Study of carbohydrate-breakdown in meat and meat products. Preliminary study

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Introduction

Carbohydrate content of meat and meat products decreases during storage and ripening. As a consequence short chain organic acids may form that lower pH, possibly hinder spoilage and contribute to flavour.

Breakdown of carbohydrates is catalyzed by glycolytic enzyme system of meat and/or microbes. This decomposition can proceed either hetero- or homofermentatively. Although glycolysis has been known for long, in vitro processes in meat, rate of breakdown, qualitative and quantitative aspects of formed compounds bear many questions to be answered.

One faces several contradictions concerning mode of breakdown. PEZACKI and FISZER /1966/ claims an exclusively heterofermentative decomposition of sugars, while ANDERSEN and TEN CATE /1965/ and CORETTI and SCHEPER /1966/ suggest a model where heterofermentative processes are followed by homofermentative ones.

Rate of breakdown and reaction products formed are not agreed upon either. According to GRAU et al. /1960/ and GÜNTHER and GRAU /1962/ glucose and fructose content in meat increases as a result of glycolysis.

De KETELAERE et al. /1974/ found decrease of amount of glucose. Lactic acid is considered as main product of carbohydrate decomposition, of which less is formed than stoichiometrically calculated /ANDERSEN and TEN CATE /1965/, DE KETELAERE et al. /1974//. In addition to lactic acid also acetic acid, pyruvic acid /PEZACKI and SZOSTAK /1962//, volatile fatty acids /HALVERSON /1973// and other compounds like ethanol, CO_2 /PEZACKI and JAROZEWSKI /1963// are formed. ANDERSEN and TEN CATE /1965/ claims lactic acid as dominant, others as negligible, while PEZACKI and SZOSTAK /1962/ suggest the formation of pyruvic and lactic acid in equal amounts.

This brief review shows how contradictory the views on this field are, main reason of which is the use of different methods under different conditions with different aims.

Elucidation of carbohydrate-decomposition added to or present in muscle tissue can be considered important also in case of fermented sausages made by starter cultures.

In this paper breakdown of added or originally present carbohydrates in pre- and post rigor muscle has been investigated in presence and absence of starter cultures.

Experimental

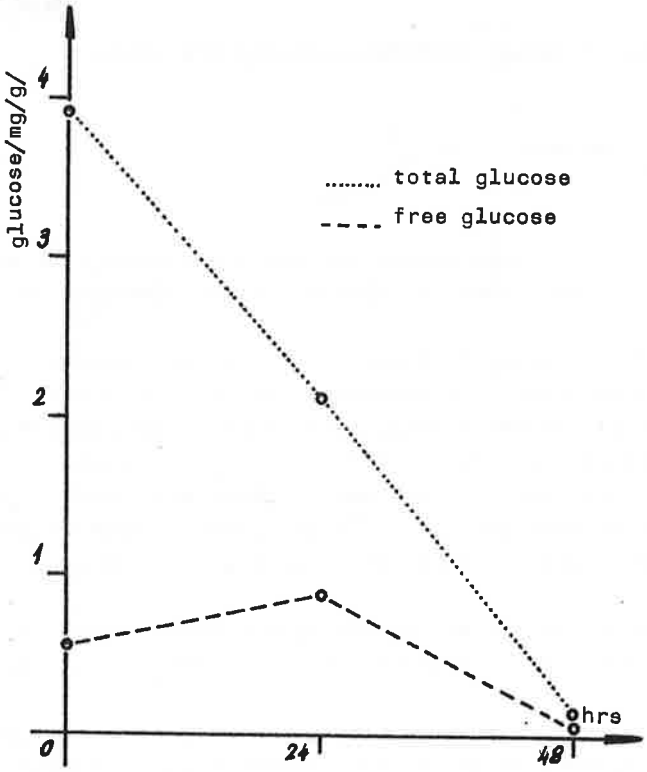
a./ Samples of semimembranosus muscle of randomly selected pork were taken and ground immediately after slaughter. Change of glucose content in 10 muscle samples has been studied. Amount of total and free sugar has been determined immediately after slaughter as well as 24 hr and 48 hr p.m. at +6°C.

b./ Change of added glucose has been investigated in order to study the amount of carbohydrates for starter cultures. To the 10 ground muscle samples /0, 24, 48 hr p.m./ 1% glucose was added, left for 15 mins. at ambient temperature and glucose content as well as glucose recovery in % was determined. Original glucose content before addition of sugar has also been determined.

c./ In order to clear the role of tissue enzymes in decomposition of glucose fresh ground meat was heated at 80°C for 10 mins. and cooled. To this meat 1% glucose was added and recovery was calculated.

d./ Content of carbohydrate and acids was investigated in presence and absence of starter

Fig.1. Glucose decomposition



cultures with the aim of studying the relationship between breakdown of carbohydrate and acid formation. Muscle samples were taken from 8 carcasses, were ground and with or without added glucose and/or starter cultures were incubated at 20-22°C for 0, 24, 48 hours. Total carbohydrate and acid content as well as pH were determined. Because of buffer capacity of meat titratable acidity shows the changes more sensitively than pH measurement.

Analytical methods. - Free and total carbohydrate was determined by anthron-method of DE KETELAERE et al. /1974/, acid content by method of KONIECKO /1979/. The anthron-method detects monosacharids hydrolyzed from glycogen and hexose and hexosephosphates as total glucoses, while free glucose means hexoses and hexosephosphates in meat.

Results and discussion

a./ Change in free and total glucose of meat is shown in Fig.1. As seen total amount of carbohydrate decreases during 48 hrs. of chilling. Decrease shows close to linear pattern, amount of free sugars increases slightly at the beginning of storage, the rate of this increasing being nevertheless far less than reported by GRAU et al. /1960/. Activity of glycolysis seems to be high 48 hrs p.m. too, nonetheless lower molecular sugars from glycogen do not accumulate. Only about 15% glucose formed from glycogen can be detected in muscle tissue, which causes a temporary increase of free glucose. On the other hand 85% is transformed possibly to trioses, organic acids and CO_2. Consequently residual hexose concentration is rather low in muscle tissue, additional glucose is needed for supporting acid production by starter cultures.

b./ Change of added glucose in muscle tissue can be seen in Tabl.1. As shown ground pre rigor muscle is able to break down more than 70% of added glucose: a remarkable glycolytic activity when considering the 10 fold difference in initial glucose concentration in this case compared with case a./. Results further show that glycolytic activity is only slightly decreased during 48 hrs. of cold storage causing still 60% breakdown of added glucose.

c./ Results showed no breakdown of glucose when added to heat treated muscle, recovery was 98%. Carbohydrate decomposition is obviously caused by enzymatic activity of muscle this time inactivated by heating.

d./ Results of experiment carried out for comparison the bacterial and tissue enzyme activities are collected in Figs. 2a, 2b, 2c.

In sample A carbohydrates are almost completely decomposed while acid content increases only slightly during first 24 hrs. storage. With ongoing time very slight breakdown of glucose, decrease of acid concentration and increase of pH can be noticed, presumably because of proteolysis.

Similar processes take place with sample B where proteolysis was more predominant. pH-value grew remarkably between 24-48 hrs. of storage, possibly because of lack of carbohydrate source following a rapid decomposition which made pH-drop impossible and enabled pro-

Table 1.

Recovery of added glucose from pre rigor meat

Time /hours/	0			24			48		
Sample	addition mg/g	recovered mg/g	recovered %	addition mg/g	recovered mg/g	recovered %	addition mg/g	recovered mg/g	recovered %
$\bar{x}$	10.56	3.53	33.42	10.83	3.21	30.05	10.4	3.83	36.82
s	0.52	0.26		0.46	0.19		0.43	0.23	

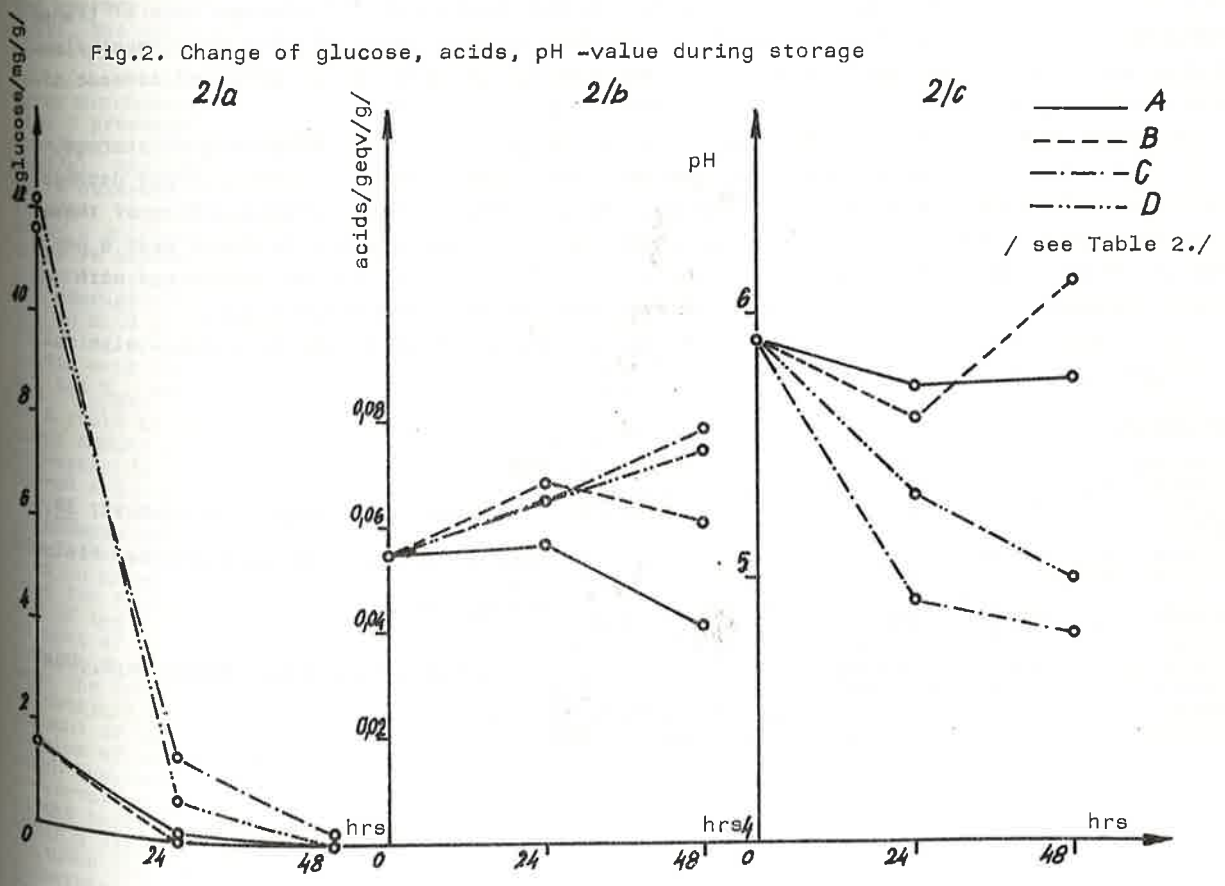
Table 2.

Rate of transformation of glucose-to -acid

Time /hours/	24			48		
	acid			acid		
Sample	calculated mg/g	measured mg/g	transformation %	calculated mg/g	measured mg/g	transformation %
A	1.43	0.09	6.2	-	-	-
B	1.58	1.1	69.6	-	-	-
C	10.05	0.90	8.9	1.57	1.07	68.1
D	12.02	0.83	6.9	0.79	0.88	111.4

A - meat, B - meat + starter, C - meat + starter + 1% glucose, D - meat + 1% glucose

Fig.2. Change of glucose, acids, pH -value during storage



teolysis.

Most of the added glucose is decomposed in sample C during 24 hrs. followed by increase of acid concentration and intensive decrease of pH. When stored further residual glucose is decomposed too, with formation of acid and pH-drop, this latter being nevertheless nonsignificant. Change in carbohydrate and acid content in sample D is practically the same as in sample C, though pH of sample D is slightly higher. These results are in good agreement with findings of ANDERSEN and TEN CATE /1965/ who claimed pH of fermented sausages adjustable by known amount of added glucose. The question is what is the cause of differences between samples A and D, what role do starters play. To find an explanation, rate of glucose-to-acid transformation was stoichiometrically calculated, presuming the generally accepted ratio of 2 moles of acid from 1 mol glucose. Results are shown in table 2, according to which only 6,2-8% of decomposed glucose in samples A, C, D is transformed to acid between 0 - 24 hrs. This transformation is clearly far from stoichiometrically calculated. Absolute amount of acid in sample C and D is about tenfold compared to sample A.

In sample B rate of transformation of glucose-to-acid amounts close to 70% suggesting a stronger tendency of acid-formation in the presence of starters. There might be a possibility that end-products of glycolysis are other intermediates /trioses?/, no acids. A better knowledge on this field /activities and roles of various enzymes/ needs further investigations.

In the second part of storage /24-48 hrs/ stoichiometric calculations could not be performed because of proteolytic changes. As known, compounds like ammonia have significant neutralizing effect on acids /Demeyer et al. 1978/.

It is worth mentioning that breakdown of glucose is shifted towards acid formation in sample C. Rate of transformation is similar to that of sample D. It seems probable that at the beginning of storage rapid decomposition of carbohydrates is brought about by glycolytic activity of tissue enzymes, while later breakdown of carbohydrates is shifted towards acid production. It is interesting to note that during the second part of storage rate of transformation turns out rather high in sample D. pH-drop is the result of this phenomenon closing thus pH-values of samples C and D. This way similar acidity can be attained in meat if extra glucose is added, no matter starters are present or absent.

It seems that glycolytic enzyme activity is predominant at the beginning of storage, and accumulation of different intermediates can take place. During further storage decomposition processes are shifted towards acid products. A more thorough understanding of these processes need further investigations. With addition of extra glucose to fresh meat a pH-value and acid concentration can be reached which is similar to that of inoculated with starter cultures. Elucidation of the mechanism needs further experiments too.

As a conclusion glycolysis in meat should be considered as a complex process with numerous questions to be answered.

Literature

- Andersen, G., Ten Cate, L., /1965/: Fleischw., 6, 599
- Coretti, K., Scheper, J., /1966/: Fleischw., 46, 251
- De Ketelaere, A., DeMeyer, D., Vandekerckhove, P., Vervaeke, J. /1974/: J.Food.Sci., 39, 297
- Demeyer, D., Vanderckhove, P., Vermuelen, L., Moerman, R. /1978/: 24. Europäischer Fleischforscher-Kongress, Kulmbach; Proceedings II. G 15 : 3
- Grau, R., Günther, H., Scheper, J. /1960/: Fleischw., 9, 728
- Günther, H., Grau, R. /1962/: Fleischw. 11, 1050
- Halverson, H. /1973/: J. Food Sci., 38, 310
- Koniecko, E. /1979/: Handbook for Meat Chemists, Ed. by Avery P.G. Inc., Wayne, N.Y., USA
- Pezacki, W., Fiszer, W. /1966/: Fleischw., 12, 1339
- Pezacki, W., Jaroszewski, Z. /1963/: Fleischw., 43, 1029
- Pezacki, W., Szostak, D. /1962/: Fleischw., 3, 180