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Growth energy and quality of beef from bulls of Maine-Anjou, Chianina, and Santa Gertrudis breeds grown in Ukraine

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Abstract. Zonal genotypes have already been created using imported breeds to increase the number of meat cattle in Ukraine, but not enough studies related to the specific features of breeding and feeding imported genotypes in the Steppe zone of Ukraine have been conducted, which is relevant. The purpose of the study is to examine the productive and slaughter indicators of bulls of imported meat breeds of various ecological and genetic origins in the climatic conditions of the steppe zone of Ukraine. Zootechnical, morphometric, biometric, and statistical methods were used in the research. The results of an analysis of the meat productivity of bulls of imported meat breeds of Maine-Anjou, Chianina, and Santa Gertrudis in the age aspect in the conditions of the steppe of the Dnieper region of Ukraine are presented. It was identified that



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when slaughtering experimental animals at the age of 18 months, the mass of paired carcasses of Maine-Anjou and Chianina was quite high and amounted to 324.2 and 311.3 kg, respectively, and the Santa Gertrudis – 233.3 kg, which is 1.39 and 1.33 times less than the young animals of Maine-Anjou and Chianina, respectively. It is proved that to use livestock more efficiently and obtain high-quality beef to improve the supply of meat to the population, it is advisable to grow them up to 18-24 months of age. Maine-Anjou animals dominate in terms of growth energy, age of reaching live weight during key growing periods, and feed conversion. In addition, due to the pronounced massiveness and habit of the body, have a larger carcass mass, the amount of internal fat, offal, as a result of which, the slaughter yield is higher. Based on the conducted studies, the possibility of effective breeding of Maine-Anjou bulls up to 12 months of age is proved, since during this period they reach a live weight of 400 kg and are characterised by the high production rate of lean beef, and for Chianina breed – up to 18 months of age and bigger weight conditions

Keywords: meat cattle; imported genotypes; young animals; live weight; slaughter indicators; beef

INTRODUCTION

Meat production and quality occupy a special place in ensuring food security. A substantial reserve for solving this problem is specialised meat cattle breeding. This is due to the fact that beef is the main source of high-value proteins in the human diet. The effectiveness of meat cattle breeding largely depends on the scientifically based choice of breeds for breeding (Kozyr *et al.*, 2018; Prudnikov *et al.*, 2019).

However, today in Ukraine the number of specialised meat cattle remains extremely low, and beef is produced mainly at the expense of dairy cattle breeding. S.P. Pankieiev (2019) notes that the quality of meat obtained from culled livestock and over-rearing dairy breeds does not meet the standards and has lower taste qualities compared to the beef of specialised meat breeds. The meat cattle industry is also attractive from the standpoint that it is less labour-intensive since it does not require complex machines and equipment, unlike dairy cattle breeding, and most importantly – there is a possibility of using resource-saving technologies. In addition, with the development of meat cattle breeding in Ukraine, the possibility of using land areas not involved in agricultural production increases (Kozyr & Petrenko, 2021).

As a result of painstaking work, a number of Ukrainian meat breeds of livestock were created in Ukraine. Imported livestock, including those of American, French, and Italian origin, was widely used in the breeding process. The ability of imported animals to adapt to new environmental conditions without reducing their productivity indicators allows for determining expediency of their use in the further breeding process in new conditions of existence (McAllister *et al.*, 2020). Such studies in the ecological and climatic zone of the Dnieper Steppe have not been conducted enough, and therefore they are of important interest, both from a scientific and practical standpoint.

The choice of growth technology for the farm must necessarily be based on the most efficient use of resources in each link of the technological process in relation to specific zonal natural and climatic conditions. An important source of increasing beef production

is grazing and fattening cattle. J. Soulat *et al.* (2018) concluded that where there is a sufficient number of pastures, grazing of animals should be conducted. For 4-5 months of the pasture period, the mass of adult cattle can be increased by 26-30%, young animals – by 60-75%. With an increase in the mass of animals, the yield of slaughter products increases sharply. In addition, beef obtained during grazing is characterised by a lower fat content.

On the way to solving the problem of sustainable development of the meat cattle industry, it is important to increase the efficiency of breeding work with the gene pool of cattle and improve the quality components of livestock products. The import of high-quality genetic material of meat cattle is usually accompanied by the transfer of new technologies, including methods for predicting the quality of meat. Modern breeding methods in the 21st century are based on the comparison of molecular genetic markers that interact with economically useful traits. At its core, this is an integrated approach that closely links genotype to phenotype, enabling the identification of valuable genetic material for targeted use in practical breeding. According to C. Berri *et al.* (2019), individual selection of animals, collection of information on breeding value, accounting for productivity, growth, development, use of modern molecular genetic, statistical methods, and computer technologies allow identifying outstanding animals in the shortest possible time.

The purpose of the study was to determine the productive qualities of animals of imported breeds of various ecological and genetic origins, considering the specific features of soil and climatic conditions, and the technology of keeping and feeding in the conditions of the Steppe of the Dnieper region.

MATERIALS AND METHODS

The study used generally accepted research methods: analytical (analysis of special literature, analysis and generalisation of the results), zootechnical (formation and introduction of groups of animals for the experiment, assessment of live weight, exterior measurements,

body structure indices, determination of growth energy, control slaughter), morphometric (physical-chemical composition of carcasses), biometric, statistical.

The experimental part of the study was conducted in the experimental farm "Polyvanovka" of the state institution "Institute of Grain Crops of the National Academy of Agrarian Sciences of Ukraine" in the period from 2018 to 2021. Three groups of 15 heads of newborn bulls of the Ukrainian generation of Maine-Anjou, Chianina, and Santa Gertrudis breeds were formed to examine the influence of the natural-climatic conditions of the Dnipropetrovsk region on the technological processes and productivity of meat cattle.

When forming experimental groups, the origin, age, and body weight of animals were considered. Young animals of experimental groups after weaning from cows were raised according to the same feeding scheme, which met the optimal detailed standards of animal feeding (Ibatullin *et al.*, 2016).

All animals during the study period were clinically healthy and kept loose in the same climatic and technological conditions. During the experiments, the growth of young animals was considered, changes in linear measurements of animals were determined, and absolute, average daily, and relative weight gains were calculated (Antoniuk, 2013). Live mass was determined by individual weighing.

Linear growth of young animals was examined by taking basic measurements in the corresponding age periods (height at the withers, height at the sacrum, oblique trunk length, chest width behind the shoulder blades, chest depth, width in the hook bones and hip joints, chest circumference behind the shoulder blades, metacarpal circumference). The following body structure indices were calculated based on measurements to determine the harmony of body development in young animals: long-legged, stretched, pelvic, thoracic, overgrowth, bony, and meaty (Huziev, 2003).

A control slaughter of young animals at 18, 24, and 30 months of age of 3 heads was performed to assess the meat qualities of the examined cattle. The assessment was conducted according to the method of V. Prudnikov *et al.* (2018) in the Dnipropetrovsk State Regional Diagnostic Veterinary Laboratory

The morphological composition of carcasses was determined by deboning three right half-carcasses from each group, cooled for 48 hours. Based on the data obtained during deboning, the absolute and relative content of bones, tendons, and meat parts and the yield of meat per 1 kg of bones, were determined. Samples of the muscles of the limbs, chest, and back were taken to examine the chemical composition of meat.

All experimental studies were conducted in accordance with modern methodological approaches and in compliance with the relevant requirements and standards, in particular, they meet the requirements of DSTU ISO/IEC 17025:2005 (2006). The keep of animals and all manipulations were conducted in accordance with the provisions of the procedure for conducting experiments and experiments on animals by scientific institutions (Law of Ukraine No. 249, 2012), the European Convention for the Protection of Vertebrate Animals used for Experimental and Other Scientific Purposes (European convention..., 1986).

RESULTS

For various reasons, imported specialised cattle breeds of Maine-Anjou, Chianina, and Santa Gertrudis are not widely distributed in Ukraine. Therewith, their features left a deep mark on the breeding process when breeding local Ukrainian, Simmental, and Southern meat breeds.

A common feature of the examined breeds was the successful acclimatisation to the sharply continental climate of the Steppe zone of Ukraine and adaptation to feeding conditions. The feed was high and amounted to 97-98%, as a result of which they showed fairly high growth energy, which is characteristic of specialised Franco-Italian and American meat breeds of livestock.

Analysis of data on the age dynamics of live weight (Table 1) showed that at birth, in accordance with their biological characteristics, bulls of the examined breeds had different live masses. The highest live weight was identified in newborn calves of the Chianina breed, in which it averaged 58.0 kg, in Maine-Anjou it was 47.7 kg, and in this indicator was lower for the Chianina breed by 17.8%. The lowest live birth weight was identified in the Santa Gertrudis breed, which did not exceed an average of 30.5 kg, which was 36.1% less than in Maine-Anjou ($p < 0.01$), and 47.4% less than in Chianina ($P < 0.001$).

Table 1. Age dynamics of live weight of bulls of different breeds, kg, $M \pm m$

Age of animals, months	Breed		
	Maine-Anjou	Chianina	Santa Gertrudis
At birth	47.7±4.14	58.0±5.11	30.5±3.11
12	398.2±7.24	369.4±9.22	308.4±6.28
18	579.5±8.17	553.8±11.31	424.3±7.36
24	723.2±12.84	676.6±14.25	548.8±15.21
30	811.0±17.98	764.7±13.41	627.5±9.42

Source: compiled by the authors

At 12 months, the live weight of Maine-Anjou bulls compared to newborns increased 8.4 times and amounted to 398.2 kg, while in Chianina peers it increased 6.4 times and averaged 369.4 kg, which was 7.2% less than in Maine-Anjou bulls ($P<0.05$). In animals of the Santa Gertrudis breed in the period from birth to 12 months of age, the live weight increased 10.1 times and amounted to 308.4 kg, which was less than in comparison with bulls of the Maine-Anjou and Chianina breeds, respectively, by 22.6% ($P<0.001$) and 16.5% ($P<0.001$).

By the age of one and a half years, the live weight of Maine-Anjou increased 1.5 times or 31.3% ($P<0.001$) compared to 12 months of age and amounted to 579.5 kg. Therewith, the live weight of Chianina bulls also increased 1.5 times to 553.8 kg, but they were inferior to their peers in Maine-Anjou by only 4.6%. The growth energy during this period in Santa Gertrudis animals was substantially lower, since the live weight was 424.3 kg and they were inferior to their peers of the Maine-Anjou and Chianina breeds, respectively, by 26.8% ($P<0.001$) and 23.4% ($P<0.001$).

At the age of two years, the live weight of Maine-Anjou bulls reached 723.2 kg, which is 19.9% more than at the age of 18 months ($P<0.001$). By the age of two years, Chianina bulls increased their live weight by 18.2% ($P<0.001$). In animals of the Santa Gertrudis breed, it increased by 22.7% ($P<0.001$) but amounted to only 548.8 kg. The highest live weight during this period was identified in Maine-Anjou bulls, which exceeded the indicator of their Chianina peers by 6.4% ($P<0.05$), and Santa Gertrudis animals – by 24.1% ($P<0.001$). Santa Gertrudis's peers had the lowest living mass, with Chianina animals exceeding them by 18.9% ($P<0.001$).

In the final 6 months of growth, the live weight of livestock of all the examined breeds increased by 11.2-11.4% ($P<0.001$). At the age of 30 months, the live weight of Maine-Anjou reached the level of 811.0 kg, while in Chianinas it was 764.7 kg, and in Santa Gertrudis – 627.5 kg. During this period, they outnumbered the indicators of Chianina and Santa Gertrudis bulls by 5.7% ($P<0.05$) and 22.6% ($P<0.001$), respectively.

The different live weight of bulls of all the examined breeds according to the periods of growth and grazing was a consequence of the different intensity of their growing indicators. Up to one year of age, the growth energy of Santa Gertrudis was 761 g per day, while the average daily weight gain of the Chianina breed was 853 g, which was an increase of 11.2%. Therewith, the highest growth rate during this period was observed in the Maine-Anjou breed, which had an average daily live weight gain of 960 g per day, which was 11.3 and 26.1% more than the peers of the Chianina and Santa Gertrudis breed, respectively.

In the period from the age of 12 months to the age of 18 months, the highest energy was characteristic of Chianina bulls, when their average daily weight gain was 1013 g and increased by 11.8% compared to the previous period. In young animals of the Maine-Anjou breed, the average daily weight gains slightly decreased and amounted to 906 g. Therewith, the growth of bulls of the Santa Gertrudis breed decreased by 20.0% and averaged 636 g.

For the growth period from the age of 18 to 24 months, the highest average daily live weight gains were observed in Maine-Anjou bulls – 789 g, while in the Chianina breed – 674 g, and in Santa Gertrudis – 684 g. In the final period of growth up to 30 months of age, the average daily weight gains in all animals substantially decreased and in the context of the breeds under study amounted to 482 g, 484 g, and 432 g, respectively. Increases in the live weight of three meat breeds of imported selection for growing periods have a wave-like character, in which they grow by the age of one year, at the age of 18 months they acquire their maximum value, after which they substantially decrease and at the age of 30 months they make up almost half of the average daily increases compared with the age of 18 months.

Thus, in terms of grazing qualities, Maine-Anjou and Chianina bulls are characterised by higher growth energy and at the end of fattening have a higher living mass compared to Santa Gertrudis animals. Considering breed differences in growth energy, experimental bulls were characterised by different indicators for the age of reaching the control fattening weight of 300 kg (Table 2).

Table 2. Age of bulls of different breeds when reaching the control live weight, days, $M\pm m$

Live weight of animals, kg	Breed		
	Maine-Anjou	Chianina	Santa Gertrudis
300	269.0±6.32	291.2±4.75	359.0±4.44
400	368.4±7.11	383.4±8.11	441.21±2.89
500	469.6±9.25	474.6±4.21	602.22±1.78
>600	577.8±12.12	581.7±3.75	766.31±3.37

Source: compiled by the authors

It took 269 days for the Maine-Anjou bulls to reach a live weight of 300 kg, while the Chianinas needed

291 days, which was 8.2% ($P<0.01$) longer than in Maine-Anjou. It took 359 days for Santa Gertrudis

animals to reach such a live weight, which was 33.5% more ($P<0.001$) and 23.4% more ($P<0.001$) compared to Maine-Anjou and Chianina bulls. In 368 days of cultivation, Maine-Anjou bulls reached a live weight of 400 kg. Animals of the Chianina breed needed 3.9% more time to achieve this indicator of live weight and animals of the Santa Gertrudis breed needed 19.8% ($P<0.001$).

The live weight of Maine-Anjou bulls at the level of 500 kg was reached in 469 days, while for young animals of the Chianina, breed only 5 more days were necessary, while for the Santa Gertrudis breed – 33 days or 28.3% ($p<0.001$) more compared to the Maine-Anjou breed, 27.0% ($P<0.001$) with the Chianina bulls. In 577.8 days, Maine-Anjou bulls and in 581.7 days, Chianinas achieved a live weight of 600 kg, while in Santa

Gertrudis animals this indicator was achieved in 766.3 days, which was 32.8 ($P<0.001$) and 31.8% ($P<0.001$), or 185-189 days more, respectively.

Thus, the different intensities of growth and development of meat breeds ultimately determine the economy of production, because the shorter the period of reaching the slaughter mass, the more efficient the production. Changes in the weight indicators of the live weight of bulls of the breeds under study naturally led to changes in the body structure and exterior. Linear assessment of the exterior, which was performed in experimental bulls at 12, 18, and 24 months of age, showed that both the height at the withers and the oblique length of the body were preferable on the side of animals of the Maine-Anjou breed (Table 3).

Table 3. Linear indicators of bulls development by growing periods, cm, $M\pm m$

Age of animals, months.	Breed		
	Maine-Anjou	Chianina	Santa Gertrudis
Height at the Withers			
12	123.0 \pm 2.11	116.5 \pm 2.14	112.3 \pm 1.24
18	137.4 \pm 1.17	124.0 \pm 7.08	115.4 \pm 1.31
24	139.6 \pm 4.25	135.9 \pm 6.31	134.9 \pm 2.77
Oblique torso length			
12	132.4 \pm 3.75	128.9 \pm 4.33	126.1 \pm 2.77
18	141.5 \pm 2.22	137.6 \pm 4.45	131.4 \pm 1.23
24	187.7 \pm 4.77	174.8 \pm 3.54	149.3 \pm 3.56

Source: compiled by the authors

Notably, there is a substantial lag in height measurements of young animals of the Santa Gertrudis breed at the age of 12 and 18 months, compared with their peers by 3.6-9.8% and 7.5-19.1%, respectively. However, by the age of 2 years, the height at the withers in animals of the Santa Gertrudis breed reached 134.9 cm, which corresponded to the same indicator of Maine-Anjou bulls at the age of 18 months and Chianinas at the age of 24 months. That is, by the age of two years, the height measurements in animals of the examined breeds were almost equal.

Analysis of data on oblique body length showed that according to this indicator, the experimental animals were more strikingly different from each other. In Maine-Anjou bulls, the oblique body length increased

from 132 cm to 187 cm, or by 42.2% ($P<0.01$), in Chianina – by 35.6% ($p<0.01$), and in Santa Gertrudis animals – from 126 to 149 cm, or by 18.4% ($P<0.001$). In the same age periods, a control slaughter of experimental bulls was conducted.

Table 4 shows the indicators that were examined after the slaughter of animals. When slaughtering experimental animals at the age of 18 months, the mass of paired carcasses of Maine-Anjou and Chianina bulls was quite high and amounted to 324.2 and 311.3 kg, respectively. Therewith, the mass of the paired carcass of Santa Gertrudis bulls was only 233.3 kg, which was less than the mass of the paired carcass of Maine-Anjou and Chianina bulls, respectively, by 1.39 ($P<0.001$) and 1.33 times ($P<0.001$).

Table 4. Slaughter indicators of bulls of different ages, $M\pm m$, ($n=3$)

Age of animals, months	Weight, kg				Slaughter yield, %	Coefficient of meat
	paired carcass	internal fat	offal	leather		
18	<i>Maine-Anjou</i>				68.9 \pm 2.03	5.7
	324.2 \pm 9.18	15.9 \pm 1.02	31.3 \pm 2.11	57.3 \pm 9.05		
24	405.0 \pm 12.11	16.2 \pm 2.09	33.8 \pm 4.23	72.11 \pm 4.11	65.3 \pm 1.11	5.6
30	473.6 \pm 15.05	18.9 \pm 4.22	38.9 \pm 4.45	81.14 \pm 9.08	63.0 \pm 2.17	5.4

Table 4, Continued

Age of animals, months	Weight, kg				Slaughter yield, %	Coefficient of meat
	paired carcass	internal fat	offal	leather		
<i>Chianina</i>						
18	311.3±5.09	14.2±1.31	30.6±2.02	52.21±1.14	62.4±1.21	5.5
24	390.5±13.14	15.8±3.42	31.9±3.11	68.1±5.22	61.6±1.38	5.4
30	454.9±14.08	17.9±5.33	36.5±4.15	74.3±12.02	61.7±2.14	5.4
<i>Santa Gertrudis</i>						
18	233.3±1.77	13.6±3.35	25.0±0.48	42.4±1.08	62.7±1.26	5.6
24	304.4±1.34	16.4±2.24	30.7±0.27	42.7±4.18	64.2±2.14	5.4
30	381.9±1.19	18.9±1.99	35.9±0.84	67.0±3.22	59.8±1.29	5.5

Source: compiled by the authors

The mass of the paired carcass of Santa Gertrudis bulls slaughtered at the age of 24 months remained the smallest since it averaged 304.4 kg. The mass of the paired carcass of Maine-Anjou and Chianina bulls was 405.0 and 390.5 kg, respectively, which is 1.33 ($P<0.001$) and 1.28 ($P<0.001$) times higher than that of the Santa Gertrudis breed, respectively. At the age of 30 months, the mass of the paired carcass of slaughtered Maine-Anjou and Chianina animals was 473.6 and 454.9 kg, respectively, which was 24.0% ($P<0.001$) and 19.1% ($P<0.001$) more than the same indicator of the Santa Gertrudis breed, respectively.

The amount of offal increased with the age of slaughter of bulls and reached its maximum at the age of 30 months. Therewith, if this production in the Santa Gertrudis breed at the age of 18 and 24 months was inferior to its peers in the Maine-Anjou and Kyan breeds, then at the age of 30 months it levelled off and averaged 35.9 kg. With the age of slaughter of animals, the weight of the skin also increases, which at the age of 30 months in Maine-Anjou bulls averaged 81.1 kg, and in Chianinas – 74.3 kg. During this slaughter period, the skin weight of Santa Gertrudis bulls was less and amounted to only 67.0 kg.

In terms of slaughter yield, the advantage was for Maine-Anjou bulls, especially for animals that were

slaughtered at the age of 18 months – 68%. In general, all experimental bulls had a slaughter yield of more than 60%, the highest was at the age of 18 months, after which it gradually decreased, and its lowest value was at slaughter at 30 months. Despite the fact that the mass of the paired carcass for three periods of the slaughter of experimental bulls was different, the indicator of the meat coefficient was very close and ranged between 5.4-5.7 conventional units.

Thus, according to the indicators of slaughter qualities, animals of the Maine-Anjou breed have the best values, and peers of the Chianina breed are characterised by indicators close to them. Santa Gertrudis bulls have relatively lower slaughter qualities, although they are not inferior in meat content to their peers of other breeds.

A complete deboning of one half-carcass was conducted to determine the chemical composition of the entire carcass, and to examine the quality of the meat, the longest back muscle was used, which was previously separated from surface fat and connective tissue membranes. Assessment of the quality of meat of experimental bulls slaughtered in different age periods, according to a complex of physico-chemical and organoleptic indicators, is given in Table 5.

Table 5. Quality of meat of bulls of different breeds, $M\pm m$

Age of animals, months	Longest back muscle				Chemical composition of the average sample, %			
	pH, units	loss in boiling, %	tenderness, g/cm ²	moisture capacity, %	water	fat	protein	fat: protein ratio
<i>Maine-Anjou</i>								
18	6.4 ±0.34	44.2 ±1.21	0.59 ±0.003	1.82 ±0.541	57.1 ±1.79	15.2 ±1.94	16.1 ±0.14	0.9
24	6.3 ±0.12	40.4 ±0.99	0.69 ±0.004	2.61 ±0.557	54.4 ±2.01	18.1 ±1.54	17.0 ±0.18	1.1
30	6.5 ±0.32	37.7 ±1.17	0.71 ±0.001	3.04 ±0.614	51.3 ±1.77	21.4 ±2.11	22.4 ±0.22	0.9
<i>Chianina</i>								
18	6.2 ±0.44	45.3 ±2.11	0.49 ±0.002	1.91 ±0.701	54.2 ±2.11	23.2 ±1.15	14.3 ±0.17	1.6

Table 5, Continued

Age of animals, months	Longest back muscle				Chemical composition of the average sample, %			
	pH, units	loss in boiling, %	tenderness, g/cm ²	moisture capacity, %	water	fat	protein	fat: protein ratio
24	6.4 ±0.54	42.6 ±1.81	0.70 ±0.007	2.72 ±0.201	52.1 ±1.28	25.4 ±2.14	14.7 ±0.25	1.7
30	6.6 ±0.74	38.0 ±1.14	0.71 ±0.005	3.17 ±0.199	50.3 ±2.14	26.5 ±1.18	17.6 ±0.19	1.5
<i>Santa Gertrudis</i>								
18	6.4 ±0.15	45.5 ±1.18	0.48 ±0.004	1.73 ±0.215	51.73 ±1.51	18.4 ±1.77	14.0 ±0.28	1.3
24	6.5 ±0.22	39.8 ±1.19	0.70 ±0.19	2.55 ±0.261	52.53 ±2.14	20.9 ±1.16	15.5 ±0.29	1.3
30	6.4 ±0.37	38.1 ±1.27	0.71 ±0.214	3.11 ±0.114	53.11 ±1.15	21.4 ±2.14	14.3 ±0.41	1.5

Source: compiled by the authors

Analysis of the obtained data showed that the acidity of meat of all experimental groups of animals was at the same level, did not go beyond the norm and the PH was 6.2-6.4 conventional units. Boiling loss indicators were in the range of 38-45% and with increasing age, this indicator decreased. This is due to an increase in the moisture capacity of animal meat, which increased with age. Notably, the meat of

Maine-Anjou bulls is the leanest in comparison with other breeds and the ratio of fat to protein in different age periods is 0.9-1.1. The highest fat content is inherent in animals of the Chianina breed, where this ratio is 1.5-1.7, and in Santa Gertrudis – 1.3-1.5. Breed age factors based on the growth energy of the examined meat genotypes also affected the conversion of feed to meat productivity of animals (Table 6) (Prudnikov et al. 2018).

Table 6. Feed energy consumption per 1 kg of live weight gain of bulls, MJ, M±m

Indicator	Breed		
	Maine-Anjou	Chianina	Santa Gertrudis
Age of animals, months	Per 1 kg of live weight		
120-15	69±1.82	84±2.41	108±2.44
15-18	78±0.96	99±2.68	110±2.49
18-24	121±4.23	139±3.01	150±2.54
24-30	138±5.02	141±3.04	154±2.61
Live weight of animals, kg	At the control live weight		
<300	71±1.39	89±2.06	84±1.96
301-400	80±1.47	97±3.04	100±2.04
401-500	118±2.12	117±4.01	123±3.01
501-600	134±3.01	133±4.68	138±4.04
>600	140±4.03	141±4.83	144±4.37
An increase per 1000 MJ, kg	9.2±2.03	8.6±1.94	8.1±1.73

Source: compiled by the authors

When assessing the energy consumption of feed, it was identified that the lowest feed consumption was inherent in the Maine-Anjou breed. This figure was 3.2% less than that of Chianina animals, and 10.3% less than that of Santa Gertrudis. As for the increase per 1000 MJ, the highest increase was also observed in animals of the Maine-Anjou breed – 9.2 kg, which is 6.9% higher compared to Chianinas, and 13.5% higher than in the Santa Gertrudis breed (Table 6).

DISCUSSION

The most important task for the meat cattle industry in Ukraine is to increase the number of livestock and improve the quality of the resulting products. No less relevant and debatable at the present time is the question of the potential of internal tribal resources in solving this problem. The practice has shown that it is advisable to create a breeding base in meat cattle breeding using the world's best gene pool by purchasing

outstanding animals, especially bulls and their sperm products (Hladii *et al.*, 2022).

Although in Ukraine, imported specialised meat breeds of cattle of Maine-Anjou, Chianina, and Santa Gertrudis breeds are not quite common, they were used in the breeding of local Ukrainian, Simmental, and Southern meat breeds.

Any breed of cattle differs in economically useful characteristics and is determined in comparison with other breeds and genotypes, and manifests itself in the development of meat productivity in different ways, depending on the accepted cultivation technology (Kozyr, 2018; Cortese *et al.*, 2019; Lee *et al.*, 2020). In addition, the degree of realisation of the genetic potential of productivity depends on the ability of animals to adapt to new ecological and climatic conditions. (Pankieiev, 2019). For further effective involvement of these breeds in the breeding process, studies on the subject of their meat productivity and product quality in the conditions of Ukraine are relevant.

Ukrainian and foreign researchers note that when considering the issue of acclimatisation, it is advisable to examine the full range of factors to which animals transferred to a new living environment should adapt. These factors will determine the viability and affect the productivity of animals over several generations. T.N. Rowan *et al.* (2021) proved that the most important indicators of successful adaptation of imported livestock from abroad are the preservation of their high productivity, the implementation of normal reproductive function, digestibility, and efficiency of feed use. Therewith, in new ecological and feed conditions, a living organism either degenerates or adapts, undergoing certain changes in the exterior, interior, and economically useful features.

The conducted analyses of growth and development indicators and productive qualities of imported genotypes based on the results of cultivation and fattening showed that they are quite successful in adapting to new conditions. The food consumption was high and amounted to 97-98%, as a result of which the animals showed fairly high growth energy, which is characteristic of specialised Franco-Italian and American meat breeds of livestock. According to the studies (Michael *et al.*, 2019; Olson, *et al.*, 2021) the food intake, high intensity of growth and development of the body also have a positive effect on the reproductive qualities of animals, which indicates the adaptive potential of the breed.

Meat productivity can be assessed both during the life of the animal and after slaughter. The lifetime definition of meat qualities is quite relative since live weight and appearance cannot give a complete description of the quality of meat. The most complete and objective meat qualities of livestock are reflected by the control slaughter. The quality characteristics of beef carcass and meat are influenced by many factors of

different origins (Maresca *et al.*, 2019; Nantongo *et al.*, 2021; Wang *et al.*, 2021). C. Berri *et al.* (2018) argue that breed, sex, slaughter age, diet, and feeding regimen can affect muscle characteristics, which in turn affects meat quality. In young animals, the process of formation of muscle fibres occurs, the intensity of which is higher the younger they are. Therewith, with intensive feeding, there is not only an increase in meat but also fat distributed between muscle fibres, forming the so-called marbled beef. In adult animals, little new muscle fibres are formed. An increase in meat yield occurs through the thickening of muscle fibres. Therefore, when grazing adult livestock, excess feed turns into adipose tissue, which is located mainly under the skin and on internal organs. It is necessary to adhere to an intensive animal feeding regimen to quickly conduct fattening. This will allow reducing labour and money costs per unit of production (Prudnikov *et al.*, 2018).

The dynamics of live weight gains of experimental animals over the growing periods had a wave character. The most intensive growth was observed in young animals up to one year of age, and the maximum value of live weight was acquired by bulls at the age of 18 months. Animals of the Maine-Anjou and Chianina breeds were characterised by higher growth energy and, when removed from grazing, while Santa Gertrudis prevailed in terms of the live weight. The shorter the period of reaching slaughter mass, the more efficient the production is, so different intensities of growth and development of animals ultimately determine the economy of production. This indicator was best in Maine-Anjou bulls, who reached a live weight of 400 kg at the age of 368 days.

Lifetime assessment of the meat productivity of animals and determination of its level is conducted mainly by the intensity of growth and live weight. Therewith, the most complete characteristic of meat productivity can be determined only after slaughtering animals. In all experimental bulls, the slaughter yield was more than 60%, and the highest at the age of 18 months, after which it gradually decreased and its lowest value was when slaughtering animals at 30 months. Slaughter indicators of experimental animals showed an advantage in the slaughter yield of Maine-Anjou bulls. Similar data were obtained in the study by Upperman (2021), where, after slaughter, an assessment of the meat productivity of bulls of different breeds showed the greatest carcass mass in bulls of the Maine-Anjou breed.

Carcasses consist of muscle, fat, bone, and connective tissues. The ratio of these tissues in carcasses is of great importance when conducting a qualitative assessment of carcasses. The demand for beef from consumers of both the population and the meat processing industry dictates high requirements for its commodity and quality indicators. In meat cattle breeding, special importance is attached to the taste characteristics of beef – its juiciness, tenderness – marbleness.

Among the genes that control qualitative traits, calpain (CAPN1), somatotropin (GH), and leptin (LEP) were identified as the most promising (Widyobroto *et al.*, 2020; Ramalingam *et al.*, 2021).

Somatotropin (GH) is produced by the anterior pituitary gland and is one of the most important regulators of somatic growth in animals. It was identified that the gene that controls the synthesis of somatotropin regulates the growth of the animal, and also plays a key role in metabolic processes (carbohydrate, fat) (Widyobroto *et al.*, 2020). Leptin (LEP), a hormone produced by adipose tissue cells, plays an important role in metabolism, especially in the accumulation of fat in the body. In cattle breeding, the leptin gene polymorphism is an important genetic factor affecting the slaughter yield and quality of meat (Ellie-Oury *et al.*, 2019). Meat should have a high nutritional value and be highly technological.

It is important to examine the slaughter parameters and morphological composition of carcasses since they are affected by the breed affiliation of the animal. It is known that the standard for determining the quality of meat in animals is the long back muscle since it consists of almost one muscle tissue. The chemical composition of meat depends on the type of animal, age, sex, fatness, level of feeding, and other factors (Anthony, 2016). Different growth rates of bone, muscle, connective, and adipose tissues change their ratio in the carcass depending on the breed.

Today, the efforts of researchers and practitioners around the world are aimed at meeting the global needs of the food industry for vital nutrients, among which protein is the main one. Therefore, appropriate requirements are put forward for animal husbandry, creating more pressure on it than ever before. For these reasons, a better understanding of the underlying mechanisms of muscle protein metabolism is essential for animal health and productivity.

Over the past two decades, advances in genomics have allowed the breeding process to be more informed and thus targeted. Recent technological findings have allowed the strengthening if not replacing of the genomic age with the age of proteomics and metabolomics (Gagaoua & Zhu, 2022). These technologies allow asking even more complex questions, directing researchers from genotype monitoring to phenotype. A deeper examination of the phenotypic mechanisms that regulate muscle mass, in turn, will provide new insights into how best to address the challenges of animal growth and development and improve the overall health of livestock to predict and manage meat quality.

Knowledge of the mechanisms of metabolism and pathways of protein synthesis opens up the prospect of regulating this process within the biological capabilities of the body. Protein is an important component of muscle tissue, and the consumer value of beef is primarily determined by the ratio of fat and protein that

accumulate during the life of the animal (Kozyr *et al.*, 2021). In muscle tissue, protein accounts for about 20% and 70-77% is water. Studies showed that the meat of Maine-Anjou bulls is the leanest compared to other breeds, and the ratio of fat to protein in different age periods is 0.9-1.1. A higher fat content was observed in the meat of animals of the Chianina and Santa Gertrudis breeds. A higher level of fat in the longest back muscle has a positive effect on the taste of meat and may indicate higher fatness and a tendency of this breed to acquire marbling during fattening, thereby providing the possibility of obtaining high-quality beef from young animals of these breeds.

Thus, the results of the study on the assessment of meat productivity of imported bulls are the basis for determining the effectiveness of their further breeding in the conditions of the Steppe zone of Ukraine and use in the breeding process.

CONCLUSIONS

Studies of productive and slaughter indicators of imported meat breeds of various ecological and genetic origins have determined the periods of their effective cultivation in the climatic conditions of the steppe zone of Ukraine and determined the most optimal slaughter time for obtaining high-quality competitive beef. Successful acclimatisation to extreme conditions of the steppe zone of Ukraine and rapid adaptation to feeding conditions are proved, which is confirmed by the high feed consumption (97-98%) and growth rate.

The wave-like nature of live weight gains of experimental bulls for the growing periods was identified, in which young animals of the Maine-Anjou breed with an average daily live weight gain reached 960 g per day by the age of one year are characterised by higher growth energy. In the period from 12 to 18 months of age, Chianina breed bulls had the highest intensity, whose average daily weight gain was 1013 g. During the period of cultivation from 18 to 24 months, the highest average daily weight gains were characteristic of the Maine-Anjou breed – 789 g, while the Chianina bulls had 674 g, and Santa Gertrudis – 684 g. At the end of the grazing period at the age of 30 months, the intensity of live weight gain in all animals, relative to the indicators of 18 months of age, substantially decreased and in the context of the examined breeds was 482 g, 484 g, and 432 g, respectively.

It was identified that in terms of grazing qualities, the Maine-Anjou and Chianina bulls are characterised by higher growth energy and have a higher living mass compared to animals of the Santa Gertrudis breed at the end of the grazing period. The advantage in growth energy and conversion of feed of animals of the Maine-Anjou breed contributed to their achievement of a greater live weight before other peers in key periods of growth and due to the massiveness and habit of the body, they were characterised by a greater mass of carcass, internal

fat, offal, and higher slaughter yield. Beef of all the examined breeds meets the demand for physical, chemical, and organoleptic qualities, has a pronounced marbling, which is due to the ratio of fat to protein.

Considering the quality indicators of beef as the final product for the consumer, growing Maine-Anjou bulls up to 12 months of age is suggested since during this period they reach a live weight of 400 kg and produce lean beef. It is advisable to raise young animals of the Chianina breed up to 18 months of age and greater

weight conditions. Further research may be aimed at determining the productive and slaughter indicators in the offspring of imported meat breeds obtained from animals grown in the Steppe zone of Ukraine.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Енергія росту та якість яловичини бугайців порід Мен-Анжу, Кіанська і Санта-Гертруда вирощених в Україні

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Анотація. З метою нарощування поголів'я м'ясної худоби в Україні вже створено зональні генотипи з використанням імпорتنих порід, проте досліджень пов'язаних з особливостями вирощування та відгодівлі імпорتنих генотипів в умовах степової зони України проведено недостатньо, що є актуальним. Мета досліджень – вивчення продуктивних і забійних показників бугайців імпорتنих м'ясних порід різного еколого-генетичного походження в кліматичних умовах степової зони України. Під час досліджень були використані зоотехнічні методи, морфометричні, біометричні та статистичні. Наведено результати дослідження м'ясної продуктивності бугайців імпорتنих м'ясних порід Мен-Анжу, Кіанської і Санта-Гертруда у віковому аспекті в умовах степу Придніпров'я України. Встановлено, що за забою піддослідних тварин у віці 18 місяців маса парної туші Мен-Анжу та Кіанських була достатньо високою і становила відповідно – 324,2 і 311,3 кг, а бугайців породи Санта-Гертруда – 233,3 кг, що менше ніж у молодняку Мен-Анжу і Кіанських, відповідно в 1,39 і 1,33 рази. Доведено, що з метою більш ефективного використання поголів'я і отримання високоякісної яловичини для поліпшення постачання населення м'ясом, доцільно їх вирощувати до 18-24-місячного віку. За енергією росту, віком досягнення живої маси у ключові періоди вирощування, конверсією корму домінують тварини породи Мен-Анжу. Вони також за рахунок яскраво вираженої масивності і габітусу тіла мають більшу масу туші, кількість внутрішнього жиру, субпродуктів, в результаті чого і вищий забійний вихід. На підставі проведених досліджень доведена можливість ефективного вирощування бугайців породи Мен-Анжу до 12-місячного віку, оскільки за цей період вони досягають живої маси 400 кг і відзначаються продукуванням пісної яловичини, а молодняк Кіанської породи - до 18-місячного віку та більш вагових кондицій

Ключові слова: м'ясна худоба; імпортні генотипи; молодняк, жива маса; забійні показники; яловичина
