Biotechnology in Animal Husbandry 23 (5-6), p 49 - 58 , 2007 ISSN 1450-9156
Publisher: Institute for Animal Husbandry, Belgrade-Zemun UDC 637.5.62

THE EFFECT OF TIME OF MATURATION AND $CaCl_2$ ON QUALITY OF YOUNG BEEF **

B. Miščević[1], S. Aleksić [2], Lj. Sretenović [2], V. Pantelić [2], S. Trivunović[3], D. Ostojić-Andrić [1]

[1]MEGA-TREND University, Faculty of Biofarming, Sombor, Serbia
[2] Institute for Animal husbandry, Belgrade-Zemun, 11080, Zemun, Serbia
[3] Faculty of Agriculture, Novi Sad, Serbia
*Corresponding author: e-mail: bramis@eunet.yu
**Original scientific paper. Research financed by the Ministry of Science of Republic of Serbia, Project TR6887 B

Abstract: Investigations were carried out on four muscles (*M. longissimus dorsi, M. semimembranosus, M. semitendinosus, M. biceps femoris*) taken from five young cattle (crosses Domestic Spotted x Limousine) of average body mass prior to slaughtering of 587 kg. On all muscles, 24 h after slaughtering, sensory evaluation was carried out and the following parameters determined: pH value, colour, water binding ability, cooking loss and tenderness (initial values). The remaining part of each muscle was divided into 6 parts, 3 were packaged in plastic foil (control samples), and other 3 were soaked in solution containing 0,4% $CaCl_2$ and 0,4% NaCl and packaged in plastic foil. Pieces of meat prepared in this way were left on temperature of + 4^0C 7, 14 and 21 days to mature. After this period, all mentioned analyses were carried out on meat samples. It was established that pH value during maturation increased, that meat packaged in plastic foil after 14 days of maturation becomes unusable, whereas the increase of pH values of meat whose maturation occurred in solution $CaCl_2$ and NaCl was slower and therefore meat was still usable after 21 days. Colour of meat in control samples was slightly lighter compared to initial condition, whereas the colour of meat whose maturation occurred in solutions of salt was statistically considerably lighter ($P<0,05$ after 7 days, a $P<0,001$ after 14 and 21 days). Water binding ability in control samples was slightly better ($P>0,05$) after 7 days and after 14 days it was statistically significantly better ($P<0,05$) compared to initial state, whereas in meat whose maturation occurred in salt solution this ability was at initial level even after 21 days. Cooking loss in control samples was lower compared to initial values whereas in meat soaked in salt solution cooking loss was higher. Meat tenderness in control samples was statistically considerably better after 14

days of maturation (when meat was not fit for use) and in meat soaked in salt solution it was statistically highly significantly better after 14 and 21 days. According to sensory evaluation, control samples of meat, after 14 days of maturation are not fit for use, whereas meat whose maturation occurred in solution of CaCl2 and NaCl even after 21 days is acceptable from the sensory aspect.

Key words: maturation of meat, pH value, meat colour, meat tenderness, calcium chloride

Introduction

Main reason why it is necessary for meat to mature is that it improves tenderness, taste, aroma and mature meat prepared for consumption will be more acceptable to consumers. Price of such meat can be considerably higher than of »usual« meat since loss of mass occurs during maturation. However, maturation in vacuum doesn't have such an effect on loss of mass, therefore it is more acceptable. Special attention should be directed to packaging and handling of meat, since any disruption of vacuum consistency (punctured wrapping) will lead to spoiling of meat due to activity of aerobic micro organisms. *Wallace et al.*,(1999) investigated the effect of duration (3, 7, 14 and 21 days) of maturation, freezing and treating of meat with 20% of $CaCl_2$ solution on meat tenderness and established that control (3 days after slaughtering) and frozen samples were less tender than meat which under went maturation, also that meat treated with solution of $CaCl_2$ was considerably more tender (value of cutting force on consistency meter according *Warner-Bratzler* and sensory evaluation) compared to control samples. *Perez–Chabela et al.* (2005) investigated the effect of solution of $CaCl_2$ on samples of M. *biceps femoris* on activation of protease for softening of meat and determined that meat which contained higher amount of collagen wasn't tenderer after treatment with this solution. *Wicklund et al.* (2005) investigated the effect of treatment of meat with solution containing 0,4% of alkaline phosphatase, 0,3% NaCL and 0,1% of spices on major sensory traits of meat and established that treated samples were more tender (meat was most tender 14 days after maturation) and with better taste than control. *Bratcher et al.,* (2005) investigated the effect of the type of muscle (*M. infraspinatus, T. brachii, M. romboideus, M. splenius, M. rectus femoris*) on duration of maturation and established that tenderness measured on consistency meter according to *Warner-Bratzler* depended on

type of muscle and duration of maturation (in order for meat to be categorized in higher quality class it should mature 7 to 14 days). *Simoes et al.,* (2005) investigated the effect of age of young cattle (18 and 24 months) at slaughtering on some traits of meat quality in different muscles and established that *M. biceps femoris* and *M. semimimbranosus* had more favourable investigated traits compared to *M. long. toracis*, *M. long. lumborum* and *M. semimtendinosus.*

Material and methods

Investigations were carried out on central parts of four muscles: 1. loin section of *M. longisimus dorsi*, 2. *M. semimembranosus*. 3. *M. semitendinosus* and 4. *M. biceps femoris* which were taken from five young bulls crosses of Domestic Spotted breed and Limousine, average of 630 days and average mass prior to slaughtering of 587 kg. Each muscle was divided into 6 parts. One part of each muscle, 24 hours after slaughtering the pH value was determined by measuring potential difference between glass and reference electrode in water extract of meat sample (JUS ISO 2917, 2004); water binding ability by method of centrifuge (IS-LDM-55); colour of meat was determined by measuring of absorbance of water pigment extract of meat by method according to Hart (IS-LDM-53); tenderness of meat was determined by measuring of resistance of meat when cut on consistency meter according to Wolodkewisch and it is expressed in kg of maximal force necessary to cut muscle tissue (IS-LDM-65); loss of mass (cooking loss) during cooking was determined on following way: in laboratory glass of 250 cm^3, 100 cm^3 of distilled water is poured, glass is than covered with small glass and water heated to boiling. Piece of meat in form of cube, mass of 50 g (meat is measured immediately before putting in the water) is put in boiling water, glass is covered again with small glass and cooking continued for another 10 minutes (time is measured from the moment when meat is placed in the glass). After the time has passed, piece of meat is taken from the water, using filter paper excess of water is removed and meat is immediately measured. Difference between mass of piece of meat before and after cooking is loss (cooking loss) occurring during thermal processing and it is expressed in percentage of mass. Results of these investigations were taken as initial value of meat quality indicators. Other three parts of each muscle were packaged in plastic foils and kept in refrigerator on temperature of $+4^0$C (control samples) and other three were soaked in solution containing 0,4% $CaCl_2$ and 0,4% NaCl and packaged in plastic foil. Meat samples

prepared in this way are stored on temperature of + 4^0C 7, 14 and 21 days. After this period, stated investigations were carried out on samples of all muscles. On samples of roasted meat (piece of meat of 60 g wrapped in aluminium foil and roasted 15 min. on temperature of 180 – 190^0C) sensory evaluation of smell, taste, tenderness and succulence was carried out using point awarding system according to *Radovanović et al.,*. (2000): very acceptable-5; acceptable-4; tolerant-3; unacceptable-2; very unacceptable-1). Statistical processing of obtained data was done by variance analysis, and significance of differences between mean values was determined using t-test, *Mulić* (1969).

Results and discussion

1. pH value

In the meat of four investigated muscles, pH value 24 hours subsequent to slaughtering was practically the same (Table 1) and varied within the usual values for young beef in this period after slaughtering (5,49 – 5,53). In control samples (Table 2) pH value after 7 days of maturation was 5,78 – 5,79, and after 14 days 6,13 - 6,17, and meat was not fit for use in regard to sensory traits. Differences in pH values between muscles weren't statistically significant during maturation. During maturation of meat soaked in solution of $CaCl_2$ and NaCl and stored on temperature of +4^0C (Table 3), pH value increased gradually and after 7 days it was 5,54 - 5,54, after 14 days 5,63 – 5,64, and after 21 days 5,71 – 5,78 (meat had no changes in sensory traits).

2. Colour of meat

According to values for absorbency (tab. 1) *M. biceps femoris* was of the lightest colour (1,38), and *M. semitendinosus* the darkest (1,83). After 7 days of maturation of meat packaged in plastic foil (Table 2), colour of meat was slightly lighter (absorbency value 1,11 – 1,69), and after 14 days slightly darker (absorbency value 1,27 – 1,73). Differences between muscles were slight and tendency determined as initial value remained. In meat soaked in solution of $CaCl_2$ and NaCl (tab. 3) differences between muscles were slight, but colour in all muscles was statistically significantly ($P<0,05$) lighter (absorbency value 0,66 – 0,99). After 14 days of maturation of meat in same conditions, colour of all muscles was even more lighter (absorbency value 0,54 – 0,80), and the same can be concluded after 21 days (absorbency value 0,44 - 0,71), which can be explained by transfer of pigment into

solution. Differences between initial state of meat colour and after 14 and 21 days of maturation in $CaCl_2$ and NaCl were statistically highly ($P<0,001$) significant.

Table 1. Initial values of investigated muscle traits

Investigated muscle	pH	Colour*	WBA**	Cooking loss (%)	Tenderness (kg)
M. longissimus dorsi	5,52	1,497	9,2	36,65	12,11
M. semimembranosus	5,49	1,746	9,1	34,05	12,13
M. semitendinosus	5,53	1,830	9,3	32,62	10,40
M. biceps femoris	5,53	1,383	9,2	36,73	10,03

* Colour of meat expressed as value of extract absorbance;
** Water binding ability expressed in cm^3 of water released after centrifuge.

Table 2. Changes in investigated traits of meat during maturation (control samples)

Muscle	7 days					14 days				
	pH	Colour*	WBA **	Cooking loss (%)	Tenderness (kg)	pH	Colour*	WBA **	Cooking loss (%)	Tenderness (kg)
1	5,89	1,34	8,8	34,68	9,70	6,16	1,36	6,8	33,89	7,05
2	5,78	1,58	8,8	31,37	9,38	6,17	1,69	7,2	30,35	6,05
3	5,87	1,69	9,2	29,14	6,55	6,13	1,73	7,0	29,02	5,02
4	5,85	1,11	8,8	34,94	5,85	6,16	1,27	7,2	34,21	4,93

1 - *M. longissimus dorsi*; 2 - *M. semimembranosus*; 3 - *M. semitendinosus*; 4 - *M. biceps femoris*
* Colour of meat expressed as value of extract absorbance;
** Water binding ability expressed in cm^3 of water released after centrifuge.

3. Water binding ability

Water binding ability (table 1) was practically the same in all investigated muscles (9,1 – 9,3 cm^3 unbound liquid) at the beginning of trial. Control samples after 7 days of maturation (table 2) had better water binding ability (8,8 – 9,2 cm^3 of unbound liquid) and after 14 days of maturation

water binding ability was statistically insignificantly (P>0,05) better (6,8 – 7,2 cm^3 of unbound liquid). In meat samples which matured in solution of $CaCl_2$ and NaCl (tab. 3) after 7 days, water binding ability was slightly better (8,9 – 9,2 cm^3) compared to initial state, after 14 days it was even better (8,8 – 9,1 cm^3), and after 21 days it was still on the same level as after 14 days (8,8 – 9,2 cm^3). In the procedure of determination of water binding ability, after removal of meat from the solution and before cutting, meat was left for 120 minutes in the glass covered with small glass for the remaining solution to drain.

4. Cooking loss

Cooking loss of meat at the beginning of trial (Table 1) was higher in *M. biceps femoris* (36,73%) and *M. longissimus dorsi* (36,65%), and lower in *M. semimembranosus* (34,05%) and *M. semitendinosus* (32,62%). Control meat samples (tab. 2), after 7 days of maturation had lower cooking loss (*M. l. dorsi* 34,68%, *M. semimebranosus* 31,37%, *M. semitendinosus* 29,14% and *M. biceps femoris* 34,94%), but differences weren't statistically significant. After 14 days of maturation, cooking loss decreased statistically insignificantly and was determined from 29,02% in *M.semitendinosus* to 34,21% in *M biceps femoris*. Differences between mean values at the beginning of trial and after maturation of 14 days weren't statistically significant. In meat whose maturation occurred in solution of $CaCl_2$ and NaCl, cooking loss was statistically insignificantly lower compared to initial values in first 7 days of maturation (improved binding of water due to the effect of salt) and with prolonging of maturation time it remained on approximately same level (Table 3). After 7 days of maturation, cooking loss was the lowest (29,13%) in *M. semitendinosus*, and the highest (34,67%) in *M. longissimus dorsi*. In procedure of determination of cooking loss, after removal from the solution, meat was left 126 hours (over night) for loosely bound water to drain.

5. Meat tenderness

At the beginning of trial, force necessary for muscle tissues to be cut (tab. 1) was in *M. longissimus dorsi* 12,11 kg, in *M. semimembranosus* 12,13 kg whereas *M. semitendinosus* and *M. biceps femoris* were statistically insignificantly more tender (10,40 kg in *M. semitendinosus* and

10,03 kg in *M. biceps femoris*). Control meat samples (tab. 2) after 7 days of maturation were considerably (P<0,05) more tender (necessary force for cross sectional cutting of muscle tissues was from 5,85 kg in *M. biceps femris* to 9,7 kg in *M. l. dorsi*), and after 14 days of maturation statistically highly significantly (P<0,01) more tender (necessary force for cutting of muscle tissues was from 4,9 kg in *M. biceps femoris* to 7,05 kg in *M. l. dorsi*) compared to initial values. Differences in meat tenderness after 7 and 14 days of maturation were also statistically significant (P<0,05). During maturation in solution of $CaCl_2$ and NaCl (tab. 3) meat was becoming more tender, so differences after 7 days were statistically significant (P<0,05), and after 14 days statistically highly significant (P<0,01). Established differences after 14 and 21 days of maturation weren't statistically significant.

Table 3.maturation of meat in solution of CaCl2 and NaCl

I	7 days					14 days					21 days				
	pH	A	B	C	D	pH	A	B	C	D	pH	A	B	C	D
1	5,54	0,86	8,9	34,67	8,67	5,63	0,70	8,8	34,23	5,29	5,71	0,63	8,8	34,01	5,42
2	5,53	0,99	9,0	30,14	6,32	5,63	0,80	9,0	30,06	4,53	5,71	0,71	9,0	30,45	4,04
3	5,54	0,84	9,1	29,13	6,30	5,64	0,76	9,0	28,93	5,55	5,75	0,68	9,0	28,66	5,03
4	5,54	0,66	9,2	31,37	5,38	5,63	0,54	9,1	30,74	4,38	5,78	0,44	9,2	30,69	4,08

I. Muscle: 1. *M. longissimus dorsi; 2.- M. semimembranosus; 3. - M. semitendinosus; 4. – M. biceps femoris*.

II. A – Colour of meat; B – Water binding ability; C – Cooking loss; D - Tenderness

6. Sensory traits

Meat of investigated muscles 24 hours after slaughtering, in regard to smell and taste was evaluated as acceptable (average grade 4,12 points). After 7 days of maturation, meat (control samples) of all muscles was evaluated as acceptable in regard to its investigated traits (average grade for smell and taste 4,42 points, and for tenderness and succulence 4,38 points). After 14 days of maturation meat of all muscles in regard to smell was unacceptable (other traits weren't evaluated). Meat which matured in solution of $CaCl_2$ and NaCl after 7 days of maturation was evaluated in regard to smell, taste, tenderness and succulence as acceptable (average grade for all traits 4,47 points), after 14 and 21 days as very acceptable (average grade for all traits after14 days was 4,92 points, and after 21 days 4,81 points).

Conclusion

Based on results obtained in investigation of the effect of maturation of meat packaged in plastic foils (control sample) and maturation of meat soaked in 0,4% solution of $CaCl_2$ and 0,4% solution of NaCl on major quality traits of meat (tenderness, sensory traits) the following can be concluded:

- pH value of meat packaged in plastic foils (control samples) during maturation increased so that meat after 14 days was unfit for use, whereas pH value of meat which matured in solution increased insignificantly so after 21 days meat is still usable;
- colour of meat packaged in plastic foils (control samples) during maturation turned darker, and in meat which matured in solution, colour with prolonging of maturation time turned lighter;
- meat tenderness improved significantly during maturation in both observed treatments;
- in regard to sensory traits, meat packaged in plastic foils (control samples) after 14 days of maturation was not fit for use, whereas meat which matured in solution even after 21 days was still very acceptable.

UTICAJ VREMENA ZRENJA I $CaCl_2$ NA KVALITET JUNEĆEG MESA

B. Miščević, S. Aleksić, Lj. Sretenović, V. Pantelić, S. Trivunović, D. Ostojić-Andrić

Rezime

Ispitivanja su obavljena na četiri mišića (*M. longissimus dorsi, M. semimembranosus, M. semitendinosus, M. biceps femoris*) uzetih od pet junadi (melezi domaće šareno goveče x limuzin), prosečne mase pred klanje 587 kg. Na svim mišićima 24 sata posle klanja obavljena je senzorna ocena i određeni su: pH vrednost, boja, sposobnost vezivanja dodate vode, kalo kuvanja i mekoća (početne vrednosti). Ostatak svakog mišića podeljen je na 6 delova od kojih su po 3 upakovani u plastičnu foliju (kontrolni uzorci), a ostala 3 dela su potopljena u rastvor koji sadrži 0,4% $CaCl_2$ i 0,4% NaCl i

upakovani u plastičnu foliju. Ovako pripremljeni komadi mesa ostavljeni su pri temperaturi od + 4^0C 7, 14 i 21 dan na zrenju. Posle isteka zadatog vremena urađena su na komadima od svih mišića navedena ispitivanja.Utvrđeno je da se pH vrednost tokom zrenja povećava i da u mesu koje je upakovano u plastičnu foliju posle 14 dana zrenja dospeva u oblast kad je meso neupotrebljivo, dok je povećanje pH vrednosti kod mesa čije se zrenje odvijalo u rastvoru $CaCl_2$ i NaCl sporije tako da je meso i posle 21 dan upotrebljivo. Boja mesa kod kontrolnih uzoraka bila je neznatno svetlija u odnosu na početno stanje, dok je boja mesa čije se zrenje odvijalo u rastvoru soli bila statistički značajno svetlija ($P<0,05$ nakon 7 dana, a $P<0,001$ nakon 14 i 21 dan). Sposobnost vezivanja vode kod kontrolnih uzoraka bila je neznatno ($P>0,05$) bolja nakon 7 dana dok je nakon 14 dana bila statistički značajno bolja ($P<0,05$) u poređenju sa početnim stanjem, dok je kod mesa čije se zrenje odvijalo u rasdtvoru soli i posle 21 dan bila na nivou početnog stanja. Kalo kuvanja kod kontrolnih uzoraka bio je manji u poređenju sa vrednostima na početku ogleda dok je kod mesa potopljernog u rastvor soli bio veći. Mekoća mesa kod kontrolnih uzoraka bila je statistički značajno bolja nakon 14 dana zrenja (kad je meso bilo neupotrebljivo) dok je kod mesa potopljenog u rastvor soli bila statistički visoko značajno bolja posle 14 i 21 dan. Prema senzornoj oceni kontrolni uzorci mesa nakon 14 dana zrenja postaju neupotrebljivi, dok je meso čije se zrenje odvijalo u rastvoru $CaCl_2$ i NaCl i nakon 21 dan zrenja senzorno veoma prihvatljivo.

References

BRATCHER CL., JOHNSON DD., LITTELL RC., GWARTNEY BL. (2005). The effects of quality grade, aging, and location within muscle on Warner-Bratzler shear force in beef muscles of locomotion. Meat Science 70 (2): 279-284.

MULIĆ J.: *(1969*). Eksperimentalna statistika primenjena u poljoprivredi. Poljoiprivredni fakultet, Srajevo

PEREZ–CHABELA, GUERRERO I, GUTIEREZ-RUIZ MC, BETANCOURT-RULE J*M* (2005): Effect of calcium chloride marination and collagen content on beef, horse, rabbit and hen meat hardness. Jornal of Muscle Foods 16 (2), 141-154

RADOVANOVIĆ R., POPOV-RALJIĆ JOVANKA, (2000): Senzorna analiza prehrambenih proizvoda, Beograd-Novi Sad.

RISVIK E., (1994): Sensory properties and preferences. Meat Science, 36, p.67-77.

SIMOES JA., MENDES MI., LEMOS JPC: (2005). Selection of muscles as indicators of tenderness after seven days of aging. Meat Science 69 (4): 617-620.
WALLACE C.D., MORGAN J.B., MAFI J.C., GUENTHER L.L., NOVOTNY K.K, DOLEZAL H.G., RAY F.K.: 1999. Effect of freezing method and calcium chloride injection on beef longissimus muscle tenderness. Animal Scince Research Report (72 – 77).
WICKLUND SE., HOMCO-RYAN C., RYAN KJ, MCKEITH FK, MCFARLANE BJ, BREWER MS, (2005): Aging and enhacement effects on quality characteristics of beef strip steaks. Journal of Food Science 70 (3), 242-247.