DYNAMICS OF SALT DIFFUSION DURING DRY CURING OF BEEF *M.biceps femoris*

Radomir Radovanović, Jovanka Popov-Raljić*, Mirjana Ivanović, Dušan Živković, Natalija Džinić*

University of Belgrade, Faculty of Agriculture, 11080 Belgrade, P.O.Box 127 - Yugoslavia
*University of Novi Sad, Faculty of Technology, 21000 Novi Sad - Yugoslavia

BACKGROUND A significant deal of information on the curing process has been related to salt diffusion and its final effects on the preservation and some sensory properties (especially on colour and flavour). Namely, it is well known that the production of the specific "cured meat" colour and aroma requires a fairly slow process, but nowadays this process is constantly being made faster. For some gropus of meat products, owing to innovative technologies (injection; massage; vacuum tumbling) and using modernized equipment, it has become possible to speed up the process fairly successful. So, penetration of salt/brine into meat under these conditions (resembling tank curing) has been well studied, as well as dry curing, but with the use of raw meat model pieces **(Körmendy and Ganter, 1958; Andujar and Tarrazo, 1981; Djelveh and Gros, 1988; Leutenschlager, 1995).** However, dry curing under the real production conditions, particularly during the processing of traditional dry meat products, as an additional activity of farmers' households, has not been fully investigated.

OBJECTIVES The objective of our work was to study the dynamics of salt diffusion into beef *M.biceps femoris* during dry curing, as well as the effects of this process on weight changes, chemical composition, colour characteristics and selected texture properties of the final product.

METHODS The investigations were conducted using beef *M.biceps femoris* (MBF). The selected muscles were of normal pH (5.4 - 5.7) and were not affected by PSE **(Trout, 1992)**. Each muscle was well trimmed of fat and connective tissue. Coarse-grained sea salt (2-3 mm) was used for dry curing. Salting was carried out using the surface massage of the previously formed muscles - in the ratio of 5% salt to muscle weight. Curing was done for 7 days at 2-4 ^{0}C. Data for weight changes (%) were determined by weighing one half of **12** MBF each - daily during a 7-day curing. Average initial weight of this group of the examined muscles amounted to **2.980** g. The dynamics of salt diffusion, chemical composition, colour characteristics and selected texture properties were monitored on **12 MBF** samples of the second half, the average weight being **2.855** g. The investigated muscle slices 20 mm thick were taken daily for the analysis of the contents of water (%), salt (% NaCl) and proteins (%) and for a_w values determination, respectively. From each slice, three layers - a, b, and c - were separated and investigated. The first two concentric layers (a, b) were 10 mm thick each. The last layer (c) was the central remnant of the muscle. Also, a sample was taken daily of a spontaneously separated exudate for determination protein content. Measurements of water activity (a_w) were made in homogenized samples of slices of 12 muscles each (at 25 ^{0}C, Thermoconstanter TH2, Novasina). Based on the results obtained, daily calculations were performed of the corresponding mean values. In the same fashion, samples for determination basic chemical composition were prepared - prior to and after the curing process **(AOAC, 1990).** On the samples of all 12 muscles, instrumental measurements ("INSTRON"-4301) were made (0th, 3rd and 7th day) for texture assessment (tenderness; firmness; plasticity/compressibility). Determination of colour characteristics in MBF samples was carried out using photoelectric tristimulus colorimeter (the MOM Color – D). The values for psychometric lightness (L*), psychometric hue – redness (a*) and psychometric chrome – yellowness (b*) are expressed based on the CIELAB, 1976 system **(Robertson, 1977).** Data statistical analysis was carried out by standard methods **(Snedecor and Cochran, 1980).**

RESULTS The data for weight changes during dry curing of beef MBF are presented in **Fig.1.** Average weight decrease after 7-day curing amounted to 80 g (2.69%) relative to the initial weight of the investigated muscles ($p>0.05$). Increase in average weight is evident between 2nd and 5th day of curing (approx. 1.14%), while the further course of the process is accompanied by a constant, though slight, weight decrease ($p>0.05$).

Tab.1 presents data for average chemical composition of homogenized samples of the investigated muscles, established at the start (day 0) and the end of curing (day 7). NaCl content of 4.95% at the process termination demonstrates that during a 7-day curing the desired salt concentration has been achieved. This is associated with water content decrease at the process termination, on average, by approx. 6.0% ($p<0.01$). For the content of total proteins, the difference between initial and final means values (0.95%) has not been statistically confirmed ($p>0.05$). In exudate, the final protein content amounted to 3.7%.

Fig.2. show the data for changes in salt content (% NaCl). Average values in the investigated layers evidence that salt content in the central layer ***(c)*** constantly increases - from 0.29 to 2.24% ($p<0.01$). The surface ***(a)*** and mid-layer ***(b)*** reach maximal salt content on day 7 - 6.26 and 3.28%, respectively, which is followed by minimal water content - 66.65 and 69.00%, respectively **(Fig.3),** which is in agreement with data reported by **Fox (1980), Andujar and Tarrazo (1981)** and other authors.

The results established for water content (within three investigated layers) during dry curing of beef MBF are given in **Fig.3.** In the surface layer ***(a)***, during the 7-day curing process, the water share declines all the time - approx. 4.7% ($p<0.05$). For the equal time length, in the other two layers ***(b*** and ***c)***, water content also declines constantly: ***b*** - by 8.8% ($p<0.01$) and ***c*** - by 6.3% ($p<0.01$). Generally, water content per layer, throughout the entire curing process, has a regular schedule: it is highest in the central (76.2 - 71.4%) and the lowest in the surface layer (69.9 - 66.6%). The data related to water activity (a_w) range within a relative small scope thus demonstrating nearly regular tendency towards decreasing average a_w values during dry curing: from day 0 (0.982) to day 7 (0.971) - $p<0.01$. This is in full agreement with the results reported by **Ventanas et al., 1989.**

Average values parameters determining the characteristics of colour in the investigated muscles (L*; a*; b*) are given in **Tab.2**. During three time periods of instrumental measurements, lightness (L*) of samples constantly increases: from 33.98 to 44.33, or by 30.45% ($p<0.01$). Simultaneously, the share of redness (a*) increases from 11.80 to 21.32, or by 80.68% ($p<0.01$); the share of yellowness (b*) also rises from 9.35 to 14.66 (56,79% - $p<0.05$).

The results of texture assessments are given in **Tab.3**. For all investigated properties, the decrease of mean values has been established, which may affect the quality of the final product and consumer satisfaction during consumption: firmness decreased by 28.02% ($p<0.01$), plasticness/compressness by 51.62% ($p<0.01$), and tenderness by 51.6% ($p<0.01$).

CONCLUSIONS The results of our investigations point out that during dry curing of chilled beef *M.biceps femoris (MBF)*, using 5% of salt, at 2-4 ^{0}C, satisfactory results are achieved after 7th day of dry curing. It should be emphasized that MBF muscle has a small but not significant weight increase - 2.69% ($p>0.05$). The penetration of salt into the muscle center (4.95% NaCl - $p<0.01$), water loss (6.09% - $p<0.01$) and a_w value decrease ($p<0.01$), is quite satisfactory. Concurrently, good results were established for some more important colour characteristics (L*; a*; b*), as well as for some more significant parameters of texture (firmness; plasticity/compressibility; tenderness) in the investigated MBF samples ($p<0.01$). So, it may be stated that all favorable tendencies have been expressed to a higher degree by extending the dry curing process from 5th to 7th day.

LITERATURE ***1. Andujar, G., Juana Tarrazo, 1981.*** Fleischwirtschaft, 61, 9, 1366. ***2. AOAC, 1990***. Official Method of Analysis, 15th ed., Washington, DC. ***3. Djelveh, G., Gros, J.B.,1988***. Meat Sci., 23, 11. ***4. Fox, J.B.***, 1980. J.Food Sci., 45, 1740. ***5. Kormendy, L., Gantner, G.Y, 1958.*** Lebensmittel-Untersuchung und -Forschung, 107(4), 313. ***6. Leutenschlager, R. 1995***. 41st ICoMST. Proceedings, Vol.II, 507. San Antonio, USA. ***7. Radovanovic, R. et al., 1998.*** *44th ICoMST. Proceedings C 77, 978. Barselona, Spain.* ***8. Robertson, A.R., 1977.*** The CIE 1976 Color-Difference Formulae. Color Research Applied, 2, 7. ***9. Snedecor, G.N., Cohran, W.G., 1980.*** Statistical Methods. The Iowa State University Press, Ames, USA. ***10. Trout, G.R., 1992.*** 38th ICoMST. Proceedings, Vol.5, 983. Clemont-Ferrand, France. ***11. Ventanas, J. et al., 1989.*** 35th ICoMST. Proceedings, Vol.III, 707. Copenhagen, Denmark.

Fig. 1. Weight changes of beef MBF during dry curing

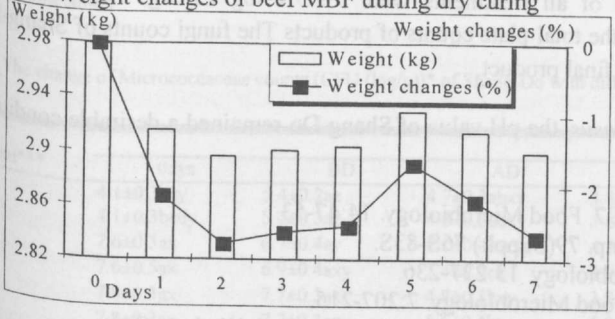


Fig. 2. NaCl (%) content changes of beef MBF during dry curing

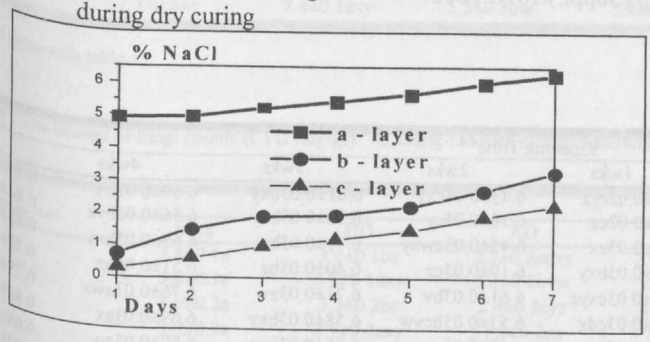
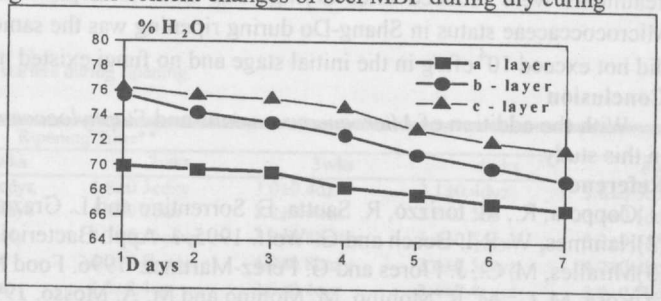


Fig. 3. Water content changes of beef MBF during dry curing



Tabl. 1. Chemical composition of beef MBF at the beginning (B) and at the end (E) of dry curing

		$\bar{X}$	SD	Cv
Water (%)	B	76.69	1.502	1.96
	E	72.02	1.299	1.83
Proteins (%)	B	21.06	1.047	4.95
	E	21.26	0.734	3.47
Fat (%)	B	0.86	0.228	24.97
	E	0.97	0.504	62.77
Ash (%)	B	1.10	0.050	4.53
	E	5.29	0.537	11.58
NaCl (%)	E	4.95	0.399	8.07

Tabl. 3. Texture values of beef MBF during dry curing

Days	Firmness	Plasticness/ Compressibility	Tenderness
0. day	0.0489	0.4206	0.1932
3rd day	0.0423	0.3111	0.1615
7th day	0.0352	0.2035	0.0935

Tabl. 2. CIELAB (1976) L* (lightness), a*(redness) and b* (yelowness) values of beef MBF during dry curing

	Days			Significance		
	0	3rd	7th	0:3	3:7	0:7
L*	33.98	39.79	44.33	3.10*	4.37*	6.39**
a*	11.8	19.56	21.32	5.28**	1.95^{NS}	6.85**
b*	9.35	13.93	14.66	2.96*	1.49^{NS}	3.38*