

UDC 637.5.03

EFFECTS OF THE LONG-TIME RIPENING OF BEEF UPON ITS QUALITY PARAMETERS

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Subject. The subject is beef obtained from young bulls of the Aberdeen-Angus beef breed. **Purpose.** The purpose is to investigate the effects of dry ripening of beef upon its quality and safety parameters. **Methods.** The content of protein (by mass) was determined by the content of total nitrogen according to Kjeldahl followed by distillation of ammonia; the content of water (by mass) – by drying the portion to constant weight at the temperature of 105°C; content of fat (by mass) – Soxhlet method; pH – potentiometric method; water-binding ability – by pressing the test sample; sensorial parameters – consumer assessment using a hedonic scale of 9 levels; rheological parameters – using a universal electromechanical testing machine; microbiological parameters – based on the total number of microorganisms in 1 g of product. **Results.** The quality parameters of long-ripened meat (within 21 days) were studied in comparison with traditionally ripened meat (within 5 days). Sensorial assessment has shown the benefits of long-ripened meat. It was found that in long-ripened beef samples the content (by mass) of protein and fat is higher by 12.97% and 21.41%, respectively; water-binding capacity is 10.69% higher. This leads to a reduction in meat moisture loss during heat treatment by 6%. It has been determined that the penetration force of long-ripened meat is less important compared to similar parameters of traditionally ripened meat. Microbiological studies have shown that meat on the 21st day of ripening corresponds to standard values. **Scope of results.** A technological instruction for the production of fermented meat has been developed. The developed solution was tested in industrial conditions, and a production inspection certificate was obtained.

Key words: pH, sensorial parameters, rheological properties, long-term ripening, beef.

ВПЛИВ ДОВГОТРИВАЛОГО ВИЗРІВАННЯ НА ПОКАЗНИКИ ЯКОСТІ ЯЛОВИЧИННИ

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Предмет. Предметом є яловичина отримана від бичків абердин-ангуської м'ясної породи.
Мета. Метою є дослідження впливу сухого визрівання м'яса яловичини на показники його якості та безпечності. **Методи.** Масову частку білка визначали за вмістом загального азоту за К'ельдалем з наступною відгонкою аміаку; масову частку води – сушінням наважки до постійної маси за температури 105°C; масову частку жиру – методом Сокслета; pH – потенціометрично; вологосв'язуючу здатність – методом пресування досліджуваної проби; органолептичні показники – оцінювання споживачами з використанням гедонічної шкали з 9 рівнів; структурно-механічні показники – на універсальній електромеханічній випробувальній машині; мікробіологічні показники – за загальною кількістю мікроорганізмів в 1 г продукту.
Результати. Досліджено показники якості м'яса довготривалої визрівання (протягом 21 доби) порівняно із м'ясом традиційної витримки (протягом 5 діб). Органолептичні дослідження показали переваги м'яса довготривалого визрівання. Встановлено, що у зразках яловичини довготривалого визрівання масова частка білка та жиру вище на 12,97% і на 21,41% відповідно; водосв'язуюча здатність вища на 10,69%. Це призводить до зменшення втрат води м'яса при тепловій обробці на 6%. Визначено, що зусилля penetрації м'яса довготривалого визрівання має менші значення порівняно з аналогічними показниками м'яса традиційної витримки. Мікробіологічні дослідження показали, що м'ясо на 21 добу визрівання відповідає нормативним значенням. **Сфера застосування результатів.** Розроблено технологічну інструкцію на виробництво ферментованого м'яса. Розроблена технологія випробування у промислових умовах, отримано акт виробничої перевірки.

Ключові слова: величина pH, органолептичні характеристики, структурно-механічні показники, довготривале визрівання, яловичина.

Formulation of the problem. Expectations of Ukraine's accession to the European Union with the possibility of entering the capacious solvent market of the united Europe determine the interest of the domestic meat processing industry in premium class products. A large number of scientific studies [1-3] indicate that consumers are willing to pay more for a product with guaranteed high consumer quality. In this regard, the most preferred meat raw material is beef, but obtaining a product with high culinary value from it requires additional processing [4, 5]. One of the most common practices is to let beef ripen sufficiently long to ensure proper progression of changes in muscle tissue after the animals are slaughtered. In meat immediately after slaughter, a number of biochemical and physicochemical changes occur, associated with the breakdown of carbohydrates and nucleotides, proteins and lipids, which leads to the development of special characteristics of aged meat. These changes are called meat fermentation, aging or ripening.

Ripening is a process of tenderizing meat, through the action of endogenous enzymes that break down muscle proteins, after rigor mortis [6-8]. Ripening is the process of storing meat in a controlled environment for a specified period to enhance flavor. During ripening, the protein components of raw meat undergo significant changes: the activity of tissue enzymes of meat and microorganisms is activated, which leads to the destruction of the cellular structure of muscle tissue and proteolysis [9, 10]. An important substance for successful ripening is lactic acid, which is formed during anaerobic glycogenolysis. The structure of muscle fibers is loosened under the influence of natural enzymes that break down proteins. Lactic acid weakens cellular junctions, so cellular proteolytic enzymes can act on muscle tissue and break down hardened muscle structure after mortem rigor. Thanks to this, the meat becomes tender [8, 11, 12]. In this process there are intrinsic and extrinsic factors that influence its proper development. Internal factors include the breed, age and sex of the animal, pH, enzyme activity, intramuscular fat, and external factors include temperature, environmental humidity, air movement, and duration of the process [8, 13].

In the meat industry, the most common methods that producers typically use are dry and wet ripening.

Wet ripening involves aging pieces of meat or steaks in a vacuum, in barrier packaging, and then placing them in a refrigerator – usually for a period of 7 days to 28 days. The advantage

of wet ripening is the lower loss of moisture compared to dry ripening (approximately 5% and 10%, respectively).

During the dry ripening meat is kept unpacked [14]. Dry and wet ripened beef is influenced by various environmental factors. Dry-ripened beef is affected not only by temperature, humidity and air flows, but also oxygen, while wet-aged beef is exposed to anaerobic conditions. Accordingly, different physical and chemical properties of dry- and wet-ripened beef are formed. In addition, dry-aged beef has a meatier, roasted, and nuttier flavor – unlike wet-ripened beef, which is characterized by a more intensely sour, metallic, and bloody flavor [15].

Wet ripening is the dominant method in the US and UK. This method is popular among wholesalers and retailers because it takes less time, usually only a few days, and results in relatively little moisture loss.

American researchers studied the effect of long-term outdoor and packaged ripening (14–49 days) on the quality of bone-in and boneless beef with low marbling. It was found that consumers preferred boneless steak aged for 28 days using the wet aging method [16]. Similar results were obtained when studying the qualitative characteristics of the thigh. According to the results, consumers preferred beef aged (14–21) days, while tenderness parameters such as shear strength reached optimal values after ripening (21–42) days [17].

Another study dealt with the ripening vacuum-packed beef steaks. It turns out that consumers prefer ripened brisket steaks; there were no differences in color development during ripening, but shear stress was slightly lower than vacuum-ripened beef [18].

There are also combined ripening technologies. The effects of staged dry/wet ripening (10 days as a whole carcass and 7 days as cuts in vacuum packaging and subsequent freezing) on the quality of beef were studied. It was concluded that the step ripening method accompanied by cryogenic freezing could be a good solution for the industry as it improves parameters such as shear stress and water holding capacity [19].

Japanese researchers found that the best duration of dry ripening for the Aberdeen Angus breed of marbled beef was 40 days [20].

Experiments of ripening beef in a vacuum bag for 14 days were held. Compared to dry ripening, higher quality characteristics were obtained, it was also possible to reduce losses during defrosting and prevent the development of pathogenic microorganisms [21]. It was found that vacuum ripening for 5 days or 15 days was better than aging in a modified gas environment, as it did not have a negative effect on color stability [22].

Three ripening methods (traditional dry maturation, wet maturation in a vacuum heat-shrinkable package and in a moisture-permeable bag) were studied during 0, 7, 14, 21, 28 days of exposure to influence the physical, chemical, microbial, and histological characteristics of the lumbar muscles of calves. Lumbar muscles were ripened in film and shrink vacuum packaging for 28 days at a temperature of $0.5^{\circ}\text{C} \pm 0.5$ and a relative humidity of 80%. An increase in pH values was observed in all samples, as well as an increase in the total number of viable microorganisms, psychrophilic bacteria, *Enterobacteriaceae*, lactic acid bacteria and yeast in all samples. Ripening in a vacuum can have a positive effect on the safety, quality and durability of beef. Storage significantly improves both rheological and sensorial properties of meat. The most positive effect on taste, juiciness, and tenderness was observed when ripening in vacuum shrink packaging on the 14th day of aging. The scientists concluded that the use of vacuum heat-shrink packaging is an alternative to moisture-permeable packaging material during wet ripening to improve the physical, chemical and sensorial parameters of beef [23].

A study was performed of the effect of dry and wet ripening of meat on physical, chemical and microbiological parameters: the meat was hung in the refrigerator at a temperature of $(8 \pm 1)^{\circ}\text{C}$ and relative humidity $(85 \pm 2.1)\%$ for 14 days wet ripened meat immersed in a 3.5% salt solution and placed in a vacuum bag. After 7 days and 14 days of ripening, the red color of the meat was more intense than dry-aged meat compared to wet-ripened meat. At day 14,

firmness, chewiness, and stickiness were lower in dry-aged meat samples compared to wet-aged meat samples [24].

Dry ripening of beef was held for 14 days and 28 days at 4°C and 75% relative humidity, suggested that the microbial composition on the surface of the meat may change depending on the presence and speed of air flow, and then leads to significant differences in the sensorial parameters of dry-ripened meat. The author of [25] found that yeast/fungi may play a role in the development of desirable flavor qualities in beef during ripening. The author fulfilled the dry ripening of beef at a temperature of (1–4)°C and relative humidity (80–90)% for 60 days; and sections of Longissimus thoracis (LT) and Biceps femoris (BF) 5.0 cm thick from the surface of each carcasses were analyzed by 3; 25; 40; 50; 60 days. Total bacteria and yeast/mold counts increased significantly in both samples throughout the ripening periods, with growth slowing significantly after 50 days. Lactic acid bacteria were found in both samples. It has also been observed that longer ripening times lead to an increase in the number of these microorganisms. No *E. coli* or foodborne pathogens were detected during dry aging for 60 days, concluding that the samples remained acceptable for 60 days. In addition, at longer periods ((40–60) days), *Penicillium camemberti* and *Debaryomyces hansenii*, which are used in the production of aged cheese, were observed. The said author states that these fungi may be involved in the development of beef flavor [26].

The above-mentioned studies prove that the duration of ripening has a significant impact on the consumer properties of meat and is an actual advantage for production and marketing. In addition, conducting research on meat maturation is important in the sense of the rapid development of beef cattle breeding, the introduction of new systems for growing and fattening cattle, and the production of new types of high-quality beef from beef breeds.

The purpose of the work is to study the effect of dry ripening of beef upon its quality and safety parameters.

Materials and methods. The object of the research was meat samples from Aberdeen Angus bulls. To determine physical, chemical, sensorial, microbiological and rheological parameters, standard research methods were used. The content (by mass) of protein was determined by the content of total nitrogen according to Kjeldahl followed by distillation of ammonia, the content (by mass) of water was determined by drying the sample to constant weight at a temperature of 105°C, the content (by mass) of fat was determined by the Soxhlet method; pH values were determined by the potentiometric method; water-binding ability – by pressing the test sample; sensorial assessment – by the consumer assessment method using a hedonic scale of points, rheological parameters – with the use of a universal testing machine "SANS SMT 2503", microbiological parameters – by measuring the total number of microorganisms in 1 g of a product.

Research results. The process of dry ripening is accompanied by the evaporation of moisture, an increase in the content of dry substances, and the activation of tissue enzymes. The process is time-consuming and requires a special selection of raw materials according to physical, chemical and microbiological parameters, a sufficient amount of fatty inclusions and their uniform distribution in the fiber structure [27].

The results of the research are implemented in a chart of the technological process for obtaining high-quality beef of long ripening, taking into account the effects of possible external and internal factors on the formation of its quality parameters (Fig. 1).

Using the developed chart, the process of dry ripening of meat from Aberdeen Angus young bulls was carried out.

Ripening was carried out in cuts isolated from the dorsal-lumbar part under the following conditions: cuts from the first group were kept at a temperature of 2°C, relative air humidity – (75–80)%, air speed – 0.2 m/s for 5 days (traditional ripening); cuts from the second group were kept in refrigeration chambers at a temperature of 2°C, relative humidity – (72–75)%, air speed – 0.5 m/s for 21 days (dry ripening).

Before the study, the top layer (crust) was first removed from dry-ripened cuts. Next, the cuts were divided to form steaks.

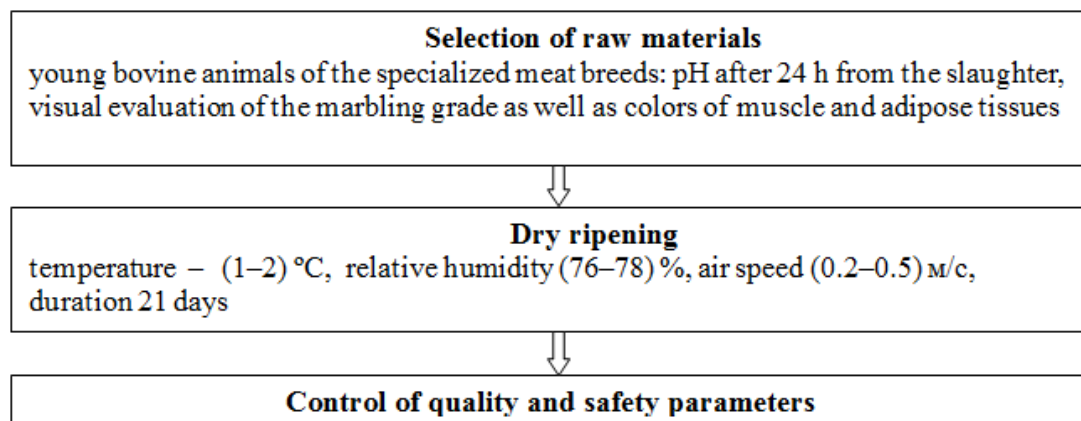


Fig. 1. Chart of the technological process for obtaining high-quality beef of long ripening

Considering that dry ripening is aimed primarily at improving taste properties, a sensorial assessment of meat after heat treatment was carried out using the consumer assessment method using a hedonic scale with 9 levels. The research results are presented in Table 1.

Table 1

Consumer assessment of beef steaks

Parameter	Beef, duration of ripening	
	5 days	21 days
Appearance	8 Good	9 Good
Aroma	8 Pleasant	9 Intensive and pleasant
Taste	8 Taste of the cooked beef	9 Very rich, pleasant
Texture	8 Slightly stiff	9 Tender
Succulence	9 Slightly dry	9 Succulent

From the results of sensorial evaluations it is clear that tasters accepted the consistency of beef steaks with longer ripening period (21 days) as more desirable, chewable and succulent. This is evidenced by the results of the assessments, which turned out to be better than for steaks with traditional ripening periods (5 days).

It should also be noted that the majority of tasters rated the taste and aroma of long-ripened meat as pleasant and pronounced, which indicates a higher level of enzymatic changes and, accordingly, the accumulation of substances involved in the formation of taste and aroma.

Sensorial properties largely depend on physical and chemical parameters being the indicators of the development of biochemical and physical processes during ripening.

Table 2 shows the physical and chemical parameters of beef depending on the duration of ripening.

It was found that in long-ripened beef samples, the contents (by mass) of protein and fat are higher by 18.5% and 21.41%, respectively, compared to samples that were ripened for 5 days.

The recorded changes in the amount of substances are associated with losses during aging, which are 6 times higher for long-ripening meat, which is explained by the evaporation of water. However, due to the formation of a drying crust on the surface, the content of water (by mass) is at a fairly high level.

During ripening, due to the development of proteolytic changes, hydration characteristics improve. In long-ripening meat, the water-binding capacity is 10.69% higher than in meat that

was aged for 5 days. As a result of the higher water-binding capacity, in this case, losses during heat treatment of meat are reduced by more than 6%.

Table 2

Effects of ripening duration upon physical and chemical parameters of beef

Parameter	Beef, duration of ripening	
	5 days	21 days
Content of protein,% (by mass)	17.89	21.20
Content of fat,% (by mass)	9.25	11.23
Content of water,% (by mass)	69.34	65.20
pH	5.75	5.92
Water-binding capacity,% by mass of a portion	52.45	56.36
Penetration force, kN/m ²	370.60	320.60
Loss during ripening,%	2.50	15.00
Loss during heat treatment,%	28.40	22.30

Destructive changes in the structure of meat contribute to the improvement of rheological characteristics. The penetration forces of long-ripening meat are characterized by lower values, which coincide with the results of sensorial evaluation.

A very important requirement for the meat of long dry ripening is its microbiological safety. Microbiological studies were carried out to assess the safety of meat ripened for 21 days. The research results are presented in Table 3.

Table 3

Results of microbiological research of beef after 2 days of dry ripening

Parameters	Results of research	Norm
<i>E. coli</i> group	in 0.1 g not detected	in 0.1 g not allowed
Bacteria of the genus <i>Proteus</i>	in 0.1 g not detected	in 0.1 g not allowed
QMAFAnM	5.1 · 10 ² CFU/g	no accedes 1 · 10 ³ CFU/g
Pathogenic microorganisms	in 25 g not detected	in 25 g not allowed

The microbiological parameters of beef on the 21st day of ripening did not exceed the permitted values.

Conclusion. The research fulfilled let it possible to determine the rational duration of long-term “dry” ripening of beef. According to the totality of indicators, high-quality beef of long ripening is characterized by higher quality compared to traditionally ripened meat. It has been established that it has the best consumer characteristics, rich aroma and taste compared to beef aged using traditional technology (5 days). So, the effectiveness of the process of long maturation (21 days) of beef in the formation of the desired characteristics of meat has been confirmed.

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