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Comparative Studies of Chemical Composition and Post-Mortem Hydration in Muscles of Buffalo and Cattle

As already known, numerous works have been published about chemical composition and post-mortem hydration of meat during the past decades. Intensive work is still being done on these problems, since it has become clear that it is the basis of meat technology. This conception was strongly expressed by Stewart (6) by the following quotation: "As a result the technology in use today has almost all been developed on an empirical basis. This must be changed if we are to have technology soundly based on science. As I see it, this is one of the most irgent needs in meat science today."

If the above mentioned statement holds good for meat in general, then it must even more refer to buffalo meat, as stressed by Cockrill (2) with the following words: "Science has neglected the water buffalo. No mere symbol of backward agriculture, this living tractor of the East is invaluable as a source of work, milk, meat and leather, and so docile that a child can manage it. Research could make it even more useful, especially as a source of food."

Since buffaloes in their zoological characteristics are very similar to cattle, it is considered that there are not any essential differences in meat properties between these two animal species. Furthermore, in the same analogy it has been concluded that the quality of buffalo meat is more similar to the meat of primitive cattle breeds, since it is known that little work has been done on the improvement of buffaloes. However, from the investigations by Wilson (7) it may be seen that the eating quality of buffalo meat is much better than may be presumed on the basis of the mentioned analogies.

In Yugoslavia, on the basis of experience it has been observed that the buffalo meat is more suitable for processing into ready meat and some sausages than beef. Similar conceptions were also observed in Bulgaria. Without going into further details, it may be said with some certainity, that for the present, we cannot answer many questions with regard to the eating quality and technologic properties of buffalo meat.

We are inclined to join hands with those scientists who consider that without any justification, science has neglected this field of research. We are doing this for the following reasons: according to Ivanov and Zahariev (17) there are over 100 millions of buffaloes in the world. It is true that they are more prevalent in Asia and Africa than in Europe, since only in India there are over 45 millions of buffaloes. However, it is also true that science should not have any boundaries, accordingly, science is responsible to do more in the study of buffalo meat, since it is an important source of food.

Starting from the above mentioned statements, we have set ourselves the task that within the limit of our modest possibilities, we make a contribution to this problem. Namely, our investigations of some physico-chemical and structural characteristics of buffalo meat (11) are still in progress. In this paper endeavours have been made to answer only some controversial opinions which we observed in Yugoslavia, with regard to water holding capacity of meat (WHC), which comprises the following: Some practical workers claim that buffalo meat has a better WHC than beef, while others claim the contrary. We believe that with such claims, different ante-mortem and post-mortem factors have not been taken into account, since it is known that their influence may be considerable (3, 4, 5, 10, 11, 12, 13, 14, 19, 20).

We have chosen this theme with the desire to draw attention to a branch of meat science which has hitheto been rather neglected. It is to be hoped that other and more experienced research workers will make their contribution in further enlightening this problem.

Methods used in research

Muscles and meat of nine domestic female buffaloes about 10 - 12 year old were used in the experiment. The same number of domestic Simental cows with similar characteristics were used in parallel. The tables contain muscles and meat categories which were analyzed. Case was taken that samples were always taken at the same time and from the same anatomic regions.

The following methods were used in the investigations:
- Water content was determined by dehydrating in the drying chamber at 105 °C until the constant weight.
- The content of proteins was determined by the Kjeldahl method.
- The ash content was determined by direct combustion at 525 °C.
- The fat content was determined by Krol and Meester method (8).
- The content of glycogen was determined by the method of Drozdov modified by Savić et al (13).
- The content of oxyproline was determined by the modified

method of Neumann and Logann (18).

- The water holding capacity (by compression method) was measured by method of Grau and Hamm (3). The values have been shown in ccm^2 by moistening the area of the filter paper around the compressed meat.
- The binding capacity of added water (the swelling of meat) was implemented as follows: 30 g of homogenized meat sample and 20 ml destilled water was placed into a previously weighed glass. After mixing, which lasted 15 minutes, thus prepared mixture of meat and water was left to stand for another 30 minutes. After this, the mixture was filtrated for 45 minutes, while the residue on the filter paper was weighed. The quantity of the binding water (the swelling of meat) was calculated in percentages.
- pH was measured in aqueous extract 1 : 4, with glass electrode in Philips´pH-metre, Modell PHM 22p No. 23850.

Results Achieved

Chemical composition. There are relatively more data on chemical composition of buffalo meat (9, 14, 15). However, it is known that the percentage ratio of individual nutrients greatly varies, depending on many factors. Due to this, our comparative investigations of chemical composition of buffalo meat and beef were implemented in the first place, which was done in order to get a clear picture of the material, wich should be used for the investigation of the post- mortem hydration.

The results of the investigations of chemical composition of muscles (M. supraspinatus and M. longissimus dorsi) are given in Table 1, while the results on chemical composition of meat from round, shoulder and neck are given in Table 2.

By comparing our data on the content of water, proteins, fat, and mineral matter, with the corresponding data found in literature, we may state that there is a concurrence in principle.

Our data on glycogen content and connecting tissue (oxyproline) in buffalo meat, cannot be compared with the data of other authors, since similar investigations were not found in the literature at our disposal. However, our data on cattle largely range within the limit as found in literature. Accordingly, further observations in this paper will be relied on comparisons of our own data for buffalos meat and beef.

Table 1.

Average values and Variations of Nutrients in Muscles of Buffalo and Cattle (in %)

Nutrients	Values	Buffalo A	Buffalo B	Cattle A	Cattle B	Differences A	Differences B
Water	$\bar{X}$	76,910	76,730	77,500	77,190	0,59	0,46
	S	0,659	0,869	0,580	0,577		
	C	0,857	1,130	0,748	0,750		
	$S\bar{x}$	0,233	0,310	0,290	0,288		
Protein	$\bar{X}$	21,400	21,240	20,800	21,050	0,60	0,19
	S	0,653	0,590	1,410	0,580		
	C	3,050	2,780	6,770	2,750		
	$S\bar{x}$	0,230	0,980	0,700	0,290		
Fat	$\bar{X}$	0,610	0,740	0,860	1,130	-0,25	0,39
	S	0,393	0,330	0,443	0,495		
	C	64,430	44,590	51,510	43,800		
	$S\bar{x}$	0,138	0,116	0,220	0,244		
Ash	$\bar{X}$	1,040	1,110	0,980	1,090	0,06	0,02
	S	0,001	0,038	0,001	0,081		
	C	0,0009	3,430	0,0009	7,430		
	$S\bar{x}$	0,0004	0,010	0,0004	0,040		
Glycogen	$\bar{X}$	1,030	1,100	0,740	0,800	0,29 *	0,30 **
	S	0,412	0,360	0,280	0,270		
	C	40,000	32,730	37,830	33,750		
	$S\bar{x}$	0,1373	0,1200	0,0933	0,0900		

A = M. Supraspinatus;
B = M. Longissimus dorsi
* = $P < 0,05$
** = $P < 0,01$

From Table 1 we may see that there are not any significant differences with regard to water content, proteins and fat between the investigated muscles of buffalos and cattle. There was however, a somewhat greater of glycogen and mineral matter in the muscles of buffalos. These differences were mainly statistically significant ($P < 0,05$; $P < 0,01$ for M.long. dorsi and $P < 0,05$; $P < 0,01$ for M. supraspinatus). However, from Table 2 we may see that there are also considerable and statistically significant differences with regard to the content of total proteins, also in favor of buffaloes. This data agrees with our earlier investigations (14), while the data in Table 1 agree with statements given by Ferrara _et al_ (9). The explanations for these differences are as follows: in Table 1 samples of muscles which were well cleaned from connecting tissue were analyzed, while samples for analysis given in Table 2 were taken from finely ground meat taken from the mentioned regions, which, before it was finely ground had been cleaned from the chords and coarse parts of the connecting tissues as it is done in practice. On the other hand, from the data on the content of oxyproline we may see that the büffalo meat contains more connecting tissues. Accordingly, the greater values of the protein content in the buffalo meat are probably and to a greater part, the result of the calculation of total nitrogen (determined by the Kjeldahl method) into the total proteins, multiplied by the factor 6,25 which does not correspond to the connecting tissue.

Table 2.

Average Values and Variations of Nutrients in Meat of Buffalo and Cattle from Round, Shoulder and Neck (in %)

Nutrients	Values	Buffalo			Cattle			Differences		
		I	II	III	I	II	III	I	II	III
Water	$\bar{X}$	73,020	71,630	69,810	71,980	71,600	70,540	1,04	0,03	0,73
	S	2,041	1,980	2,240	3,170	2,520	2,470			
	C	2,795	2,764	3,209	4,404	3,519	3,501			
	$S_{\bar{x}}$	0,6803	0,6600	0,7466	1,0566	0,8400	0,8233			
Protein	$\bar{X}$	21,820	20,360	20,050	20,180	19,380	19,260	** 1,64	** 0,98	0,79
	S	0,689	0,666	1,080	1,030	0,638	1,130			
	C	3,158	3,271	5,386	5,104	3,292	5,867			
	$S_{\bar{x}}$	0,2296	0,2220	0,3600	0,3433	0,2126	0,3766			
Fat	$\bar{X}$	5,000	5,980	7,550	6,270	5,960	6,580	0,96	0,02	0,97
	S	2,092	1,637	0,239	2,910	2,027	1,490			
	C	41,840	27,374	3,165	46,411	34,010	22,644			
	$S_{\bar{x}}$	0,6973	0,5456	0,0796	0,9700	0,6756	0,4966			
Ash	$\bar{X}$	1,120	1,060	1,020	1,010	1,030	1,090	* 0,11	0,03	0,07
	S	0,040	0,020	0,030	0,160	0,308	0,350			
	C	3,571	1,887	2,941	15,841	29,903	32,110			
	$S_{\bar{x}}$	0,0133	0,0066	0,0100	0,0533	0,1026	0,1166			
Oxyproline	$\bar{X}$	0,384	0,412	0,486	0,290	0,387	0,431	** 0,094	0,025	* 0,055
	S	0,047	0,063	0,049	0,035	0,071	0,052			
	C	12,240	15,291	10,082	12,069	18,346	12,065			
	$S_{\bar{x}}$	0,0150	0,0210	0,0163	0,0116	0,0236	0,0173			

I = Round; II = Shoulder; III = Neck

* = P 0,05 ** = P 0,01

The Post-Mortem Hydration. For comparative investigations of this phenomenon we had a recourse to M. Longissimus dorsi. Nine samples of buffalos and nine samples of cattle were investigated, which were placed into refrigerators directly after slaughtering the animals, and they were kept at about $0^{\circ}C$ temperature during the whole investigation period. The results are given in Table 3.

The same number of samples from buffalos and cattle were frozen after 1, 6, and 24 hours from the time of slaughter. The frozen samples (by quick freezing method), placed in polyethylene bags were stored for 35 days then they were de-frosted by the slow procedure in two stages: the meat was kept first at a temperature of $+2$ to $+4^{\circ}C$ until a temperature of $-1^{\circ}C$ was reached in the center of the sample meat piece: b) the meat was kept at room temperature (18 to $21^{\circ}C$) until the temperature was $+1^{\circ}C$ in the center of the meat. Directly after this the meat was taken out of the bags, the surface was gently dried by filter paper, and proceeded by investigating the same values as for the meat without freezing. The data of these investigations are given in Table 4.

Table 3.

Average Values and Variations of WHC, Swelling and pH in M. longissimus dorsi from buffalo and Cattle (in %)

Time of determination	Values	Buffalo			Cattle			Differences		
		WHC	Swell.	pH	WHC	Swell.	pH	WHC	Swell.	pH
1 hs post mortem	$\bar{X}$	5,60	36,40	6,950	7,40	34,25	6,680	1,80**	2,15	0,27*
	S	0,95	3,80	0,223	1,23	3,98	0,249			
	C	16,96	10,43	3,208	16,62	11,62	3,727			
	$S_{\bar{x}}$	0,31	1,26	0,074	0,41	1,32	0,083			
6 hs post mortem	$\bar{X}$	9,80	23,15	6,140	10,15	28,60	6,120	0,35	5,45**	0,02
	S	1,48	3,95	0,250	1,20	2,74	0,240			
	C	15,10	17,06	4,071	11,82	9,58	3,921			
	$S_{\bar{x}}$	0,49	1,31	0,083	0,40	0,91	0,080			
hs 24 post mortem	$\bar{X}$	12,35	8,75	5,520	11,70	10,50	5,630	0,65	1,75	0,11*
	S	1,96	1,83	0,084	1,84	1,97	0,106			
	C	15,87	20,91	1,521	15,72	18,76	1,882			
	$S_{\bar{x}}$	0,65	0,61	0,028	0,61	0,65	0,035			
48 hs post mortem	$\bar{X}$	13,40	12,94	5,410	12,45	11,75	5,480	0,95	1,19	0,07*
	S	1,16	1,94	0,065	1,95	2,01	0,072			
	C	8,65	14,99	1,201	15,66	17,10	1,313			
	$S_{\bar{x}}$	0,38	0,64	0,021	0,65	0,67	0,024			
96 hs post mortem	$\bar{X}$	12,10	18,40	5,450	12,15	16,35	5,510	0,05	2,05	0,06
	S	1,85	3,19	0,094	1,90	2,69	0,102			
	C	15,28	17,33	1,724	15,63	16,45	1,185			
	$S_{\bar{x}}$	0,61	1,06	0,031	0,63	0,89	0,034			

* = P 0,05; ** = P 0,01

Table 4.

Average Values and Variations of WHC, Swelling and pH in M. longissimus dorsi, which frozen at different times post mortem (in %)

Time of Freezing	Values	Buffalo			Cattle			Differences		
		WHC	Swell.	pH	WHC	Swell.	pH	WHC	Swell.	pH
1 hs post mortem	$\bar{X}$	10,41	24,30	6,07	9,07	21,95	5,94	1,34	2,35	0,13
	S	1,56	4,92	0,270	1,43	3,78	0,280			
	C	14,98	20,24	4,448	15,76	17,22	4,713			
	$S\bar{x}$	0,52	1,64	0,090	0,47	1,26	0,093			
6 hs post mortem	$\bar{X}$	11,10	8,46	5,61	9,23	15,65	5,74	1,87	7,19**	0,13
	S	2,35	2,15	0,204	1,86	2,60	0,160			
	C	21,17	25,41	3,636	20,15	16,61	2,787			
	$S\bar{x}$	0,78	0,71	0,068	0,62	0,86	0,053			
24 hs post mortem	$\bar{X}$	13,06	18,50	5,42	12,80	17,20	5,58	0,26	1,30	0,16*
	S	2,80	4,05	0,140	2,50	4,12	0,095			
	C	21,43	21,89	2,583	19,53	23,95	1,702			
	$S\bar{x}$	0,93	1,35	0,046	0,83	1,37	0,031			

* = P 0,05; ** = P 0,01

As shown by the above data, besides the changes of the post-mortem hydration, expressed by the WHC (whereby we understand the capacity of meat to retain its own water when it is subjected to compression) and swelling (retention of a portion of added water), we also took the pH values.

On the basis of data given in Tables 3 and 4 (without going into further details) the following statements may be made:

- WHC in the buffalo meat is greater during the first few hours after slaughter, decreasing considerably a few hours after, reaching nearly the same level as beef, or it may be even lower;
- Swelling of meat is also somewhat greater directly after slaughter (although this difference is not statistically significant); 6 hours after the slaughtering, the swelling of buffalo meat is considerably smaller than that of beef, while later on it equalizes with the beef, and it even has a greater capacity for swelling;
- pH values in the buffalo meat are greater directly after slaughter. However, the drop is quicker, so that after 6 hours these values practically equalize, while in later periods they are permanently somewhat lower.

Similar values were obtained for meat after freezing (Table 4). However, it should be noted that the differences are greatly pronounced between the buffalo meat and beef which was frozen 6 hours after slaughtering. In our opinion, this might be connected with the phenomenon of "Thaw - rigor" (5).

If we now look back at the total results of these investigations it may be stated that they are mainly in agreement with the generally accepted theory on post-mortem hydration of meat. Hence we consider that further and detailed interpretations are irrelevant, since they have already been published in many papers, and more especially in works by Hamm (3) and Soloviiev (19). It is our wish to draw the attention once again to the fact that when observing the established differences between the buffalo meat and beef, we should first consider the differences in the content of glycogen and connecting tissues, since they are probably one of the main causes for all other differences too.

Conclusions

On the basis of the results obtained the following conclusions may be drawn:

1. Buffalo meat contains more glycogen and connecting tissues compared with beef. There are indications that buffalo meat is somewhat richer in mineral matter, too. Likewise, it may be said that buffalo meat contains somewhat more total proteins, which is primarily the result of the greater content of connecting tissues. No significant differences were found in the content of other properties.
2. Directly after slaughtering the buffalo meat has a greater capacity for retaining its own and added water than beef; during the Rigor Mortis the WHC decreases relatively more in the buffalo meat than in beef. Likewise, it seems that the "Thaw Rigor" too, leaves more unfavorable consequences in the buffalo meat than in beef. After the ceasing of Rigor Mortis, the buffalo meat has almost the same or somewhat greater WHC than beef. These differences in favor of the buffalo meat are expecially pronounced with regard to swelling.
3. When using the buffalo meat in culinary and technological processes, considerations should be given to the differences mentioned with regard to beef.

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