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Technological Chracteristics of Gamma-Irradiated Buffalo-Calf Meat During Storage

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Abstract

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An experiment was carried out with cooled shoulder from 14-month-old buffalo-calves of the *Moura* breed.The observations involved one control group and two experimental groups, irradiated with gamma-ray doses of 4 kGy and 8 kGy, accordingly. The experiment was carried out on preliminarily vacuumized samples over a period of 21 days. The technological characteristics of the meat were monitored by determining the water-retaining and emulsion ability. The meat color characteristic was derived by spectrophotometric determination of Mb, MetMb and OMb.The behaviour of total lipids was analyzed accounting for the level of free malone dialdehyde.The experiment showed that gamma-irradiation improves meat's water-retaining and emulsion ability, which is better expressed at irradiation with dose of 4 kGy, while the colour characteristic of non-irradiated and irradiated samples is preserved throughout the testing period.The content of free malone dialdehyde increased and decreased, whereas in the end of the storage period, in the group irradiated with a dose of 8 kGy, the aldehyde amount reached 1.5 mg/kg, while in the group irradiated with a dose of 4 kGy, the aldehyde amount was below 1 mg/kg.The analysis of the results provides grounds to recommend irradiation of cooled buffalo-calf meat with gamma-ray dose of 4 kGy, which has good effect on meat's technologic properties and extends the storage period subject to preliminary vacuumization of samples.

Key words: buffalo-calf meat, gamma-irradiation, water-retaining ability, emulsion ability, thiol groups, free malone dialdehyde

Introduction

One of the key trends of modern food industry relates to preservation of food quality and safety and their reliable long-lasting storage(Georgieva et al.,2006). Irradiation is the only method which warrants food safety. This method does not create radioactivity in the processed foods and it is the best-known method for control and decontamination of pathogenic microorganisms (Mossel and Stegeman, 1985).

According to Niemand et al. (1981) and Rodriguez et al. (1993), irradiating raw veal with low irradiation doses up to 2 kGy extends the storage period up to 17 days. When applying intensity dose of 7.25 kGy on raw pork, Thayer et al. (1993) established extension of the storage period up to 35 days at temperature of 2^0C.

Barlett et al. (2005) came to the conclusion that ionizing radiation is an effective method to reduce pathogenic microflora and extend the storage period, recommending a dose of 4.5 kGy for cooled meat and 7 kGy for frozen meat.

It is impressive that the authors working in the field of meat and meat product irradiation focus their investigations on decontamination and the objects' microbial status.

Meat's technological characteristics are important for its processing.

In this aspect, the contribution aims to monitor the influence of gamma-irradiation with doses of 4 and 8 kGy on some technological indicators of cooled buffalo-calf meat during storage.

Materials and Methods

The used material was shoulder from 14-month-old buffalo-calves.

Upon removal of the bones and tendons, all visible facii, conjunctive tissue and blood coagulates, the samples were vacuumized in polyethylene bags of 600 d each and distributed in three groups, as follows:

No.1 – control group, non-irradiated;

No.2 – experimental group, irradiated with a dose of 4 kGy;

No.3 – experimental group, irradiated with a dose of 8 kGy. The gamma-irradiation was carried out on an irradiation installation using ^{137}Cs as a radiation source.

The groups were tested for 21 days. The analyses of the control group were carried out every 7 days p.m. over the storage dynamics. With respect to the experimental groups, the tests started immediately upon irradiation, thereafter featuring the same dynamics. During the time of the experiment, the samples were stored in a refrigerator at temperature from 0^0C to 2^0C.

Before conducting the analyses each bag was additionally cleaned of visible tendons and fascii, and ground using a laboratory robot.

The following analyses were performed:

1. Technological indicators:

• pH-value, determined using pH-meter 604;

• water-retaining ability (WRA), determined by pressing a 300 mg sample using 3 kg weight for 5 minutes;

• emulsion ability, determined by reading the amount of exudate, released upon centrifuging a 20 g sample at 3,000 rotations for 10 minutes;

• thiol groups (SH–groups), determined after the Sedlak and Lindsay method (1968).

• colour, determined by identifying meat pigments – Mb, MetMb and OMb after the method of Steward et al. (1965).

2. Secondary oxidation products – by determining malone dialdehyde (MDA) after the Newburg and Concon method (1980)

The results were processed mathematically after the Sokal and Rohlf method (1995), applying one-factor and two-factor analysis. The reliability of the factors „storage period", „irradiation" „dose intensity" and "interaction" was determined based on the studied factors by comparing the results of the control group and the experimental group.

Results and Discussion

Buffalo meat, which is the subject of this study, is characterized by high protein content – over 20%, and low fat content – below 1.5%, as a result of which it is qualified as low-energy meat with dietetic properties.

During the storage process, the physico-chemical parameters change in a reliable manner. This could be attributed to vacuum disturbance and the formation of ice crystals in the packagings which, by the way, was observed during the experiment. Therefore, the selection of an appropriate vacuum packaging and the maintenance of constant temperature and deep vacuum over continuous storage periods, as the one laid down in our experiment, are important experimental and technologic requirements.

Figures 1–5 present the results characterizing meat technological characteristics over the study dynamics.

Figure 1 presents the pH-value behavioural dynamics. The observations on control group No.1 at the 72-nd hour p.m. reveal pH value of 5.44, which is close to protein's isoelectric point, evidencing of meat *rigor mortis* status. On the 7-th day p.m., the pH value increases up to 5.61, which is indicative of passed meat rigour, to change insignificantly thereafter until the end of the storage period.

In contrast to the foregoing, in the two experimental groups with Nos.2 and 3, the pH value was a bit greater than 5.6 in the beginning of the study. During the storage period the value fluctuated until on the 14-th day following gamma-irradiation it dropped markedly to the protein's isolectric point, which is manifested with particular emphasis in experimental group No.2, after which it increases in the alkaline direction.

This is probably due to the duration of the irradiation where the 1-st day from the study is actually the 15-th, accordingly the 18-th day following slaughter when the post-mortal processes in the meat have ended completely.

The pH value is one of the post-mortal indicators for meat upon slaughter, which are functionally related with many factors, such as animal age, muscle type, stress before slaughter, storage temperature upon slaughter etc.

Analyzing the obtained results, the conclusion can be made that, in the control group, the *post-mortem* processes in the meat develop following their logical course. The fluctuations in the two experimental groups during storage can be attributed to the effect of gamma rays on the enzyme systems, related with the process of the meat's becoming tenderer upon slaughter. In this respect, our results do not coincide with the results of Ahn et al. (2001), who establish minor decrease of the pH value with vacuum and aerobic-packed pork irradiated with doses of 2.5 and 4.5 kGy following 10-day storage at 4^0C.

Regarding meat's water-retaining ability, which is illustrated in Figure 2, it may be noted that for control group No.1, this parameter changes insignificantly until the 14-th day p.m., after which it increases to achieve its maximum on the 21-st of storage upon slaughter.

For experimental groups with Nos.2 and 3, the water-retaining ability was highest on the 7-th and 14-th day following

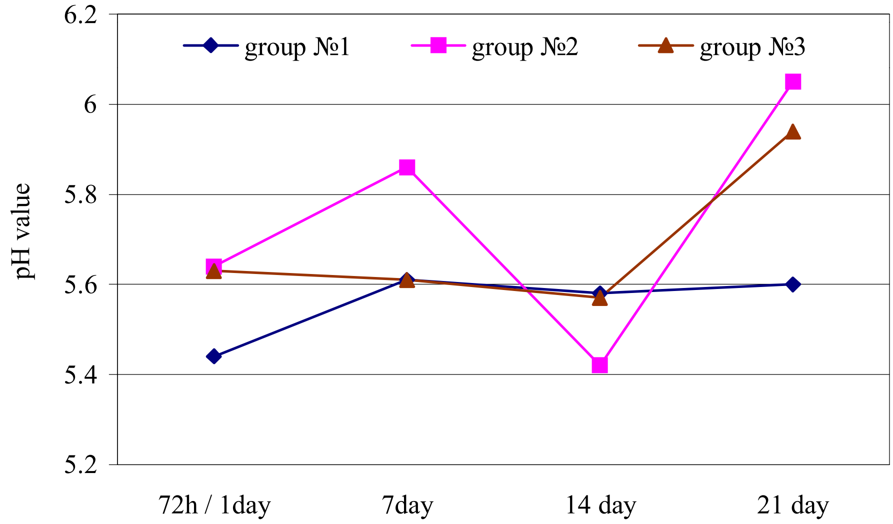

Fig. 1. pH value of non-treated and treated refrigerated beef meat

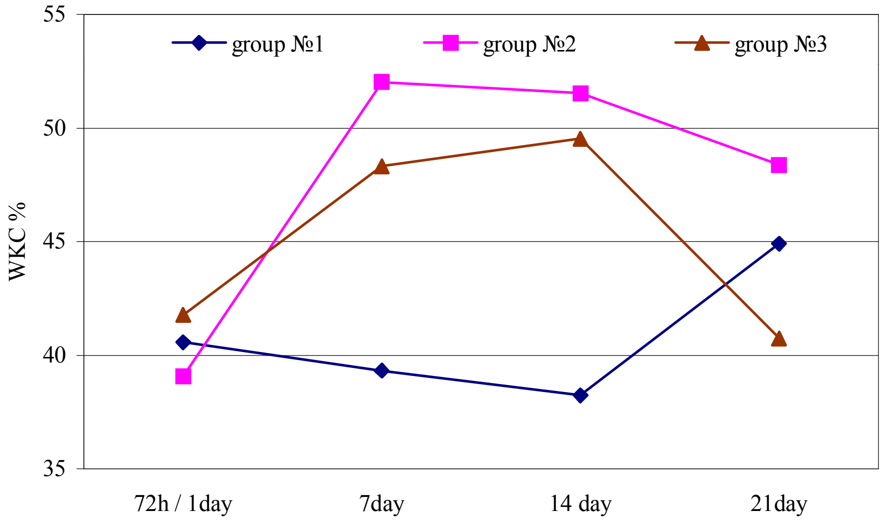

Fig. 2. Water keeps capacity of non-treated and treated refrigerated beef meat, %

gamma-irradiation. In the end of the study, the water-retaining ability decreased more markedly in experimental group No.3, which was irradiated with a dose of 8 kGy, to reach 40.75%, a value which is close to the value on the 72-nd hour *post mortem* when there is indication that the meat is still in *rigor mortis*.

It should be pointed out that, throughout the study period, experimental group No.2 displayed a markedly higher water-retaining ability than the control group and

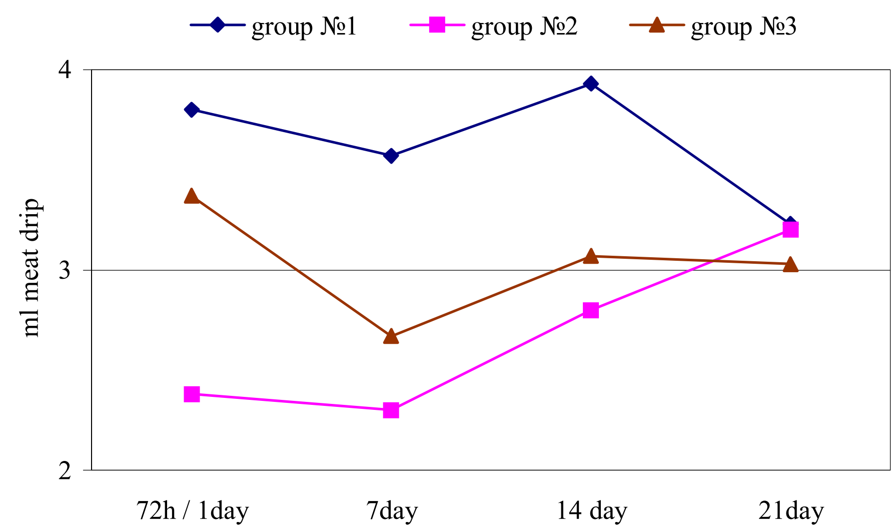

Fig. 3. Emulsion capacity of non-treated and treated refrigerated beef meat, ml meat drip

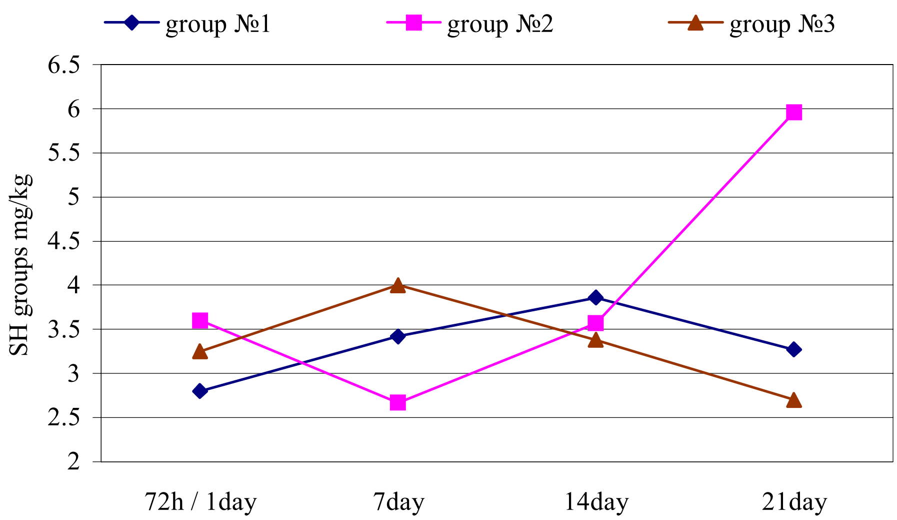

Fig. 4. SH-groups of non-treated and treated refrigerated beef meat, mg/kg protein

experimental group No.3 which is an exclusively important indicator from technological point of view.

Functionally correlated with the water-retaining ability is the indicator emulsion ability, which characterizes the property of myofibril proteins to form emulsion which determines the strength and thickness of meat prat during meat processing. The greater the amount of released exudates during the sample's centrifuging, the smaller the meat's emulsion ability. The

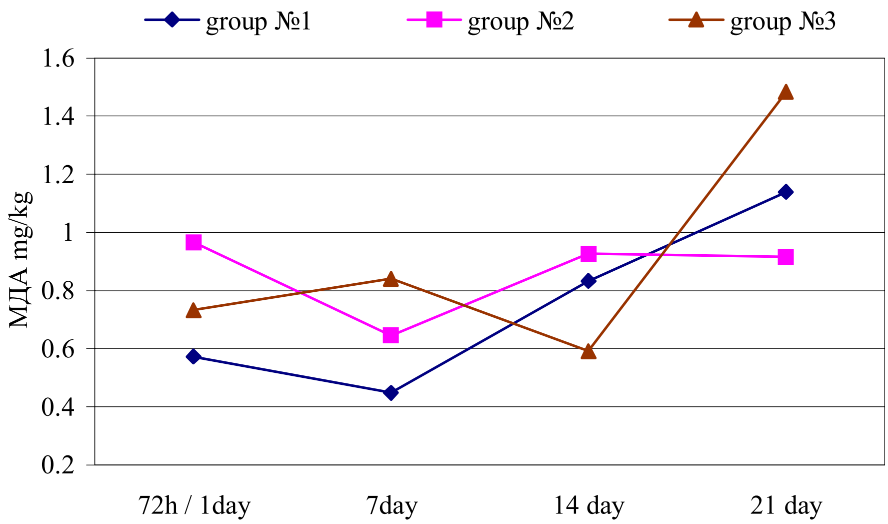

Fig. 5. Malondialdexyde of non-treated and treated refrigerated beef meat, mg/kg product

graphics in Figure 3 shows that, in contrast to the experimental groups, the control group features the lowest emulsion ability.

Experimental groups with Nos.2 and 3 manifested best emulsion ability on the 7-th and 14-th day following gamma-irradiation which coincides with their highest water-retaining ability as well.

The high water-retaining ability and better emulsion ability on the 7-th and 14-th day with both experimental groups provide grounds to assume that, in our experiment, gamma-irradiation affects positively meat's technological characteristics.

The experiment also monitors the thiol groups illustrated in Figure 4. It is notable that, in control group No.1, the SH-groups do not actually change, while in both experimental groups, visible dynamics may be observed. The behaviour of the thiol groups is a signal of change in the protein molecule's configuration, accompanied by formation of S-H and S-S bridges.

In their investigations on irradiated meats, packed in aerobic medium and vacuumized, Ahn and Olson (1999) and Ahn et al. (2001) establish that gamma-irradiation causes radiolithic interruption of sulphur-containing amino-acid methionine and cysteine, as a result of which S-volatile components are formed, which are responsible for the specific flavour of irradiated meats. Our observations comply completely with the foregoing and probably, this is the reason for the unstable behaviour of SH-groups with irradiated samples.

Meat colour is the first characteristic visually established by the consumer, which determines the product's eligibility. Minding consumers' sensitivity for the term "irradiated meat", we monitored the colour characteristics of the experimental specimens in the course of storage dynamics, which are shown on Table 1.

The results presented on the Table 1 show that colour characteristics change in a trustworthy manner only in control group No.1. Both experimental groups

Table 1

Colour characteristic of non-irradiated and irradiated cooled buffalo meat during storage

Experimental groups n=3, N=12	No.1 Days of storage p.m.				No.2 Days of storage, following irradiation				No.3 Days of storage, following irradiation			
Indicators	3d pm	7d pm	14d pm	21d pm	1d 15d pm	7d 22d pm	14d 29d pm	21d 36d pm	1d 18d pm	7d 25d pm	14d 32d pm	21d 39d pm
Myoglobine	1.13	1.10	1.07	1.06	1.06	1.08	1.06	1.08	1.06	1.11	1.07	1.08
Mb=E475/E525	±0.01	±0.01	±0.003	±0.004	±0.01	±0.01	±0.002	±0.01	±0.002	±0.008	±0.01	±0.01
P		**				ns				**		
Metmyoglobine	0.91	0.90	0.96	0.92	0.93	0.90	0.91	0.93	0.94	0.92	0.93	0.93
MetMb=E570/E525	±0.002	±0.003	±0.01	±0.07	±0.004	±0.002	±0.01	±0.01	±0.003	±0.006	±0.003	±0.003
P		***				ns				ns		
Oximyoglobine	97.96	98.00	97.99	98.02	98.00	98.02	98.03	97.99	98.00	97.97	97.99	97.99
OMb=100-Mb-MetMb	±0.01	±0.02	±0.007	±0.01	±0.005	±0.006	±0.02	±0.02	±0.001	±0.006	±0.004	±0.004
P		*				ns				ns		

Key:

The statistically significant differences are revealed in their dynamics for each individual group and the "storage period" factor is determined.

** - indicates statistically significant differences (P<0.05);*

*** - indicates statistically significant differences (P<0.01);*

**** - indicates statistically significant differences (P<0.001);*

ns – indicates statistically insignificant differences.

Appendix 1

Mathematical processing of the results for non-irradiated and gamma-irradiated cooled buffalo meat during storage

n=3, N=24		№1 - №2				№1 - №3				№2 - №3			
pH		Px	Pa	Pb	Pab	Px	Pa	Pb	Pab	Px	Pi	Pb	Pib
value	P	***	***	***	***	***	***	***	***	***	***	***	***
ВЗС, %	P	***	***	***	***	***	***	***	***	***	***	***	***
Emulsion ability, ml	P	***	***	***	***	***	***	***	***	***	***	***	***
SH – groups, mg/kg protein	P	***	***	***	***	***	***	***	***	***	***	***	***
MDA, mg/kg product	P	***	***	***	***	***	***	***	***	***	ns	***	***

Key:

Px – trustworthiness of all studied factors;

Pa – trustworthiness of the "irradiation" factor;

Pb – trustworthiness of the "storage period" factor;

Pab – trustworthiness of the "interaction of the Pa and Pb factors" factor;

Pi – trustworthiness of the "dose intensity" factor;

Pib – trustworthiness of the "interaction of the Pi and Pb factors" factor.

with Nos.2 and 3 display non-trustworthy differences throughout the overall dynamics, whereas in group No.3, irradiated with a dose of 8 kGy, the only trustworthy change observed concerns the main meat pigment – myoglobin.

According to Nam and Ahn (2002), the component accounting for the red colour in irradiated veal is the CO-hem pigment complex. Gamma-irradiation results in formation of a CO carbonyl group to combine with myoglobin in CO-myoglobin complex, which accounts for hem-pigments' red colour.

Possibly, this is the explanation for the preservation of the red colour in irradiated meat during storage, as may be seen with naked eye.

The behaviour of the total lipids of the tested buffalo meat was monitored by determining the free malone dialdehyde shown in Figure 5.

In the control group, MDA decreased on the 7-th day of storage after which it increased to reach 1.1391 mg/kg on the 21-st day. Immediately after irradiation, the experimental groups with Nos.2 and 3 featured higher MDA values than the control one. This is in agreement with the results of Ahn et al. (2000), who establish higher values with raw pork steaks that have been irradiated with doses of 4.5 and 7.5 kGy than with the non-irradiated ones.

In the end of the study, in experimental group No.3, MDA reached 1.48 mg/kg which is twice greater than the value immediately upon irradiation and three times greater than the initial value of the control group.

In the course of the expe-riment's dynamics, malone dialdehyde increased and decreased irregularly in all groups. This behaviour of the MDA may be attributed to lipids chain-radical oxidation mechanism where aldehydes combine with other oxidation products.

Analyzing the results from the experiment by applying the two-factor processing analysis described in Appendix 1, the conclusion should be made that the technological characteristics of non-irradiated and gamma-irradiated cooled buffalo meat are affected with third-class trustworthiness by all studied factors: "irradiation"; "storage period", "dose intensity" and the interaction of the studied factors.

Conclusions

The experiment shows that gamma-irradiation improves meat's water-retaining and emulsion ability, which is better expressed at irradiation with a dose of 4 kGy.

The colour characteristic of non-irradiated and irradiated samples is preserved throughout the study period.

Malone dialdehyde increases and decreases over the entire dynamics. In the group irradiated with a dose of 8 kGy, aldehydes increase twice to achieve the value of 1.5 mg/kg in the end of the storage period.

Irradiation of cooled buffalo meat with a dose of 4 kGy has better effect on meat's technological properties and extends the storage period subject to preliminary vacuumization of the samples.

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