and sterols. Many of these were altered during storage and may affect the storage life of the meat. Rancidity is caused by many factors, one of which is microorganism (Singhal et al., 1997). TBA value has been suggested as an empirical method to measure the oxidative deterioration of fatty foods (Botsoglou et al., 1994). TBA value increased with storage time at both temperatures. The correlation between TBA and microbial counts during the storage time was as high as other indicators. Conductivity increased in beef and pork with storage time as the freshness decreased at both temperatures. It was higher in pork than in beef at the beginning of the experiment. Conductivity exhibited reasonably high correlation with microbial quality of meat during the storage time. Changes in resistance or conductivity caused by the growth of microorganisms are applicable to the detection of spoilage of fish and meat (Singhal et al., 1997). Microbial associations developing on meat stored aerobically at chill temperatures are characterized by an oxidative metabolism. The aerobic Gram-negative bacteria are the common cause of spoilage of meat stored under aerobic conditions at 4^0 C(Davies, 1995). Pseudomonads that are the dominant species on meat used D-glucose and L- and D-lactic acid sequentially. D-glucose was used preferentially to DL-lactate (Drosinos and Board, 1994). In this experiment the continuous decrease of D-glucose with storage time was observed in beef and pork stored at 0^0 C and 4^0 C, faster at higher temperature. L-lactic acid, however, increased up to 4-8 days of the storage in beef and 4 days in pork, and decreased thereafter. The change of D-glucose concentration with microbial counts during the storage time showed better correlation than that of L-lactic acid in beef and pork. The slope of the glucose gradient, which develops in meat as bacteria grow at the surface, was shown to correlate with bacterial numbers (Kress-Rogers et al., 1988). Ammonia, which is the major cause of the increase of pH, can be produced by many

Table 1. **Correlation coefficients of indicators with microbial counts of beef and pork during cold storage**

Meat	Beef				Pork			
Storage Temperature	0℃		4℃		0℃		4℃	
Parameter*	TPC**	Psy***	TPC**	Psy	TPC	Psy	TPC	Psy
Put	0.90	0.86	0.93	0.91	0.85	0.81	0.95	0.97
Hit	0.91	0.89	0.92	0.91	0.90	0.87	0.91	0.95
Cad	0.84	0.82	0.95	0.93	0.93	0.90	0.94	0.97
Tyr	0.87	0.91	0.94	0.92	0.85	0.80	0.93	0.96
VBN	0.96	0.93	0.97	0.94	0.95	0.91	0.95	0.96
TBA	0.91	0.89	0.91	0.85	0.94	0.90	0.95	0.96
Cond	0.71	0.81	0.88	0.94	0.91	0.91	0.89	0.84
PH	0.43	0.40	0.48	0.48	0.46	0.49	0.40	0.72
Glu	-0.95	-0.94	-0.97	-0.93	-0.96	-0.92	-0.95	-0.91
Lac	-0.82	-0.75	-0.85	-0.80	-0.87	-0.80	-0.95	-0.90

*Put: putrescine, Hit: histamine, Cad: cadaverine, Tyr: tyramine, VBN: volatile basic nitrogen, TBA: thiobarbituric acid, Cond: conductivity, Glu: D-glucose, Lac: L-lactctate
** total plate count; *** psychrotrophic bacterial count

microbes, including pseudomonds, during amino acid metabolism. Incipient spoilage is accompanied by a rise in pH, increase in bacterial numbers along with other changes (Shelef and Jay, 1970). A rise in pH with storage time was also observed in this study but its correlation with microbial counts was relatively poor, compared to other indicators. Among indicators for beef at Table 1, VBN and D-glucose contents showed highest correlation with bacterial counts at both temperatures. In pork, VBN and D-glucose contents gave highest correlation at 0^0 C but at 4^0 C, all the indicators except pH and conductivity had more than 0.9 of coefficient value.

Conclusion

Data showed that among various indicators VBN and D-glucose would be best indicators for predicting the microbial quality of beef and pork during chilled storage under aerobic condition. VBN correlated positively with microbial numbers while D-glucose negatively within the range of microbial count of $10^{2.5}$ - $10^{8.5}$ /cm^2

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