Effect of heating on quality of meat products *)

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1. INTRODUCTION

Man has preserved meat since 6000 BC, as is stated by Jensen in his excellent survey (6) of the history of food technology. During the last 2000 years still more attention has been paid to the preparation of meat products. Also rather strictly sanitary regulations were set up for making high quality products with a good keepability. Much work is being done to develop methods for preparing these products without losses in colour, taste, consistency, etc. However, very little is known of the effect of heating on the nutrition value of these products (except work published by 4, 5, 7, 10 and 11) although this is one of the aspects of the quality of meat products. In our opinion quality is a complex of criteria which forms as a whole the typical, individual characteristics of the product and which influences the acceptability of the product for the consumer. Because many problems concerning the preservation of meat products have already been solved, we started a programme for studying a wide range of aspects concerning the quality of cooked and sterilized meat products.

In our Institute we have the opportunity to study these problems: besides facilities for all kinds of technological work also chemical and biological analyses (2) of the products can be carried out.

In a first series we investigated the influence of various heat treatments on the quality of meat balls, luncheon meat and liver products. A provisional review of some of the results is reported here.

2. EXPERIMENTAL METHODS

2.1. Preparation of products

2.1.1. Meat balls

A thoroughly mixed sample of beef and pork was ground in a meat mincer and mixed with salt, starch, phosphate and spices (see table 1). From the mix meat balls were prepared, fried at 170 °C for 5 minutes and then heated in open pans, or sterilized in cans at 110 °C (F_o value 0.38 till 0.58) or at 125 °C (F_o value 0.46 till 0.65) using temperature controlled autoclaves and Cu-Cn thermo couples.

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2.1.2. Luncheon meat

A number of luncheon meats were prepared from beef, pork, lard, rind, starch, salt, phosphates and spices (see table 1).

A part of the emulsion was heated in a coll gen type casing at 78 °C after predrying for two hours at 45 °C another part was sterilized at 110 °C and at 125 °C (F_o value 0.5).

2.1.3. Liver products

Liver products with 10 or 20 % liver and varying percentages of lean meat and collagen, were prepared in an ordinary way. In all products the broth, obtained by cooking offals or meat at 85 °C, was used. After emulsifying in a colloid mill cans were filled and heated as follows:

heating time in minutes	temperature in °C	F_o value
93	80	0.0
83	100	0.06
75	108	0.30
85	120	6.5
48	124	0.37

The products sterilized at 120 °C got an extremely high F_o value. In doing so we hoped to get the strongest effects of heating on the quality of the product.

2.2. Analytical methods

For the evaluation of the quality of the heated products we applied chemical as well as biological and organoleptic methods of analysis.

2.2.1. Main constituents

Water, protein (N x 6.25), fat, carbohydrates and ash were determined according to routine methods already used in the Institute for years.

2.2.2. Collagen content

Collagen was determined according to Bergmann and Loxly (1). The collagen value is calculated from the formula: $\frac{\text{collagen N}}{\text{total N}} \times 100$

2.2.3. Vitamines

In some products vitamine B_1, B_2, B_6 and B_{12} nicotinic acid and pantothenic acid were determined by well known routine methods, used in our laboratory (2).

2.2.4. Amino acids

Most of the amino acids were determined column chromatographically using an automatic amino acid analyser (2).

2.3. Biological methods

The biological value, digestibility and net protein utilization was determined according to Mitchell (9) except for liver products A and B. In these products the carcass analysis method of Miller and Bender (8) was used. Rations containing meat products C and D as the sole source of protein were fed ad libitum to groups of 12 or 10 young albino rats (protein quantity of ration : 10 % of dry weight base). The quantity of nitrogen in feed eaten by the animals was determined during an experimental period of 7 or 10 days. The amounts of nitrogen excreted in faeces and urine or the amounts of nitrogen in faeces and carcasses, were determined. From these data the biological value (BV: i.e. the percentage of the resorbed nitrogen that was utilized for synthesis of body protein) was calculated.

In addition we calculated the digestibility (D: viz. the percentage of the nitrogen eaten that was not excreted in the faeces) and the net protein utilization (NPU: i.e. percentage of the nitrogen eaten that was utilized for synthesis of body protein).

2.4. Organoleptic methods

The products were tested organoleptically by 5 well trained persons. Each of them was asked to give his preferences if any in the series of several products. All products were examined in a room at 15 °C.

3. RESULTS AND DISCUSSION

3.1. Analytical results

In table 2, 3 and 4 analytical data are given for the meat balls series and the luncheon meat series.

As can be seen, the fat content of most balls is lowered during frying and there is a water uptake during heating in the can. It is not clear why the ash content is higher in the meat balls heated at 110 °C and 125 °C. There is a loss of vitamine B_6, B_{12} and pantothenic acid by heating at the highest temperatures. The same tendency was observed when heating luncheon meats; the ash content of luncheon meat diminishes during heating.

The amino acid content of these products was not influenced by heating, except for the methionine + cystine content of luncheon meat with 15 % rind. There were no real differences in the main constituents of the liver product series A and B and between series C and D (see table 5) except in the collagen value. No vitamine and amino acid determinations were done in liver products.

3.2. Biological results

In table 6 the results of the determinations of the nutritional value are given.

It appears that the NPU and the BV of meat balls are slightly lowered by sterilization; there was no difference between the products prepared at 110 °C and 125 °C.

The same conclusion can be drawn from the results obtained on luncheon meat. However, the effect of the higher temperatures is strongest in products with 15 % rind.

It is interesting to note that no distinct difference occurred in protein quality between the raw products with 7.5 and 15.0 % rind.

From these experiments it can also be concluded, that 10 % liver did not noticeably influence the nutritive value of liver products A and B. The heat treatment seemed to have no effect either.

In products with a high percentage of offals (series D) a slight deleterious effect of high temperatures could be noted. But, as already mentioned the sterilization value at 120 °C is extremely high. We assume that destruction of cystine and methionine is responsible for these low values. Moreover these essential amino acids are low in collagen and elastin which represent the most important proteins of offals (11).

3.4. Organoleptic results

The results of the organoleptic test are summarized in table 7. Taking into account that the number of tests is rather low the conclusion can be drawn that no significant preferences are detectable between comparable meat products, except for the liver products heated at 120 °C (F_o value 6.5).

4. CONCLUSIONS

Heating meat balls, luncheon meats and liver products at various temperatures indicates that:

1. there is a loss of vitamines B_6, B_{12} and pantothenic acid at temperatures higher than 110 °C
2. no alterations in amino acid contents are detectable, except for methionine and cystine
3. the net protein utilization, digestibility and biological value of the proteins are not significantly influenced by heating in products with a low or moderate collagen content.
4. no significant preferences in organoleptic criteria could be demonstrated between meat balls and luncheon meat, heated at 110 °C vs 125 °C, except for products with a high collagen content.

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Table 1. Composition of products

Components in %	Minced meat	Luncheon meat		Liver product			
		A	B	A	B	C	D
beef	20.0	41.0	41.0	30.0	26.0	-	-
pork	20.8	17.5	11.5	-	-	40.5	-
beef fat	20.0	-	-	-	-	-	-
lard	20.0	20.0	20.0	19.3	17.3	28.6	27.8
rind	-	7.5	15.0	6.0	6.0	4.8	13.9
liver	-	-	-	10.0	20.0	19.0	18.5
offals	-	-	-	30.0	26.0	-	30.1
water	10.0	7.0	5.5	4.0	4.0	4.8	7.4
starch	6.0	4.0	4.0	-	-	-	-
salt	1.6	2.0	2.0	1.9	1.9	1.9	1.9
phosphate	-	0.5	0.5	-	-	-	-
spices	0.5	0.5	0.5	0.7	0.7	0.5	0.5

Table 2. Analysis of samples raw and fried meat balls

Main constituents in %	raw	fried meat balls heated at		
		100 °C	110 °C	125 °C
moisture	44.0	54.0	51.3	52.2
protein (N x 6.25)	10.3	15.4	16.1	16.6
fat (Gerber)	39.9	22.6	22.7	22.0
carbohydrates	2.9	4.2	4.2	4.4
ash	2.4	2.7	3.3	3.3
total	99.5	98.9	97.6	98.5
phosphate (P_2O_5)	0.42	0.50	0.58	0.59
Vitamines in mg pro 100 g				
vitamine B_1	0.06	0.08	0.07	0.06
vitamine B_2	0.12	0.12	0.15	0.13
vitamine B_6	0.09	0.06	0.04	0.06
vitamine B_{12} (in µg/100 g)	1.45	1.70	1.38	1.38
nicotinic acid	3.1	3.3	2.9	3.4
pantothenic acid	0.37	0.3	0.27	0.27

Table 3. Analysis of samples luncheon meat

Main constituents in %	raw product		luncheon meat heated at					
	rind		78 °C		110 °C		125 °C	
	7½ %	15 %	7½ %	15 %	7½ %	15 %	7½ %	15 %
moisture	52.6	52.8	52.8	52.9	-	-	52.5	53.0
protein (N x 6.25)	13.1	12.8	13.2	13.1	-	-	13.3	13.5
fat (Gerber)	29.4	27.3	28.1	28.3	-	-	27.4	27.3
carbohydrates	3.4	3.4	3.2	3.2	-	-	3.5	3.5
ash	3.3	3.4	2.9	2.9	-	-	2.9	3.0
total	101.8	99.7	100.2	100.4	-	-	99.6	100.3
phosphate (P_2O_5)	0.55	0.53	0.55	0.53	-	-	0.57	0.55
Vitamines in mg pro 100 g								
vitamine B_1	0.13	0.13	0.19	0.17	0.12	0.13	0.09	0.10
vitamine B_2	0.11	0.09	0.10	0.10	0.11	0.10	0.11	0.10
vitamine B_6	0.10	0.10	0.11	0.10	0.06	0.07	0.05	0.06
vitamine B_{12} (in µg/100 g)	0.53	0.5	0.61	0.59	0.60	0.5	0.5	0.5
nictotinic acid	4.1	4.1	4.1	4.0	3.8	3.6	3.8	3.8
pantothenic acid	0.38	0.38	0.37	0.33	0.32	0.31	0.25	0.28

Table 4. Amino acids in g pro 100 g

Amino acids	luncheon meat with 7½ % rind				luncheon meat with 15 % rind				meat balls			
	raw	heated at:			raw	heated at:			raw	fried and heated at:		
		78 °C	110 °C	125°C		78 °C	110 °C	125 °C		100 °C	110 °C	125 °C
A. Essential												
i isoleucine	0.52	0.50	0.53	0.52	0.51	0.51	0.51	0.52	0.68	0.65	0.56	0.57
leucine	0.89	0.88	0.94	0.91	0.89	0.90	0.88	0.90	1.15	1.10	0.96	0.97
lysine	1.05	0.99	1.02	1.01	0.94	0.97	0.94	0.97	1.12	1.15	0.95	0.96
methionine	0.27	0.28	0.28	0.28	0.29	0.29	0.27	0.27	0.33	0.32	0.29	0.29
cystine	0.11	0.12	0.12	0.12	0.12	0.13	0.12	0.11	0.15	0.15	0.13	0.13
methionine + cystine	0.38	0.40	0.40	0.40	0.41	0.42	0.39	0.38	0.48	0.47	0.42	0.42
phenylalanine	0.47	0.45	0.50	0.48	0.47	0.47	0.49	0.48	0.62	0.60	0.51	0.52
tyrosine	0.38	0.37	0.41	0.40	0.37	0.38	0.41	0.39	0.52	0.49	0.42	0.42
threonine	0.50	0.48	0.53	0.52	0.50	0.50	0.50	0.51	0.52	0.62	0.54	0.53
tryptophane	0.15	0.15	0.15	0.16	0.13	0.14	0.14	0.14	0.18	0.18	0.16	0.16
valine	0.59	0.57	0.61	0.60	0.60	0.58	0.59	0.59	0.74	0.69	0.62	0.61
histidine	0.41	0.38	0.42	0.39	0.36	0.36	0.37	0.39	0.46	0.49	0.38	0.40
B. Non—essential												
arginine	0.85	0.89	0.87	0.87	0.83	0.87	0.85	0.87	0.90	0.89	0.75	0.75
alanine	0.76	0.84	0.84	0.84	0.86	0.89	0.88	0.88	0.91	0.87	0.76	0.76
aspartic acid	1.09	1.09	1.15	1.08	1.09	1.06	1.07	1.10	1.21	1.23	1.09	1.07
glutamic acid	1.76	1.79	1.91	1.78	1.78	1.77	1.82	1.78	2.45	2.36	2.07	2.06
glycine	0.94	1.21	1.05	1.06	1.18	1.19	1.22	1.20	0.88	0.86	0.77	0.76
proline	0.66	0.76	0.75	0.73	0.76	0.81	0.87	0.82	0.85	0.75	0.68	0.66
serine	0.48	0.47	0.51	0.50	0.47	0.50	0.49	0.51	0.60	0.58	0.51	0.50
total N	2.03	2.08	2.07	2.03	2.02	2.07	2.05	2.04	2.46	2.38	2.04	2.14

Table 5. Chemical analysis of liver products

Main constituents in %	A	B	C	D
moisture	51.5	52.3	53.6	55.7
protein	15.6	15.5	14.5	13.4
fat	30.3	30.5	30.2	29.3
collagen value	-	-	19.4	43.8

Table 6. Results of the biological determination of protein quality in meat products
(A, B, C and D represent different compositions of the items)

Products	Biological Value				Digestibility				Net Protein Utilization			
	A	B	C	D	A	B	C	D	A	B	C	D
Minced meat												
raw	78.4				101.2				79.3			
fried, well done	79.8				99.1				79.0			
sterilized at 110 °C	75.5				98.4				74.3			
sterilized at 125 °C	75.7				98.6				74.6			
Luncheon meat												
raw	76.8	75.5			101.9	101.4			78.3	76.6		
heated at 78 °C	72.8	73.5			101.6	102.3			74.2	75.2		
sterilized at 110 °C	73.3	72.3			102.6	101.3			75.2	73.2		
sterilized at 125 °C	73.0	68.1			100.4	100.8			73.3	68.6		
Liver product												
heated at 80 °C	-	-	71.5	68.6	-	-	99.8	98.7	-	-	71.4	67.7
heated at 100 °C	-	-	71.8	65.7	-	-	99.4	99.2	-	-	71.4	65.0
sterilized at 108 °C	52	46	-	-	96	98	-	-	50	45	-	-
sterilized at 120 °C	-	-	68.8	62.9	-	-	97.7	98.1	-	-	67.2	61.7
sterilized at 124 °C	50	50	-	-	96	96	-	-	48	48	-	-

Table 7. Organoleptic evaluation of products

	Meat balls	Luncheon meat A	Luncheon meat B	Liver products C	Liver products D
No preference	5	5	3	0	0
Preference to 80 °C	-	-	-	3	4
Preference to 100 °C	-	-	-	2	1
Preference to 110 °C	0	0	2	-	-
Preference to 120 °C	-	-	-	0	0
Preference to 125 °C	0	0	0	-	-