4-P30

Osmolality of bovine muscle juice as affected by cooking temperature

[1] M.Christensen, [1] P.P. Purslow and [2] L.M. Larsen

The Royal Veterinary and Agricultural University, [1]Institute of Dairy and Food Science, Department of Meat Science, Rolighedsvej 30, 1958 Frederiksberg C, Denmark. [2]Chemistry Department, Thorvaldsensvej 40, 1871 Frederiksberg C, Denmark

Introduction

The osmotic properties of muscle and hence the osmolality of muscle juice are an important element of the properties of meat. Thus, Winger and Pope (1980-81) found that the osmotic pressure of meat increases considerably during rigor development from about 300 mOsmole to 530 mOsmole. Because osmotic pressure is a colligative property it seems possible that the osmolality of muscle juice squeezed out from meat during cooking at different temperatures could be affected by heat induced changes in protein concentration and release of ionic species (Hamm, 1966). Investigations of the osmotic properties of muscle juice have previously been performed by Winger and Pope (1980-81) and Bonnet et al. (1992). However, these experiments dealt with the juice extracted from raw meat and its properties on heating. The osmolality could therefore be different from the osmolality of muscle juice squeezed out from meat during cooking. Heat induced changes of the muscle juice osmolality obtained from cooked meat have not been addressed in the literature. An experiment was conducted to determine the influence of cooking temperature on the osmolality of bovine muscle juice and also to investigate the effect of different treatments (freezing and aging) which affects the structure and biochemistry of the meat.

Materials and Methods

M. Semitendinosus were obtained from the right side of four Friesian heifers (2-2½ years old) 24 hours post-mortem (p.m.). The meat was cut in slices (app. 4 x 5 x 2 cm) transverse to the muscle fibre direction. All samples were individually vacuum packed and subjected to a combination of four different treatments (frozen vs. fresh and 10 days aged vs. 24 h p.m.). Fresh samples (24 h p.m.) were immediately cooked by suspending the individual bags in a water bath at 50, 60 or 80 °C for 1 hour. Frozen samples (24 h p.m.) were immediately frozen at -20 °C and stored at this temperature prior to use (approximately 1 week). The frozen slices were thawed in running tap water for 30 min and then cooked as described above. Muscle juice from these samples was a combination of juice released upon thawing and cooking. Aged samples were kept at 4 °C for 10 days and thereafter divided into frozen and fresh samples which were treated as mentioned above. Muscle juice was filtered through filter paper. The fluid was stored at -20 °C until use. Two repeats were used for two of the animals and four repeats were used for the two other animals.

All samples were centrifuged at 3000 x g for 10 min through a 90 µm microfilter prior to osmolality measurements. Osmotic pressure of the filtrates was determined by an automatic micro-osmometer (Advanced™ micro-osmometer, Model 3MO). Osmolality (expressed as mOsmoles/kg of water) was measured on 20 µl of filtrate. Protein concentration were determined using a BCA protein assay kit (PIERCE). pH was measured using a Knick Portamess 751 Calimatic pH meter equipped with a Mettler Toledo glass electrode. Dry matter content was determined from 100 µl of the filtrate dried at 110 °C for 24 hours. The non-protein component of the dry matter was calculated by subtracting the protein concentration from the dry matter concentration.

Results and Discussion

According to Hamm (1966) the most remarkable heat induced structural changes of meat occur at temperatures between 40 and 60 °C and include decreased myofibrillar protein solubility, denaturation of sarcoplasmic proteins, decreased water-holding capacity and increased release of cations (Ca^{2+} and Mg^{2+}). At 65 °C most of the myofibrillar and globular proteins are coagulated and collagen will be partially transformed to gelatin. These heat-induced changes of the meat could alter the osmolality of muscle juice upon cooking.

Figure 1 and 2 shows changes of the muscle juice osmolality with cooking temperature for combinations of the four different treatments. We found that ageing, freezing and cooking temperature only had a small influence on muscle juice osmolality. Variations between animals were rather large. These animal variations are probably caused by variations in the dry matter concentration of the individual samples. Thus, if the osmolality values was corrected to 5% dry matter content, which standardises the values, the variations between animals decreased markedly (data not shown). It was concluded that a suitable osmolality value for post rigor meat is app. 530 ± 40 mOsm/kg.

Table 1 shows changes in the concentration of dry matter, protein and the non-protein component with cooking temperature. The concentration of protein in the muscle juice showed a 10% decrease with cooking temperature, whereas the non-protein concentration, which includes ionic species, only showed small changes. The decreased protein concentration could be explained by heat denaturation of sarcoplasmic and myofibrillar proteins which either forms coagulates with other proteins inside the meat and therefore is not released into the muscle juice or the released proteins precipitates upon centrifugation and filtration of the muscle juice prior to osmolality measurement. Protein constitutes approximately 67% of the dry matter (Ewan et al., 1979) and will therefore account for most of the decrease observed in the dry matter concentration.

The slight changes observed in the non-protein component can presumably be explained by the fact that most of the changes in ionic concentrations of the intra- and extracellular muscle fluid and thereby changes in osmotic properties of meat occurs during rigor development (Winger & Pope, 1980-81). This means that even though the concentration of free ionic species probably increases

slightly with cooking temperature, this increase is very small relative to the changes in concentration of free ions which takes place during rigor development. The changes are probably not big enough to influence the osmolality of post rigor meat independent of the treatments used in this study. Osmotic pressure is a colligative property. As (from figure 1 and 2) the osmolality of juice expressed from muscle on cooking shows a very slight trend to reduce at higher temperatures, we can speculate that the drastic reduction in concentration of proteins in solution on heating, has relatively little effect, but is sufficient to offset any increase in free ionic species. We conclude that heat induced protein denaturation does not significantly affect the osmolality of the muscle juice because release of ions from post rigor meat is relatively small.

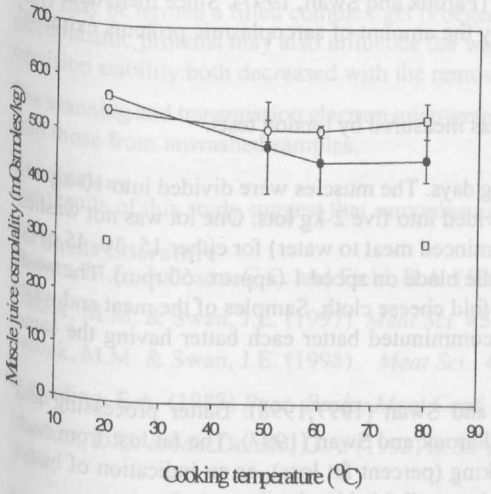

Figure 1. Changes in muscle juice osmolality with cooking temperature. The muscle juice is obtained from fresh meat. The values are given as means and standard deviations (n=4). 24 h pm (●), 10 days pm (○), literature values, Bonnet et al. (1992) and Winger & Pope (1980-81) (▫).

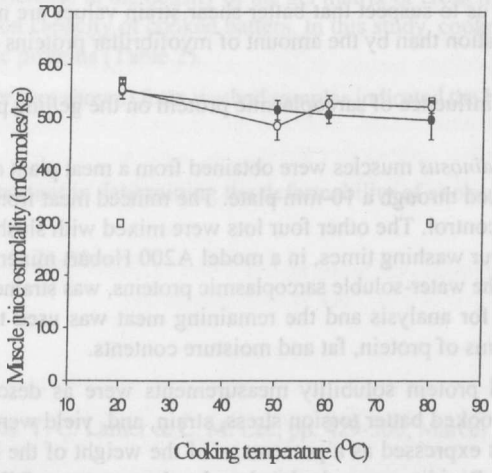

Figure 2. Changes in muscle juice osmolality with cooking temperature. The muscle juice is obtained from frozen meat. The values are given as means and standard deviations (n=4). 24 h pm (●), 10 days pm (○), literature values, Bonnet et al. (1992) and Winger & Pope (1980-81) (▫).

Conclusion

The results show that an osmolality of approximately 530 ± 40 mOsmole/kg is a suitable mimic of bovine muscle juice obtained from post rigor meat under a wide variety of conditions, such as cooking temperature, conditioning and freezing. Because the osmolality does not depend on the protein concentration of the muscle juice, artificial bathing media need not contain fixed protein concentrations, however, the ionic strength of the solutions seems more important.

References

Bonnet,M.Ouali,A. & Kopp, J. (1992). Int. J. Food Sci. Tech., **27**: 399.
Ewan, R.C. Topel,D.G. & Ono,K. (1979). J. Food Sci., **44**: 678.
Hamm, R. (1966). In: Briskey et al. (editor), Physiology and Biochemistry of Muscle as a Food. North Central Publishing Co., St. Paul, Minnesota. pp 437.
Winger, R.J. & Pope, C.G. (1980-81). Meat Science, **5**: 355-369.

Table 1. Changes in dry matter (D.M.), protein (P.) and non-protein (N.P.) concentrations with cooking temperature in muscle juice obtained from fresh or frozen meat stored for 24 hours post mortem or 10 days post mortem, respectively. Values are given as means and standard deviations (n=4).

	Muscle juice from fresh meat						Muscle juice from frozen meat					
	24 h pm			10 days pm			24 h pm			10 days pm		
	D.M. (mg/ml)	P. (mg/ml)	N.P. (mg/ml)	D.M. (mg/ml)	P. (mg/ml)	N.P. (mg/ml)	D.M. (mg/ml)	P. (mg/ml)	N.P. (mg/ml)	D.M. (mg/ml)	P. (mg/ml)	N.P. (mg/ml)
raw	89.8±4.5	57.3±6.4	32.5±10.9	91.7±4.9	58.1±4.6	33.6±1.8	95.1±4.0	62.8±3.3	32.3±6.3	93.1±2.3	64.3±1.7	28.8±2.7
50 °C	63.2±17.4	39.2±5.3	23.9±15.8	70.3±6.7	37.5±10.2	32.7±8.0	73.3±6.5	41.7±4.9	31.6±6.4	65.3±2.5	41.3±6.3	24.0±6.5
60 °C	44.4±9.1	18.6±3.8	25.8±6.1	57.8±8.4	16.6±3.8	41.2±7.2	53.3±4.2	13.3±1.0	40.0±3.2	55.2±1.4	17.9±3.3	37.2±4.4
80 °C	33.6±7.0	5.2±0.3	28.5±6.9	44.6±6.5	8.3±1.0	36.2±5.8	39.7±3.1	6.5±0.7	33.2±3.1	42.4±3.2	9.6±1.1	32.7±3.3