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ORIGINAL PAPER

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EVALUATION OF CULINARY AND FUNCTIONAL-TECHNOLOGICAL PROPERTIES OF THE MEAT OF STEERS OF DIFFERENT GENOTYPES

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ABSTRACT

Background. The purpose of this article is to study the functional-technological and culinary properties of beef obtained from the carcasses of bulls of different genotypes and to establish the influence of various methods of heat treatment on sensory indicators and product yield.

Materials and methods. The subject of research was the meat of steers of the purebred Swedish breed, as well as its crossbreeds with the Hereford and Belgian Blue breeds grown in farm conditions in Sumy region, Ukraine.

Results and discussion. All samples were characterized by high nutritional quality of beef. The fat content was highest in Swiss×Belgian Blue 2.93 ±0.41%, which influenced the energy value of this meat: 113.61 kcal/100 g. There is a certain tendency to increase the WBC in the meat of crossbred steers (by 1.67% on average), both for total moisture and for the mass of minced meat. Muscle tissue from the neck of Swiss×Belgian Blue steers was distinguished by a lower intensity of color, compared to other groups due to the highest content of intracellular fat. It was found that minced meat from Swiss×Hereford and Swiss×Belgian Blue has a better (on average by 8.13%) emulsifying capacity compared to beef from the Swiss breed, and the emulsions themselves are characterized by greater stability. The Swiss×Belgian Blue cutlets received the highest scores for all organoleptic indicators, regardless of the cooking method. The sensory properties of all patties cooked in a microwave oven or electric grill were lower compared to cooking in a pan with oil.

Conclusion. Based on the results obtained in the study of the functional-technological and culinary properties of beef obtained from the steers of different genotypes regarding the influence of various methods of heat treatment on sensory indicators and cooking loss, it can be concluded that meat obtained from crosses is of high quality regarding to chemical and technological properties and has favorable sensory scores.

Keywords: steer meat, functional properties, genotypes, cooking methods

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INTRODUCTION

Many studies show that genetic variation can improve carcass and meat quality (Mwangi et al., 2019; Bittante, 2023) and change the concentration of fatty acids in beef.

Beef also contains a significant amount of proteins of high biological value. The bioavailability of these proteins for humans due to their proximity to the optimal set of essential amino acids varies depending on the amount of connective tissue, and ranges from 70% to 100% (Stadnik, 2024; Leroy et al., 2023; Lorenzo et al., 2020). In addition, beef contains many minerals, especially phosphorus, iron, zinc and selenium, and is also the main source of vitamin B_{12}, which is necessary for humans but found in plant foods, as well as other important B vitamins: B_2, B_3, B_5, B_6. The importance of beef consumption has been repeatedly proven by numerous studies of its nutritional and energy value (Piston et al., 2020; Leroy et al., 2023; Maciel et al., 2021).

When considering the characteristics of beef, attention should be paid to its organoleptic profile, especially its taste and smell. The taste of meat is one of the most important sensory factors directly affecting the consumer's purchasing decision. The flavor of cooked meat is the result of non-volatile substances in fresh meat that undergo chemical reactions during heat treatment (Leroy et al., 2022; Gravador et al., 2022; Wang et al., 2021). It is important that the level of these precursors is as high as possible, and one of the factors affecting this is the age of the animal (Gómez et al., 2020).

Meat obtained from animals slaughtered at an older age contains more connective tissue, so a long cooking time is required (Lee et al., 2018). However, researchers (Choi et al., 2019) indicate the possibility of an unpleasant aftertaste during long-term heat treatment of beef above 80°C due to the complex physicochemical processes in muscle tissue. As a result of these processes, the initial color, texture, and taste qualities change, and changes occur in the physical and structural properties of the meat, which leads to a change in the nutritional value because of the loss of nutrients.

Meat can be cooked at high temperatures for a long time, but this method of cooking can affect the nutritional and sensory qualities of the meat, contributing to the loss of water-soluble vitamins and heat-labile minerals (Ma et al., 2020). Cooking temperature has different effects on meat proteins. During cooking or microwaving, temperatures exceed 100°C, causing proteins to denature. When the cooking temperature ranges from 100 to 140°C (when cooking under pressure and baking), the digestibility of meat decreases due to the formation of intramolecular and intermolecular covalent bonds. In fried meat, at a cooking temperature above 140°C, the destruction of amino acids occurs, in particular cysteine or tryptophan, with subsequent isomerization to the D-configuration and a further decrease in nutritional value. (Wei et al., 2022; Bleicher et al., 2022).

Meat and meat products are considered cooked if an internal temperature of 65–70°C is maintained for 10 minutes, which is accompanied by coagulation of proteins and the effect of softening the meat due to partial hydrolysis of collagen (Dominguez-Hernandez et al., 2018). The end of the cooking process can usually be detected by a change in color from red to brown, with a corresponding development of flavor. The aroma of ready-to-eat meat is the result of several thermal cleavage reactions of peptides and amino acids (Ayub and Ahmad, 2019).

During cooking, a certain amount of water is lost, which also affects the perception of the product. It has been shown (Leroy et al., 2022) that water loss strictly depends on cooking time, cooking temperature, cooling method, portion size, heat penetration and initial meat chemistry. The loss of water causes an increase in the concentration of fat and protein in cooked meat.

Meat cooking technologies show a significant impact on the vitamin content, especially considering the significant loss of the B complex of vitamins (Stevens et al., 2023). Vitamin B12 and thiamine are the most affected of the B vitamins, while riboflavin and niacin show less decline. B vitamins are water-soluble and thermally unstable, thus some cooking methods, such as blanching and boiling, can cause high losses of the vitamin, while shorter cooking times can reduce these losses. Thiamin losses are usually 15–40% in boiled meat, 40–50% in fried, 30–60% in fried and 50–70% in canned food. On the other hand, the average loss of riboflavin during cooking is about 10%, as riboflavin is relatively resistant to most cooking methods, except for the high temperatures required for roasting meat.

Niacin is quite resistant to several heat treatments: usually, losses average about 10% in cooked meat.

During meat processing, depending on the temperature, time conditions and technological processes, structural changes of varying degrees occur. Above all, heat treatment contributes to serious changes in the main components of the protein as a result of protein denaturation, amino acid oxidation and aggregation processes (Ge et al., 2020; He et al., 2018).

Hence, based on literary sources, it can be stated that heat treatment, which is used during the preparation of products based on muscle tissue to improve taste qualities and organoleptic properties, as well as ensuring the safety of processed products, can lead to undesirable changes in the sensory and nutritional quality of the final products. Therefore, there is a need to research the effect of high processing temperatures on the culinary and functional-technological properties of steer meat obtained from animals of different genotypes.

The purpose of the work is to study the functional-technological and culinary properties of beef obtained from the carcasses of bulls of different genotypes in order to establish the influence of various methods of heat treatment on sensory indicators and cooking loss.

MATERIALS AND METHODS

Animals

The experiment was conducted on 30 bulls from three breeds: Swiss, Swiss×Hereford, and Swiss×Belgian Blue. The animals were slaughtered at 15 months, and the live weight of animals was 620–650 kg. The carcasses were then cooled for 24 h at 2–4°C, after which 300 g of the longest back muscle (Longissimus dorsi) was sampled from 3 selected carcasses of each group for further research. The bulls were raised in the same conditions according to the technology of meat cattle breeding, which involves the milking period, rearing and fattening of young animals in unattached group housing on deep litter. All the bulls received the same ration.

Meat sampling and meat quality analyses

Heat treatment

At the first stage, the object of the study was minced beef from the muscle tissue of the neck cut obtained by grinding on a meat grinder with a particle size of 2–3 mm (Fig. 1.)

In the second stage of research, the influence of different methods of heat treatment (frying in oil, frying on an electric grill, and processing in a microwave oven) on the sensory and technological parameters of burger patties prepared on its basis was evaluated. For this, patties with a diameter of 100–110 mm were formed from the prepared minced meat, weighing 85–90 grams each.

In the first variant of heat treatment, a pan was used for frying with a small amount of oil. The process of cooking cutlets was carried out according to the method described by Lee et al. (2018) at 180°C for

a b c

Fig. 1. Minced meat from the muscle tissue of the neck (for burgers) of steers of different genotypes: a – Swiss; b – Swiss×Hereford; c – Swiss×Belgian Blue

5–10 min. In the second variant of heat treatment, cutlet samples were prepared using a Silex folding grill (160°C) until an internal temperature of 75°C was reached. In the third variant of heat treatment, the samples were placed in the center of the carousel of a microwave oven Whirlpool (EMEA, Wroclaw, Poland).

Two heating cycles of 2 min each (700 W power setting) were used and rotated between processes until the internal temperature reached 75°C. A TP101 digital electronic thermometer with a needle probe was used to control the sample heating temperature.

Determination of moisture content

Moisture content was determined using the gravimetric method (Bozhko et al., 2021). 3 g of minced meat sample was added to the box with dried sand, thoroughly mixed with sand with a glass stick and dried in a drying cabinet in an open box at 150 ±2°C for 1 hour. Then the mixture was cooled to room temperature and weighed. The moisture content was calculated from the difference in weight before and after drying and expressed as a percentage.

Determination of raw protein content

Protein content was measured by the Kjeldahl method (ISO 937:2005.2007). 5 g of meat and 20 mL of H_2SO_4 with 8 g of catalysts were mixed. The sample was heated at 350°C for 30 minutes. After that, the sample was quantitatively transferred to a solution of 33% NaOH, sealed, and distilled off with the steam. The resulting distillate was transferred to a flask with several drops of the Tashiro indicator. The titration was performed with a solution of 0.01 N sulfuric acid.

Determination of raw fat content

Fat content was determined by the Soxhlet method (ISO 1443:2005. 2008). 4 g of the dried meat sample was extracted in a Soxhlet apparatus (Simax, Czech Republic) using petroleum ether with a boiling point of 45°C. After extraction, the weight of the sample was measured to a constant weight. The fat content was calculated as the difference between the initial and final weight of the sample.

Determination of ash content

Ash content was determined by the method of dry ashing at a temperature of 520°C (Bozhko et al., 2023). 1 g of minced meat was transferred to a porcelain crucible and placed in a muffle furnace (MLW, Germany) and ashed to a constant mass at a temperature of 520°C. After that, the porcelain crucible was weighed, and the mineral content was determined according to the difference in weight before and after.

Determination of the energy value

The energy value was calculated according to the method (FAO, 2003). The energy value was determined by multiplying the amount of proteins, fats and carbohydrates by the corresponding coefficients of the energy value: the value for proteins is 4; for fats – 9; for carbohydrates – 4 kcal/g.

Methods of measuring functional indicators

The functional and technological properties of meat raw materials in the technology of meat and meat products are a set of indicators characterizing emulsifying, water-binding, fat-binding, water-holding and gel-forming capacities, structural and mechanical properties (stickiness, viscosity, plasticity, etc.), yield and losses during heat treatment of various types of raw materials and meat systems.

The WBC (water-binding capacity) of minced meat was determined by the pressing method (Bozhko et al., 2023). 0.3 g of the sample was weighed on the filter paper circle. The circle was covered with a plate, on which a load weighing 1 kg was placed for 10 minutes. The area of the wet spot was measured with a planimeter. The WBC was determined as the mass fraction of moisture (relative to the total moisture content in the sample) remaining after pressing. The WHC (water-holding capacity) of the minced meat was measured as the difference between the mass fraction of moisture in the minced meat and the amount of moisture released during heat treatment.

Emulsifying capacity (EC) was measured according to the method described by Bozhko et al. (2024). 7 g of minced meat was emulsified with 100 cm^3 of water and 100 cm^3 of oil in a homogenizer at a speed of 1500 s^{-1} for 5 minutes. After that, the emulsion was centrifuged at 500 s^{-1} for 10 minutes. Emulsifying capacity (EC) was calculated as the ratio of the emulsion layers. The stability of the emulsion (SE) was determined by heating at 80°C for 30 minutes and cooling with water for 15 minutes followed by centrifugation and measuring the ratio of the volume of emulsified oil to the total volume of the emulsion.

The content of pigments was determined by the spectrophotometric method (Strashinsky et al., 2010), which is based on the extraction of pigments of meat and meat products with an aqueous solution of acetone followed by the measurement of the optical density of the extract (D). The content of pigments in extract was measured on a prepared Spectrophotocolorimeter Spekol-11 (Germany) at a wavelength of 540 nm to the control solution. The control test solution was replaced by 15 ml of water. The value of the optical density is proportional to the pigment concentration.

The pH value of the meat was determined using a digital pH-meter pH-150MY according to the method described by Bozhko et al. (2021). 10 g of minced meat was mixed in 100 ml of water, followed by exposure for 30 minutes.

The plasticity was determined by the area of the spot of minced meat formed under the action of a static load of 1 kg for 10 min according to the method described by Bozhko et al. (2024). The indicator was determined by the area of the minced meat stain, which was formed under the action of a static load weighing 1 kg for 10 minutes. Cooking losses were calculated as weight loss divided by the initial weight, expressed as a percentage (Bozhko et al., 2024). The total content of pigments was determined in beef by the extraction method followed by measurement of the optical density on a Srekol-11 spectrophotocolorimeter (wavelength 540 nm) using a chloroacetone solution (Bozhko et al., 2024).

Organoleptic evaluation of cutlets for burgers prepared by various methods of heat treatment was conducted on a five-point scale with the participation of 10 analysts. This standardized 5-point scoring system was used to assess various attributes of a food product. Trained analysts rated the product's appearance, color, odor, texture, and other relevant attributes on a scale from 1 (unacceptable) to 5 (good). This rigorous approach allows for a detailed understanding of the product's sensory quality.

Statistical analysis

Statistical processing of the results was carried out using the standard package of Microsoft Excel programs (USA), using the Student's t-test. A difference was considered probable if the value of $p < 0.05$. The number of repetitions in calculations was 3–4, and the number of parallel tests of studied samples was 3.

RESULTS AND DISCUSSION

Chemical composition of steer meat of different genotypes

The chemical composition of steer meat of different genotypes is given in Table 1.

Table 1. Chemical composition and energy value of steer meat of different genotypes

Indexes	Swiss	Swiss × Hereford	Swiss × Belgian Blue
Moisture, %	74.38 ±0.87	75.08 ±0.59	74.82 ±1.27
Protein, %	21.54 ±1.3	21.67 ±1.01	21.81 ±0.99
Fat, %	2.70 ±0.33	2.75 ±0.13	2.93 ±0.41
Ash, %	1.15 ±0.41	1.15 ±0.11	1.32 ±0.31
Energy value, kcal/100 g	110.46	111.43	113.61

The chemical composition and energy value of the steer meat of different genotypes did not differ significantly. At the same time, all samples were characterized by the high quality of beef. The moisture content in the meat varied from 74.38 ±0.87% (Swiss) to 75.08 ±0.59% (Swiss×Hereford). Similar data regarding the moisture content of beef of various origins have been confirmed in other studies (Ngom et al., 2022; Santana et al., 2023). The fat content was highest in Swiss×Belgian Blue 2.93 ±0.41%. As a result, the energy value of this meat was highest too: 113.61 kcal/100 g. In the scientific literature, there are numerous publications on the influence of phenotypic factors on the culinary and consumer properties of beef (Pathare et al., 2017; Alfafi et al., 2023). However, these relate mainly to the comparison of age and species differences in meat, and there are practically no studies on genetic diversity in one species of animal.

Functional and technological properties of steer meat of different genotypes

The results of the study of the functional and technological properties of steer meat of different genotypes are presented in Table 2.

Table 2. Functional and technological properties of steer meat of different genotypes

Indexes	Swiss	Swiss × Hereford	Swiss × Belgian Blue
WBC_m, %	70.39 ±0.08	71.54 ±0.13	71.63 ±0.06
WBC_a, %	94.06 ±0.30	95.73 ±0.03	95.61 ±0.78
WHC, %	65.28 ±4.18	64.07 ±4.13	68.89 ±3.76
pH	5.73 ±0.01	5.82 ±0.07	5.87 ±0.33
Plasticity, sm^2/g	19.33 ±0.11	19.05 ±0.77	20.13 ±0.05
Total pigments, mg/sm^3	9.67 ±0.75	9.69 ±1.03	9.27 ±0.87

WBC was in the range from 65.5–68.2%. There is a certain tendency to increase the WBC in the meat of crossbred steers (by 1.67% on average), both for total moisture and for the mass of minced meat. Muscle tissue of the neck of Swiss×Belgian Blue steers was distinguished by a lower intensity of color compared to other groups. The total content of pigments was 9.27 ±0.87 mg/cm³, which is 4.1–4.3% lower than in Swiss and Swiss×Hereford. This is explained by a larger layer of fat between the muscles, which is the most important feature of meat marbling and, accordingly, high culinary properties.

Meat color and its relationship to meat flavor are of concern to all members of the beef supply chain, producers, processors and consumers (Borgogno et al., 2015; Munekata, 2021). The color depends on the concentration of myoglobin on the surface of the meat, its chemical state and the structure of the muscle surface, which is directly related to pH, as well as marbling. The marbling effect is achieved due to the presence of very thin layers of fat in the muscle mass, which melt during cooking, impregnating the meat, giving it tenderness and juiciness. This is confirmed by the works of researchers (Tomasevic et al., 2021; Hoa et al., 2021).

The pH of the meat of Swiss steers was close to the optimum and was 5.73 ±0.01, while it was slightly higher in the meat of mixed breeds. However, the meat of all groups met the requirements of beef with high quality according to the pH. It is known (Bureš and Bartoň, 2017) that certain breeds of animals are genetically predisposed to a higher pH level in meat.

The ability of the fats to form emulsions is another important characteristic of meat, alongide the ability to absorb and retain moisture. The emulsifying capacity depends on the nature of the fat, its melting temperature, the degree of grinding and the presence of emulsifiers. The results of studying the emulsifying properties of young bull meat of different genotypes are shown in Figure 2.

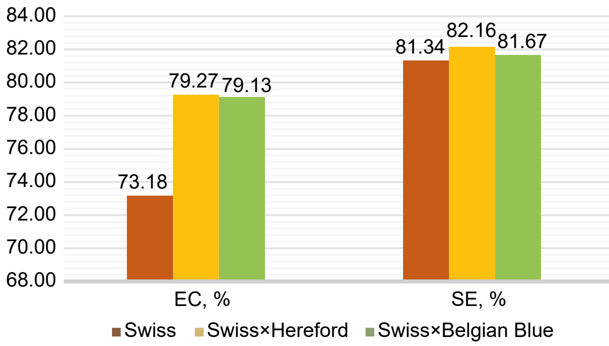

Fig. 2. Emulsifying capacity and stability of emulsion of minced meat from bulls of different genotypes

The meat of crossbred steers is characterized by higher emulsifying properties, which opens up prospects for the effective use of this type of meat in the production of products with a uniform consistency. It was found that minced meat from Swiss×Hereford and Swiss×Belgian Blue has a better (on average by 8.13%) emulsifying capacity compared to beef from the Swiss breed, and the emulsions themselves are characterized by greater stability. This is consistent with other researchers' data (Warner et al., 2010).

Cooking loss and organoleptic properties of steer meat of different genotypes depending on culinary preparations

Cooking losses and WBC reflect the ability of meat proteins to bind water and indirectly indicate the homogeneity and stability of the gel structure of meat, which is essential for evaluating the quality of minced meat products.

Quitral et al. (2020) believe that the best option is to cook patties in a conventional oven, as there is less oxidation of the fatty substance. On the other hand, there is also an assumption (Domínguez et al., 2014) that when heated in a microwave oven, a coating that prevents moisture loss does not form on the surface of the product being processed. Cooking loss of patties from different methods of heat treatment are presented in Figure 3.

According to Figure 3, cooking loss of hamburger patties during heat treatment was the lowest (22.97–25.76 %) in the Swiss breed, regardless of the method of heat treatment. There is a tendency for this indicator to increase in the product obtained from the meat of crossbred steers.

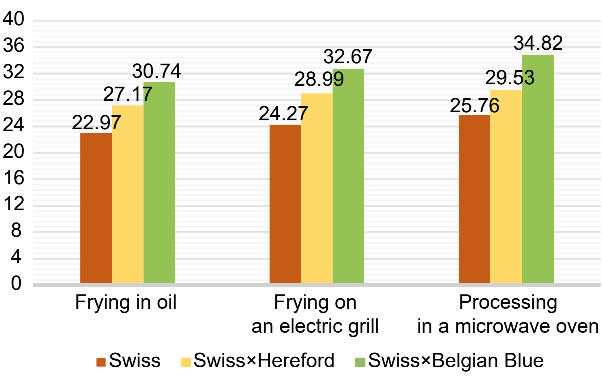

Fig. 3. Cooking loss of patties with different methods of heat treatment (%)

The results of the sensory analysis (Figures 4–6) indicate that there are significant differences between hamburgers cooked in a pan, grill, and microwave oven.

The highest scores for all indicators were given to cutlets made from the meat of Swiss×Belgian Blue. Burgers made from this meat had a good taste, aroma, and better juiciness compared to patties made from Swiss and Swiss×Hereford. This is explained by the higher content of intermuscular fat, which ensures the marbling of the meat and, accordingly, better organoleptic properties. It is known that the beef of meat breeds is more tender, juicier and has an intense taste

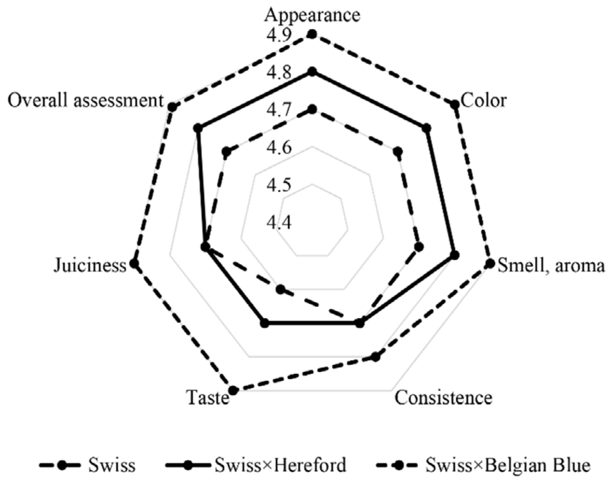

Fig. 4. Profilogram of sensory evaluation of patties for burgers cooked in a pan with the addition of oil

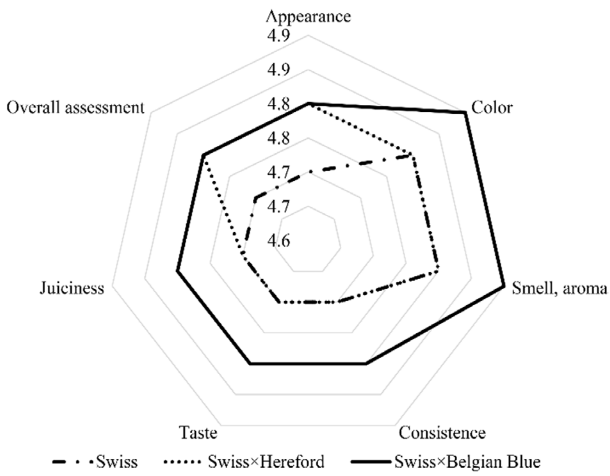

Fig. 5. Profilogram of sensory evaluation of patties for burgers cooked on an electric grill

compared to dual purpose breeds (Conanec et al., 2021). Additionally, double-muscled breeds produce the tenderest beef (Campo et al., 1999).

Similar results (Fig. 5) were obtained through organoleptic assessment of patties cooked in an electric grill. The Swiss×Belgian Blue meat burger patties had the most intense color, taste and aroma. This also affected the overall score, which was 4.85 for the Swiss×Belgian Blue meat, while the lowest overall score was given to the Swiss hamburgers at

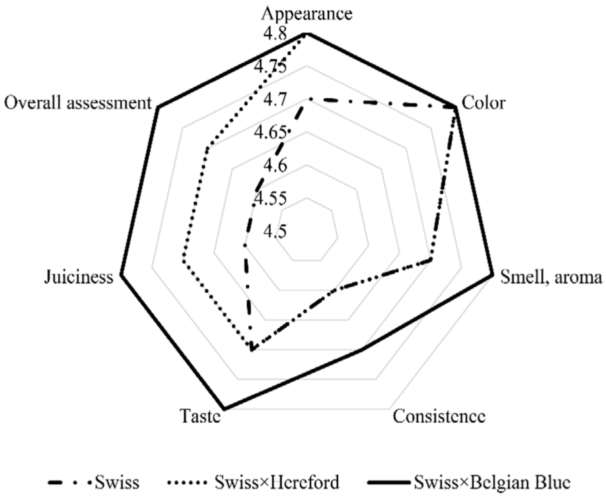

Fig. 6. Profilogram of sensory evaluation of patties for burgers processing in a microwave oven

4.7. Sensory evaluation of cutlets prepared in a microwave oven revealed that this method of preparation causes less pronounced organoleptic properties of meat compared to the previous two. Thus, there is a decrease in the taste and aroma and juiciness of burgers made from Swiss and Swiss×Hereford meat. The score of the taste, aroma, juiciness of Swiss×Belgian Blue meat patties was higher compared to the meat of other genotypes. However, in general, the organoleptic properties of patties with Swiss×Belgian Blue cooked in a microwave oven were lower compared to cooking in a pan with oil. The decrease in the taste and aroma of hamburgers cooked in a microwave oven is due to the absence of non-enzymatic browning reactions as Maillard reaction products (Starowicz and Zieliński, 2019). During rapid heating, many volatile compounds remain in the food matrix without being manifested.

CONCLUSION

Based on the results obtained in this study, it can be concluded that meat obtained from crosses is of high quality in regard to chemical and technological properties and has favorable sensory scores. The fat content was highest in Swiss×Belgian Blue 2.93 ±0.41%, which influenced the energy value of this meat: 113.61 kcal/100 g. There is a certain tendency to increase the WBC in the meat of crossbred steers (by 1.67% on average), both for total moisture and for the mass of minced meat. It was found that minced meat from Swiss×Hereford and Swiss×Belgian Blue has a better (on average by 8.13%) emulsifying capacity compared to beef from the Swiss breed, and the emulsions themselves are characterized by greater stability. The Swiss×Belgian Blue cutlets received the highest scores for all organoleptic indicators, regardless of the cooking method. The sensory properties of all patties cooked in a microwave oven or electric grill were lower compared to cooking in a pan with oil.

The increase in the functional and technological properties of meat can be explained using the heterotic effect. Crossbreeding different breeds can create a combination of traits that makes the offspring optimal for the production environment. Crossbred offspring can exhibit heterosis, an advantage of the offspring of the crossbred over the average of the parent breeds.

According to the results, minced meat from Swiss×Hereford and Swiss×Belgian Blue steers demonstrated better functional properties than steer meat from purebred Swiss. In the further processing of such meat, it is possible to recommend its use for the production of meat products. The direction of further research can be the study of functional-technological and organoleptic properties of model minced meat with a combination of beef and other types of raw materials.

DECLARATIONS

Data statement

All data supporting this study has been included in this manuscript.

Ethical Approval

Not applicable.

Competing Interests

The authors declare that they have no conflicts of interest.

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REFERENCES

Alfafi, B., Al-Ghamdi, S., Othman, M., Hobani, A., Suliman, G. (2023). Advanced Red Meat Cooking Technologies and Their Effect on Engineering and Quality Properties. A Review. Foods, 12(13), 2564. https://doi.org/10.3390/foods12132564

Ayub, H., Asif, A. (2019). Physiochemical changes in sous-vide and conventionally cooked meat. Int. J. Gastron. Food Sci., 17, 100145. https://doi.org/10.1016/j.ijgfs.2019.100145

Bittante, G. (2023). Biodiversity and genetics of beef quality, a review. Ital. J. Anim. Sci., 22(1), 867884. https://doi.org/10.1080/1828051X.2023.2216712

Bleicher, J., Ebner, E., Bak, K. (2022). Formation and analysis of volatile and odor compounds in meat – a review. Molecules, 27(19), 6703. https://doi.org/10.3390/molecules27196703

Borgogno, M., Favotto, S., Corazzin, M., Cardello, A. V., Piasentier, E. (2015). The role of product familiarity and consumer involvement on liking and perceptions of fresh meat. Food Qual. Prefer., 44, 139–147. https://doi.org/10.1016/j.foodqual.2015.04.010

Bozhko, N., Pasichnyi, V., Tischenko, V., Marynin, A., Shubina, Y., Strashynskyi, I. (2021). Determining the Nutritional Value and Quality Indicators of Meat-containing Bread Made with Hemp Seeds Flour (Cannabis Sativa L.). Eastern-European Journal of Enterprise Technologies, 4(11), 58–65. https://doi.org/10.15587/1729-4061.2021.237806

Bozhko, N., Tischenko, V., Pasichnyi V., Marynin. A., Matsuk, Y. (2023). Comparative analysis of the chemical composition, functional-technological, rheological, and antioxidant properties of wild boar meat (sus scrofa) with dfd properties and industrial pork. Acta Sci. Pol. Technol. Aliment, 22(3), 257–266. https://doi.org/10.17306/J.AFS.2023.1144

Bozhko, N., Tischenko, V., Pasichnyi, V., Matsuk, Y. (2020). Analysis of the possibility of fish and meat raw materials combination in products. Potravinarstvo Slovak Journal of Food Sciences, 14, 647–655. https://doi.org/10.5219/1372

Bozhko, N., Tischenko, V., Stepanova T. (2024). Development of meat-containing semi-finished products with pike meat and hemp seed protein. J. Chem. Technol., 32(1), 198–209. https://doi.org/10.15421/jchemtech.v32i1.296208

Bureš, D., Bartoň, L. (2018). Performance, carcass traits and meat quality of Aberdeen Angus, Gascon, Holstein and Fleckvieh finishing bulls. Livestock Sci., 214, 231–237. https://doi.org/10.1016/j.livsci.2018.06.017

Campo, M. M., Santolaria, P., Sanudo, C., Lepetit, J., Olleta, J. L., Panea, B. Albertí, P. (1999). Breed 412 type and ageing time effects on sensory characteristics of beef strip loin steaks. Meat Sci., 51, 383–390. https://doi.org/10.1016/S0309-1740(98)00159-4

Choi, Y. M., Garcia, L. G., Lee, K. (2019). Correlations of sensory quality characteristics with intramuscular fat content and bundle characteristics in bovine longissimus thoracis muscle. Food Sci. Anim. Resour., 39(2), 197. https://doi.org/10.5851/kosfa.2019.e15

Conanec, A., Campo, M., Richardson, I., Ertbjerg, P., Failla, S., …, Hocquette, J. F. (2021). Has breed any effect on beef sensory quality? Livestock Sci., 250, 104548. https://doi.org/10.1016/j.livsci.2021.104548

Domínguez, R., Gómez, M., Fonseca, S., Lorenzo, J. (2014). Effect of different cooking methods on lipid oxidation and formation of volatile compounds in foal meat. Meat Sci., 97(2), 223–230. https://doi.org/10.1016/j.livsci.2018.06.017

Dominguez-Hernandez, E., Alvija, S., Per, E. (2018). Low-temperature long-time cooking of meat: Eating quality and underlying mechanisms. Meat Sci., 143, 104–113. https://doi.org/10.1016/j.meatsci.2018.04.032

Fadeyibi, A. (2022). Modeling Rheological Behavior of Beef based on Time-Dependent Deformation and Packaging. Gazi University Journal of Science, 35(3), 997–1008. https://doi.org/10.35378/gujs.742087

FAO (2003). Food energy – methods of analysis and conversion coefficients. FAO Food and Nutrition, 77. Rome: FAO.

Ge, G., Han, Y., Zheng, J., Zhao, M., Sun, W. (2020). Physicochemical characteristics and gel-forming properties of myofibrillar protein in an oxidative system affected by partial substitution of NaCl with KCl, $MgCl_2$ or $CaCl_2$. Food Chem., 309, 125614. https://doi.org/10.1016/j.foodchem.2019.125614

Gómez, I., Janardhanan, R., Ibañez, F. C., Beriain, M. J. (2020). The effects of processing and preservation technologies on meat quality: sensory and nutritional aspects. Foods, 9, 1416. https://doi.org/10.3390/foods9101416

Gravador, R. S., Valentini, V., Harrison, S. M., Fahey, A., Moloney, A. P., Diskin, M. G., Monahan, F. (2022). Impact of cooking on the content of nutritionally important fatty acids in muscle from lambs raised to have divergent intramuscular fatty acid compositions. Small Rumin. Res., 216, 106802. https://doi.org/10.1016/j.smallrumres.2022.106802

He, J., Zhou, G., Bai, Y., Wang, C., Zhu, S., Xu, X., Li, C. (2018). The effect of meat processing methods on changes in disulfide bonding and alteration of protein structures: Impact on protein digestion products. RSC Adv., 8 (31), 17595–17605. https://doi.org/10.1039/c8ra02310g

Hoa, V., Cho, S., Seong, P., Kang, S., Kim, Y., …, Seol, K. (2021). The significant influences of pH, temperature and fatty acids on meat myoglobin oxidation: a model study. J. Food Sci. Technol., 58(10), 3972–3980. https://doi.org/10.1007/s13197-020-04860-1

Lee, Y., Lee, B., Kim, H., Yun, Y., Kang, S., Kim, K., Kim, B., Kim, E., Choi, Y. (2018). Sensory quality characteristics with different beef quality grades and surface texture features assessed by dented area and firmness, and the relation to muscle fiber and bundle characteristics. Meat Sci., 145, 195–201. https://doi.org/10.1016/j.meatsci.2018.06.034

Leroy, F., Smith, N., Adesogan, A., Beal, T., Iannotti, L., Moughan, P., Mann, N. (2023). The role of meat in the human diet: evolutionary aspects and nutritional value. Anim. Front., 13(2), 11–18. https://doi.org/10.1093/af/vfac093

Leroy, F., Beal, T., Gregorini, P., McAuliffe, G. A., van Vliet, S. (2022). Nutritionism in a food policy context: the case of 'animal protein'. Anim. Prod. Sci., 62(8), 712–720. https://doi.org/10.1071/AN21237

Ma, Q ., Hamid, N., Oey, I., Kantono, K., Farouk, M. (2020). The impact of high-pressure processing on physicochemical properties and sensory characteristics of three different lamb meat cuts. Molecules, 25, 2665. https://doi.org/10.3390/molecules25112665

Maciel, I., Schweihofer, J., Fenton, J., Hodbod, J., McKendree, M., Cassida, K., Rowntree, J. (2021). Influence of beef genotypes on animal performance, carcass traits, meat quality, and sensory characteristics in grazing or feedlot-finished steers. Transl. Anim Sci., 5(4), txab214. https://doi.org/10.1093/tas/txab214

Munekata, P. (2021). Improving the sensory, nutritional and physicochemical quality of fresh meat. Foods, 10(9), 2060. https://doi.org/10.3390/foods10092060

Mwangi, F. W., Charmley, E., Gardiner, C. P., Malau-Aduli, B. S., Kinobe, R. T., Malau-Aduli, A. E. (2019). Diet and genetics influence beef cattle performance and meat quality characteristics. Foods, 8(12), 648. https://doi.org/10.3390/foods8120648

Ngom, R. V., Ndzana, V., Bohounbele, D., Houli, V., Oumara, B., Pagnah, A. Z. (2022). Nutritional quality of meat from cattle breed in livestock production area of cameroon. Open J. Anim. Sci., 12(3), 467–483. https://doi.org/10.4236/ojas.2022.123035

Pasichniy, V., Polumbryk, M. (2016). Collagen containing mixtures impact on sensory properties of chicken forcemeat systems. Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies. Series: Food Technologies, 18(2), 150-152. https://doi.org/10.15421/nvlvet6831

Pathare, P. B., Roskilly, A. P. (2016). Quality and energy evaluation in meat cooking. Food Eng. Rev., 8, 435–447. https://doi.org/10.1007/s12393-016-9143-5

Piston, M., Suarez, A., Bühl, V., Tissot, F., Silva, J., Panizzolo, L. (2020). Influence of cooking processes on Cu, Fe, Mn, Ni, and Zn levels in beef cuts. J. Food Composit. Analysis, 94, 103624. https://doi.org/10.1016/j.jfca.2020.103624

Quitral, V., Donoso, M. L., Jimenez, P. (2020). Effect of conventional oven versus microwave cooking on rancidity, cooking loss and sensory difference of hamburger patties. Revista Chilena de Nutricion, 47, 231–237.

Santana, E. O. C., Silva, R. R., Simionato, J. I., Trindade Júnior, G., Lins, T.O. J. D., …, de Carvalho, G. G. P. (2023). Sex effect on the fatty acid profile and chemical composition of meat from beef cattle fed a whole shelled corn diet. Arch. Anim. Breed., 66(1), 51–60. https://doi.org/10.5194/aab-66- 51-2023

Santhi, D., Kalaikannan, A., Sureshkumar, S. (2017). Factors influencing meat emulsion properties and product texture: A review. Critical Reviews in Food Science and Nutrition, 57(10), 2021–2027. https://doi.org/10.1080/10408398.2013.858027

Stadnik, J. (2024). Nutritional value of meat and meat products and their role in human health. Nutrients, 16(10), 1446. https://doi.org/10.3390/nu16101446

Starowicz, M., Zieliński, H. (2019). How Maillard reaction influences sensorial properties (color, flavor and texture) of food products? Food Rev. Int., 35(8), 707–725. https://doi.org/10.1080/87559129.2019.1600538

Stevens, G., Beal, T., Mbuya, M., Luo, H., Neufeld, L. (2022). Global Micronutrient Deficiencies Research Group. Micronutrient deficiencies among preschool-aged children and women of reproductive age worldwide: a pooled analysis of individual-level data from population-representative surveys. Lancet Glob. Health. 10(11), e1590-e1599. https://doi.org/10.1016/S2214-109X(22)00367-9

Strashinsky, I. M., Goncharov, G. I., Borsolyuk, L. V., Severyn, V. Y. (2010). Improvement of recipes of cooked poultry sausages. Scientif. Bull. LNUVMBT named after S.Z. Gzhitskyi, 12, 2(44), 94–99.

Tomasevic, I., Djekic, I., Font-i-Furnols, M., Terjung, N., Lorenzo, J. (2021). Recent advances in meat color research. Curr. Opin. Food Sci., 41, 81–87. https://doi.org/10.1016/j.cofs.2021.02.012

Wang, Y., Tian, X., Liu, X., Xing, J., Guo, C., Du, Y., Zhang, H., Wang, W. (2022). Focusing on intramuscular connective tissue: Effect of cooking time and temperature on physical, textual, and structural properties of yak meat. Meat Sci., 184, 108690. https://doi.org/10.1016/j.meatsci.2021.108690

Warner, R., Greenwood, P., Pethick, D. (2010). Genetic and environmental effects on meat quality. Meat Sci., 86, 171–183. https://doi.org/10.1016/j.meatsci.2010.04.042

Wei, M., Xiaochang, L., Peng, X., Lei, Y., Haojie, Y., …, Bai, Y. (2022). Characterization of Volatile Profiles and Correlated Contributing Compounds in Pan-Fried Steaks from Different Chinese Yellow Cattle Breeds through GC-Q-Orbitrap, E-Nose, and Sensory Evaluation. Molecules, 11, 3593. https://doi.org/10.3390/molecules27113593

Zhao, D., Yan, S., Liu, J., Jiang, X., Li, J., Wang, Y., Zhao, J., Bai, Y. (2023). Effect of chickpea dietary fiber on the emulsion gel properties of pork myofibrillar protein. Foods, 12, 2597. https://doi.org/10.3390/foods12132597