Influence of carbonylic and phenolyc compounds of smoke on pH and water holding capacity (WHC) of beef

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Introduction

Smoke is an unstable, easily changeable and reactive mixture of gases and vapors arisen from incomplete pyrolysis of plants, usually woods (Kersken, 1973). It is known that numerous factors such as kind of wood,combustion temperature, and secondary reactions of primary compounds, smoke circulation and flow, do influence smoke composition. In the literature, statements can be found that smoke is composed of hundreds of components and according to other researchers thousands of components. Most important of those compounds are phenols, carbonyls and organic acids. Smoke components cause numerous alterations of meat by deposition on its surface and by penetrating it.

Numerous investigations indicate that some characteristics of meat are influnced by smoke. Klettner (1978), Tóth (1980a,b,c), Krilova (1963), Hamm (1977), Kersken (1974a,b), Reuter (1969), Foster (1961), Bratzler (1969), Tilgner (1967), Potthast (1978a,b), Ruiter (1971, 1977), Hruza (1974), Mirna (1972) and Daun (1979) have reported that smoke influences flavour and colour of meat, pointing out at the same time its preservative, antioxydative, bacteriostatic, bactericidal, fungicidal and fungistatic actions.

Hamm (1977), Randal and Bratzler (1970a,b) and Krilova (1962) found that in smoked meat amino acids break down, pH changes, free suphhydril groups content changes do occur.

In our country many traditional specialities are produced by smoking and drying of meat. Our aim was to investigate the influence of carbonylic and phenolic compounds on the changes of the water holding capacity (WHC) of DFD (dark, firm, dry) beef, as WHC is of great importance for drying of meat.

Materials and methods

Beef.- For the smoking experiments we used pieces of Longissimus dorsi muscle (LD) (the region from the 4th to the 9th thoracic vertebra) of 18 months old bulls. LD pieces of the left halves, chilled for 24 hours at 4°C, were well trimmed off from connective and fatty tissues, so prepared weighing 500 grams each. LD pieces taken from the right halves of the same carcasses, prepared in identical manner, were prior to smoking chilled for 48 hours at 4°C.

The left side pieces were smoked according to the procedure 1, the right side ones according to the procedure 2.

Smoking.- For smoking of LD pieces according to the procedure 1, traditional kiln was used. During 10-hour smoking the air temperature was about 20°C (±2°C) and the relative humidity (R.H.) from 80 to 87%. Beach tree sawdust used for smoke production contained 32 to 36% water. The size of sawdust pieces was standardized. Distance between meat (LD) pieces and the fire-box, where sawdust was smouldered, was 250 centimeters.

The smoking procedure 2 was carried out in the experimental smoking chamber (E.Schröter O.H.G., Borgholzhausen, F.R.Germany). This smoking chamber is constructed to maintain automatically the assigned values of temperature, R.H. and smoke circulation. Smoke generator is built to keep constant assigned combustion temperature, sawdust conveying and fresh air flow.

In both procedures of smoking the same type of sawdust was used, and the same amounts of sawdust were smouldered per minute. In the smoking procedure 2, all important parameters of the

smoking process have been simulated to attain greater similarity with the procedure 1 (T=20°, R.H. = 82 to 85%, duration 10 hours). It should be pointed out that in the smoking procedure, wood smoke conducted into the smoking chamber was forced through the water-screen.

pH.- pH values were measured by the pH-meter, pH-29 Radiometer, Copenhagen, by the combined glass-calomel electrode, in water extracts (1:4) of minced beef.

WHC.- WHC was evaluated by the filter-paper press-method according to Grau and Hamm (1957), and expressed as grams of bound water per gram of muscle proteins.

Chemical analyses.- Contents of water, fat and protein were determined according to AOAC (1980) procedures.

Determination of phenolic compounds.- The content of phenolic compounds in smoked meat pieces was determined by the Tucker's method (1964).

All determinations were carried out both on the surface (8 to 12 mm thick) layers and the central parts of meat pieces.

Results and discussion

It is obvious (table 1.) that beef LD pieces smoked in the automatic smoking chamber (procedure 2) contained higher quantities of smoke components (carbonylic and phenolic compounds) than beef smoked in the traditional smoking kiln (procedure 1). Beef smoked in the traditional smoking kiln contained in surface layers 2,5 times less phenolic compounds than beef smoked in the automatic smoke chamber (procedure 2). Central parts of LD pieces smoked by the procedure 1, contained phenolic compounds only in traces. Central parts of LD pieces smoked by the procedure 2, contained on average 0.18 mg% phenolic compounds.

Table 1- Content of carbonylic and phenolic compounds in smoked bull Longissimus dorsi (LD) pieces after 10-hour smoking in conventional (procedure 1) or automatic smoke chamber (procedure 2)

Smoking procedure	Bulls	Content (mg%) of carbonyls		Content (mg%) of phenols	
		Surface layer	Central part	Surface layer	Central part
1	I	0.13	trace	1.04	trace
	II	0.13	"	1.09	"
	III	0.10	"	0.99	"
2	I	0.32	0.16	2.08	0.16
	II	0.26	0.19	2.92	0.24
	III	0.18	0.15	2.32	0.14

The content of carbonylic compounds was two times higher in surface layers of beef LD pieces smoked by the procedure 2, than in those smoked by the procedure 1. Central parts of LD pieces contained only traces of carbonylic compounds if smoked by the procedure 1. Meat pieces smoked by the procedure 2, contained, according to our experiments, 0.16 mg% carbonyl compounds.

Differences in amounts of smoke components (phenolic and carbonylic compounds) penetrated into smoked beef during the smoking procedure 1 i.e., 2, are the result of different intensity of the circulation of smoke and air mixtures in smoke chambers. Namely, in the traditional smoking kiln (procedure 1) circulation is very low being caused only by upward streaming of hot air.

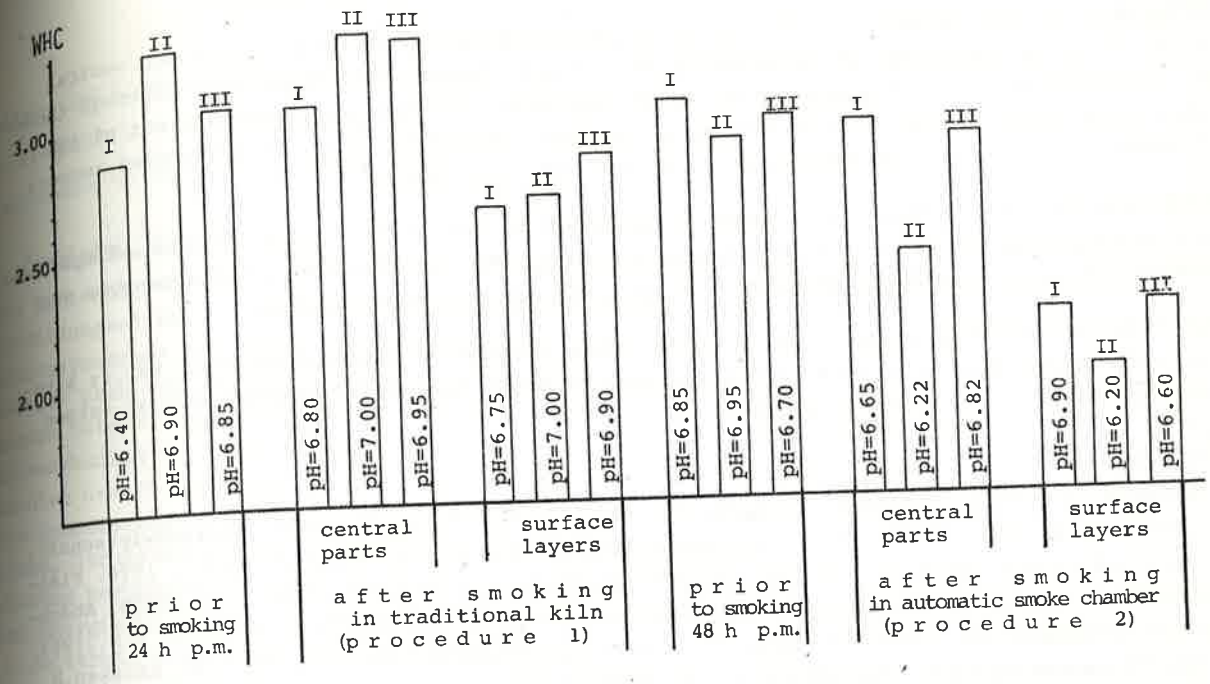

Fig.1.- WHC (grams of bound H_2O per gram proteins) of Longissimus dorsi muscle (LD) of bulls, smoked in tradicional kiln (procedure 1) or automatic smoke chamber (procedure 2) for 10 hours

The high speed circulation of air and smoke mixture (about 20 times higher than in the procedure 1) resulted in more intense deposition on and penetration into meat of smoke components, although the smoke was forced through the water-screen.

Smoke components affect meat proteins altering, among others, their WHC what is also obvious from our findings shown in the figure. So, the surface layer of smoked LD pieces, having the highest content of phenolic and carbonylic compounds, shows the lowest WHC (determinated by the press-method). Central parts of smoked LD pieces having 10 times lower content of phenolic compounds and 1,5 times lower content of carbonyls show higher WHC than surface layers (procedure 2). At the same time, LD pieces smoked in the traditional kiln (procedure 1), containing lower amounts of smoke components, show higher WHC values. Central parts of the latter pieces (procedure 1), having practically no smoke components, show nearly the same WHC values as beef prior to smoking.

The results shown in the figure 1 do indicate that the phenomenon of WHC lowering, caused by smoking, can not be simplified to linear relation: the higher the content of smoke components in meat, the lower the WHC of it. It is a notorious fact that pH of muscle, time post mortem, smoking temperature, and PSE (pale, soft, exudative), DFD (dark, firm, dry) or normal meat characteristics have great importance in affecting WHC during smoking. Considering our findings it should be pointed out that different muscles have different isoelectric points (I.P.). From the figure 1, it is also obvious that the pH lowering, simultaneously with the presence of higher amounts of smoke compounds, results in considerable WHC loss. We should point out that in our experiments beef prior to smoking had pH values of 6.9 or 6.95 what means that it had DFD characteristics.

Central parts of LD pieces smoked by the procedure 1, containing only traces of smoke components, showed almost the same WHC as unsmoked pieces. These pieces showed an inconsiderable

pH raise as a result of keeping them at 20°C during 10-hour smoking process.

Differences in WHC between surface layers of pieces smoked by the procedure 1 and central parts of pieces smoked by the procedure 2 were insignificant. This means that although there are some differences in the content of smoke compounds, differences in WHC are not of importance (regardless of the applied smoking procedure), indicating that the determined amounts of smoke compounds are not sufficient to affect WHC considerably.

Regularity of the pH effect on WHC was not observed in meat pieces where 0.1 to 0.19 mg% carbonylic compounds and 0.14 to 1.09 mg% phenolic compounds were isolated. Unhomogeneous substrates i.e. meat pieces of different I.P. probably explain such findings.

More data on complex processes taking place during smoking of meat and by which WHC is altered, will be obtained by further investigations on model systems by varying both pH values and concentrations of smoke compounds.

References

1. Kersken, H., 1973. Fleischwirtschaft, 53, 921.* 2. Potthast, K., 1974. Fleischwirtschaft, 54, 183.* 3. Klettner, G.P.,1979. Fleischwirtschaft, 59, 17.* 4. Klettner, G.P., 1978. Fleischerei, 10, 1.* 5. Tóth, L., 1980a. Fleischwirtschaft, 60, 461.* 6. Tóth, L., 1980b. Abschlussbericht, BAFF.* 7. Tóth, L., 1980c. Fleischwirtschaft, 60, 1472.* 8. Krilova, N.N.,1963. Fleischwirtschaft, 43, 1141.* 9. Hamm, R., 1977. Fleischwirtschaft, 57, 92.* 10. Kersken,H., 1974a, Fleischwirtschaft, 54, 1721.* 11. Kersken, H., 1974b. Fleischwirtschaft, 54, 1341.* 12. Reuter, H., 1969. Fleischwirtschaft, 49, 169.* 13. Foster, W.W., 1961. J. Sci. Food Agric. 363.* 14. Bratzler, L.J., 1969. Journal of Food Science, 34, 146.* 15. Tilgner, J.D., 1967. Fleischwirtschaft, 47, 373.* 16. Potthast, K., 1978a, Fleischwirtschaft, 58, 340.* 17. Potthast, K., 1978b, Fleischwirtschaft, 58, 69.* 18. Ruiter, A., 1971. Ref.: Zeitschrift für Lebensmittel - Untersuchung und Forschung, 146, 224.* 19. Ruiter, A., 1979. Food Technology, 5,54.* 20. Hruza, E.D., 1974. Journal of Agriculture and Food Chem. 22, 123.* 21. Mirna, A., 1972, BAFF Mitteilungsblat, Nr. 35, 1482.* 22. Daun, H., 1979. Food Technology, 5, 66.* 23. Randall, C.J., 1970a, Journal of Food Science, 35, 248.* 24. Randall, C.J., 1970b, Journal of Food Science, 35, 245.* 25. Krilova, N.N., 1962. VIII evropski kongres istraživača mesa, Moskva, 273.* 26. Tóth, L. 1980. private comunication.