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# Dairy productivity of Holstein cows and realization of their genetic potential

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## Abstract

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In the article are presented the results of the analysis of milk productivity of Holstein cows bred in herds of Joint-Stock Company „Aydyn", Comrat and Society of limited liability „Doksancom" v. Tomay, Administrative and Territorial Unit Gagauzia, Republic of Moldova.

The aim of the work was to study the milk productivity of Holstein cows and the realization of their genetic potential.

It is observed a significant increase in milk yields at cows of German breeding – milk productivity for the II lactation was 8740.9 kg of milk, which is by 1479.6 kg more than for the first lactation, the difference is highly reliable ($P < 0.001$).

It was identified the high coefficient of milkness at animals of Dutch and German breeding for II lactation, which amounted 1354.6 kg and 1330.9 kg of milk, respectively, with a difference of only 23.7 kg of milk.

With the increase in the number of lactations in the herd of SLL "Doksankom", an increase in milk yield for lactation occurred. On average for the second lactation were milked 10081.8 kg of milk, the increase was 1101.6 kg of milk, for the third – 10530 kg of milk, an increase of 1549.9 kg of milk, the difference is highly reliable, at $P < 0.001$.

The realization of the genetic potential (RGP) for 305 days of milking was higher for heifers of Dutch breeding and amounted by 78.15%, (JSC „Aydyn").

Realization of genetic potential by milk yield was higher at cows of the third lactation and amounted to 108.3%, (SLL "Doksankom").

*Keywords:* Holstein breed; milk productivity; milk yield; fat; lactation; genetic potential

## Introduction

Currently, the value of the Holstein breed is very large, as it is characterized by the highest milk productivity and is used to improve the dairy breeds all over the world. It is distinguished by good adaptability to various climatic and economic conditions (Dmitriev et al., 1989).

In the XX century the Holstein breed became the dominant one in the world dairy cattle breeding. The world population of Holstein cows is 25 million of heads, or 72% of the world's eight most common dairy breeds (Januchkov et al., 2011).

Valuable economic attributes are the ability of Holstein animals to eat well bulky fodder pay high by their dairy products in conditions of large dairy complexes and provide a profit of 15-20% more than from other breeds. These characteristics of breed are successfully used in almost all countries with developed dairy cattle breeding, and especially in the USA (http://www.holandesparana.com.br/).

The Holstein breed of dairy cattle of the USA and Canada is the most highly productive in the world. It is distinguished by a specialized milk type, large live weight (650-725 kg), sufficient tallness (height at the withers 141-147 cm). At bulls, these indicators are equal, respectively, 1100-1200 kg

and 165-167 cm. The animals of this breed are characterized by precocity, are adapted to suitability under the conditions of modern industrial production technology and have high adaptive qualities (Prokhorenko, 2013).

At the present time, the Holstein breed of German breeding on the genetic potential of productivity is close to the Holstein of the USA and Canada, but surpasses them in massiveness. The live weight of cows reaches 650-750 kg; the height at the withers is 140-150 cm. The milk production 2.2 million of Holstein cows or 50.8% of the total population in the country, being under the control of milk productivity in 2014, had the yield of 9291 kg, the fat content in milk is 4.0% and the protein is 3.38%. The age of the first calving was 27.8 months. At the same time, the milk yield for 305 days at heifers was 8187 kg or 90.3% of the productivity of adult animals, with a fat content of 3.95%, protein of 3.35%, (http://www.ggi.de/en/holstein-breeding/population/

Several other indicators of productivity are characteristic to the Holstein breed of Dutch breeding. The average milk productivity of cows in the Netherlands in 2009-2010, 305 days of lactation amounted to 8832 kg of milk, the content of milk fat – 4.25%, milk protein – 3.45% (Tekeev, 2015).

Pedigree work with the Holstein breed is characterized by ensuring the health, longevity and high reproductive ability of bulls and highly productive cows, as well as intensive culling of low-productive animals at an early age. Widely is used the assessment of cows in terms of the rate of feed intake and payment for their products, the shape of the udder and the rate of milk yield, the behavior of the herd (Freeman, 1984; Sarapkin et al., 2004). In creating a modern type of Holstein cattle, in addition to breeding work, it is important to provide abundant and full-value feeding of animals. In the structure of the ration of the milking herd, concentrates on general nutrition occupy an average of 40% (Aldrich, 1987). One of the factors that ensure the milk productivity of cows at the level of 6000-8000 kg of milk is full-fledged feeding (Golubkov, 2003; Ulimbashev, 2010). According to Lin and Togashi (2005), Holstein cattle are more demanding on the technology of keeping, feeding and milking.

Over the past 40 years, milk yields in many European countries have more than doubled as a result of achievements in breeding, feeding and management of the herd. At present, the average increase in milk productivity is 1.5% per year; the main role is given to the effective use of artificial insemination, which determines the high genetic potential of the herd (Lin and Togashi, 2005).

In 2015, the milk productivity of US breeding cows in 10381 tested herds of Holstein cattle averaged 11472 kg of milk with 3.67% fat and protein content 3.08%. The world record for dairy production belongs to the cow 3918, from which in 2017 is milked 35457 kg of milk, (http://www.holsteinusa.com/pdf/fact_sheet_cattle.pdf).

Canadian cattle breeders believe that for the Holstein cows, a yield of 45 kg per day is good, but not sufficient. For the future, they plan to bring milk for lactation up to 12000 kg, and daily – to increase to 80 kg or more (Wilson, 1985).

Using the high genetic potential of Holstein by purebred breeding and crossing with other less productive breeds on a background of high-grade feeding allowed in many countries to create highly productive herds and increase milk production while reducing the number of dairy cows, which also contributed to the development of beef cattle. According to Gravert & Shulte-Coerne (1986), in the EU countries almost three quarters of milk is received from cows of Holstein cattle.

It should be noted that breeding of the Moldovan type of black-motley cattle, and then its improvement, was carried out with the use of a world the genofond of Holstein animals imported from Canada, the United States, Great Britain, Germany and other countries (Konstandoglo et al., 2014, Smirnov et al., 2007). Currently (starting from 2008), in the Republic of Moldova, Holstein breeds are imported, mainly Dutch and German breeding.

The aim of the work was to study the milk productivity of Holstein cows and the realization of their genetic potential.

## Materials and Methods

The material for research were Holstein cows imported from Holland and Germany into Joint-Stock Company (JSC) „Aydyn", Comrat and Society of limited liability (SLL) „Doksancom" v. Tomay, Administrative and Territorial Unit Gagauzia, Republic of Moldova.

In 2013, JSC „Aydyn" purchased the first batch of Dutch Holstein heifers from Holland (Dutch breeding) in the amount of 198 heads, in 2014 from Germany 165 heads of heifers (German breeding) were purchased. From 2008 to 2016, SLL „Doksancom" acquired 572 heifers mainly from Holland.

On farms of cattle JSC „Aydyn" and SLL „Doksancom" are used modern technologies of growing and exploitation of animals. All technological processes – the maintenance and cultivation of cattle, manufacture and preparation of forages are mechanized, and milking of cows – is automated. The maintenance of cattle is- year–round stall, unleashed with a walk in the enclosure.

To study the productivity of cows, the data of primary zoo technical and pedigree records were analyzed: journals on the accounting of dairy productivity, pedigree cards of cows, pedigree certificates on animals and other documents

of primary zoo technical accounting. The yield for lactation, for 305 days, was calculated on the basis of control milkings.

The coefficient of milk yield of cows was determined by the formula:

$$MR = M / LM,$$

where: *MR* – milk ratio, kg;

*M* – milk for 305 days or a shortened lactation, kg;

*LM* – live weight, kg.

The parent index of cows (PIC) was calculated according to the method of Kravchenko:

$$PIB = 2M + MGD + PGD / 4,$$

where: *M* – the highest productivity of the mother;

*MGD* – the highest productivity maternal grand dam;

*PGD* – the highest productivity of the paternal grand dam.

The genetic potential of productivity of heifers was determined on the basis of the parental index of cows (PIC) according to the formula:

$$PIC = (2M + MGD + PGD): 4,$$

where: *M* – the productivity of the mother;

*PGD* – the productivity of the paternal grand dam;

*MGD* – the productivity of maternal grand dam.

Static processing of research materials was carried out according to the methods of Plohinsky (1978), Merkuryev et al., (1983). The data obtained during the research were processed biometrically on a personal computer using Microsoft Excel programs; the reliability of the indicators was determined by Student.

## Results and Discussion

Cows of the Holstein breed of the herd JSC „Aydyn" refer to the Dutch and German breeding, whose father's pedigree belongs to the numerous bulls of different lines and countries. The characteristics of female ancestors for the milk productivity of cows of different breeding are presented in Table 1.

The analysis found that the milk yield of the paternal grand dam for the highest lactation ranged from 8125 kg to 25990 kg of milk (Dutch breeding) and from 9009 kg to 22589 kg of milk (German breeding) with a fat content of 4.45-4.47% and 4.5-4.75% respectively.

The yield of mothers of cows of Dutch breeding averaged 9096 kg of milk with a fat content of 4.27%, while the mothers of German breeding cows were by 443 kg larger, with $P < 0.01$. The productivity of the paternal grand dam of German breeding exceeded the paternal grand dam of the Dutch selection by 931 kg, the difference is highly reliable at $P < 0.001$. However, the content of fat of all the ancestors of German breeding was lower, compared to similar indicators of the ancestors of Dutch breeding. For example, the fat content of mothers of German breeding was by 0.28% lower for $P < 0.001$.

The milk yield of cows of Dutch breeding for the first lactation in the herd averaged 7853.8 kg of milk, which is by 592.5 kg more than from the cows of German breeding, the difference is highly reliable ($P < 0.001$), Table 2-3.

Analysis of the average daily milk yield for a number of lactations showed that cows of Dutch breeding for the sec-

**Table 1 Efficiency of female ancestors of the herd JSC „Aydyn"**

| Mothers | | Paternal grand dam | | Maternal grand dam | |
|---|---|---|---|---|---|
| Milk yield, kg | Fat, % | Milk yield, kg | Fat, % | Milk yield, kg | Fat, % |
| Dutch breeding | | | | | |
| n=173 | | n=155 | | n=167 | |
| 9096.8±107.3 | 4.27±0.04 | 11914±197.6 | | 10084±125.2 | 4.24±0.03 |
| German breeding | | | | | |
| n=161 | | n=163 | | n=158 | |
| 9539±93.99 | 4.00±0.04 | 12845.6±178.9 | 4.15±0.04 | 9744±147.4 | 4.14±0.038 |

**Table 2. Milk productivity of cows of Dutch breeding, JSC „Aydyn"**

| Average daily milk yield, kg | Milk yield, kg | Fat content | | Coefficient of milkiness |
|---|---|---|---|---|
| | | % | kg | |
| First lactation, n = 65 | | | | |
| 26.4±0.37** | 7853.8±117.5*** | 3.79±0.05 | 296.3±3.97*** | 1225.9±23.6 |
| Second lactation, n = 59 | | | | |
| 27.6±0.50** | 8612.2±146.2*** | 3.77±0.02 | 325.2±5.2*** | 1354.6±27.6 |
| Average | | | | |
| 26.9±0.31 | 8228.0±100,9 | 3.78±0.02 | 310.1±3.5 | 1294.1±18.8 |

Note: ** $P < 0.01$ *** $P < 0.001$

**Table 3. Milk productivity of cows of German breeding, JSC „Aydyn"**

| Average daily milk yield, kg | Milk yield, kg | Fat content | | Coefficient of milkiness |
|---|---|---|---|---|
| | | % | kg | |
| First lactation, n = 91 | | | | |
| 23.8±0.03 | 7261.3±93.8 | 3.80±0.02 | 275.5±3.0 | 1092.7±14.4 |
| Second lactation, n = 28 | | | | |
| 28.7±0.62*** | 8740.9±188.9*** | 3.74±0.04 | 325.6±5.5*** | 1330.9±17.3 |
| Average | | | | |
| 24.3±0.32 | 7594.4±104.2 | 3.79±0.02 | 287.2±3.28 | 1144.1±16.4 |

*Note*: ***P < 0.001

ond lactation had an average of 1.11 kg of milk / day more than the first lactation, P < 0.01. The same is observed for full lactation – for the second lactation it was milked by 758 kg of milk more, the difference is highly reliable at P < 0.001. A similar increase occurred in the amount of milk fat – by 28.9 kg at P < 0.001.

It should be noted a significant increase of milk yields at cows of German breeding – milk productivity for the second lactation was 8740.9 kg of milk, which is by 1479.6 kg more milk than for the first lactation, the difference is highly reliable (P < 0,001), while daily yields increased by 4.9 kg of milk (P < 0.001). According to the second finished lactation, the cows of German breeding were on average superior to those of Dutch breeding by 128.7 kg of milk, the difference is unreliable.

A comparative analysis of milk yields among cows of different breeds showed that, on average, cows of Dutch breeding significantly exceeded cows of German breeding for 305 days of lactation by 633.6 kg of milk (P < 0.001), average daily milk yield – by 2.7 kg, milk fat yield – by 22.9 kg at P < 0.001.

The milk yield coefficient of Dutch cows on average was 1294.1 kg of milk, which is more by 150 kg than at cows of German breeding, the difference is highly reliable (P < 0.001). A higher coefficient of milkiness was found at animals of Dutch and German breeding on the second lactation, which amounted to 1354.6 kg and 1330.9 kg of milk, respectively, with a difference of only 23.7 kg of milk.

For a more complete assessment of the potential capacity of cows by all indicators of female ancestors was calculated their parent index which shows the genetic capabilities of the animal and the degree of transfer of productive qualities to the offspring (Lapina, 2009), Table 4.

As can it be seen from the data in the table, the parental index of cows for milk yield was the highest at German heifers (10416.9 kg) – the superiority was 369 kg of milk, the difference is significant (P < 0.01), and in terms of fat content, on the contrary, the heifers of Dutch breeding significantly exceeded the peers of German breeding by 0.23% (P < 0.001).

Realization of the genetic potential for milk yield for 305 days of lactation was higher at heifers of Dutch breeding and amounted to 78.15%, which is by 8.45% more than the average for German heifers. The realization of the genetic potential for fat was higher at heifers of German breeding – 93.4% or by 5.3% more than at heifers of Dutch breeding.

It should be noted that female ancestors of breeding cows of SLL „Doksancom" are represented mainly by Holstein breed of Dutch breeding, and also by Estonian breeding, Table 5.

Analysis of the milk productivity of female ancestors showed that the milk yield of mothers with the highest lactation ranged from 7881.7 kg (2009 – Estonian breeding) to 9307.5 kg of milk (2016 g – Dutch breeding) with a fat content of 3.92% and 4.30%. The productivity of paternal grand dam averaged 11691.2 kg of milk. Paternal grand dam of Estonian breeding had a milk yield of 12449.3 kg of milk for the highest lactation, which is by 758.1 kg more than the

**Table 4. Realization of the genetic potential of the heifers, JSC „Aydyn"**

| Indicators | | Breeding | |
|---|---|---|---|
| | | Dutch | German |
| Parent index of cows | milk yield, kg | 10047.9±134.3 | 10416.9**±128.6 |
| | fat, % | 4.30***±0.037 | 4.07±0.039 |
| Own productivity | milk yield, kg | 7853***±117.51 | 7261±93.8 |
| | fat, % | 3.79±0.05 | 3.80±0.02 |
| Realization of genetic potential, % | milk yield, | 78.15 | 69.70 |
| | fat, % | 88.10 | 93.40 |

*Note*: ** P < 0.01; *** P < 0.001

**Table 5. Productivity of female ancestors of the herd SLL „Doksancom"**

| Indicators | Productivity for the highest lactation | | |
|---|---|---|---|
| | Mothers | Paternal grand dam | Maternal grand dam |
| 2008 (n = 66) | | | |
| Milk yield, kg | 8595.5±154.8 | 11378.5±200 | 9284±193.5 |
| Fat content, % | 4.32±0.07 | 4.35±0.05 | 4.41±0.05 |
| Protein content, % | 3.43±0.03 | 3.54±0.02 | 3.41±0.03 |
| 2009 (n = 68), Estonian breeding | | | |
| Milk yield, kg | 7881.7±113.8 | 12449.3±184* | 7896.7±188.4 |
| Fat content, % | 3.92±0.04 | 4.15±0.04** | 4.09±0.05 |
| Protein content, % | 3.28±0.02 | 3.37±0.02 | 3.26±0.02 |
| 2016 (n = 78) | | | |
| Milk yield, kg | 9307.5±160 | 11353±377.1 | 10251±178.9 *** |
| Fat content, % | 4.30±0.06 | 4.31±0.06 | 4.41±0.05 |
| Protein content, % | 3.47±0.03 | 3.59±0.03 | 3.47±0.02 |
| Average: (n = 572) | | | |
| Milk, kg<br>Fat content,% | 8863.9±148<br>4.22±0.05 | 11691.2±278.5<br>4.33±0.05** | 9461.4±184.5**<br>4.32±0.05 |

*Note*: * P < 0.05; ** P < 0.01; *** P < 0.001

average milk; the difference is reliable at P < 0.05.

The milk productivity of the maternal grand dam for the highest lactation averaged 9461 kg of milk, while the maternal grand dam in 2016 – 10251 kg of milk, which is by 790 kg more milk, the difference is reliable (P < 0.01). When comparing the maternal grand dame (2016) with the maternal grand dame (2008 and 2009), it was found that the productivity of the former exceeded the second by yield by 967 and 2355 kg of milk, respectively, the difference was highly reliable (P < 0.001). The milk fat content of the paternal grand dam of Estonian breeding was by 0.18% less than the average, the difference was significant at P < 0.01.

Indicators of milk productivity, fat content in milk of breeding cows of SLL „Doksancom" for three complete lactations are presented in Table 6.

An analysis of the size of the milk yield of animals of different ages showed that less milk was obtained from the cows of the first lactation. It was found that the cows for the first lactation had milk production at the level of 85% of full-aged cows (at a rate of 70 – 75%), which averaged 8980.2 kg of milk with a fat content of 3.83%.

It should be noted that with an increase of the number of lactations, there was an increase in milk yield for lactation. So, the milk yield for the second lactation was 1101.6 kg compared to the first and amounted to an average of 10081.8 kg of milk, for the third – by 1549.9 kg of milk, the difference is highly reliable, at P < 0.001.

For a more complete assessment of cows for milk production, we calculated the yield of dairy products per 100 kg of live weight. The ratio of milk yield for lactation to the live weight of a cow, or the coefficient of milkiness, characterizes the economics of milk production. Normal is considered its value close to 1000. It has been established that this coefficient exceeds the norm for the entire population of cows of the herd SLL „Doksancom", the cows of the second lactation have the highest milking factor – 1520.6 kg.

It should be noted that all cows in all three lactations in terms of milk productivity for 305 days exceeded the minimum standard requirements for the Holstein breed.

To assess the potentialities of the analyzed animals was calculated the parental index of cows for all indicators of female ancestors and in the herd SLL „Doksancom", Table 7.

**Table 6. Dairy Productivity of cows of SLL „Doksancom" for a number of lactations**

| Lactation by account | The number of cows, heads | Milk yield, kg M±m | Fat content | | Coefficient of milkiness, kg |
|---|---|---|---|---|---|
| | | | % M±m | kg M±m | |
| I | 168 | 8980.2±122.8*** | 3.83±0.01 | 343.2±4.3*** | 1383.7 |
| II | 108 | 10081.8±159.3 | 3.77±0.01 | 379.7±5.7 | 1520.6 |
| III | 36 | 10530.1±3515.8 | 3.74±0.02 | 390.9±11.7 | 1497.9 |

*Note*: *** P < 0.001

**Table 7. Realization of the genetic potential of cows in the herd SLL „Doksancom"**

| Account lactation | Indicators | | | | | |
|---|---|---|---|---|---|---|
| | Parent index of cows | | Own productivity | | Realization of genetic potential, % | |
| | milk yield, kg M±m | fat, % M±m | milk yield, kg M±m | fat, % M±m | milk yield | fat |
| I | 9720±189.7 | 4.27±0.05 | 8980.2±122.8 | 3.83±0.01 | 92.4 | 89.7 |
| II | | | 10081.8±159.3 | 3.77±0.01 | 103.7 | 88.3 |
| III | | | 10530.1±3515.8 | 3.74±0.02 | 108.3 | 87.6 |

As a result of the analysis it was established that the indicator of the parental index is at the level of 9720 kg by milk yield and 4.27% by fat content. Realization of genetic potential by milk yield was higher by the third lactation and amounted to 108.3%, which is an average of 7.1% more than at animals of the first two lactations. According to the percentage of fat in milk, the realization of the genetic potential was slightly higher at the heifers – 89.7%. With an increase in the number of lactations, this indicator tends to decrease (87.6%), which is related, to our opinion, to the existing direct correlation between the level of milk productivity and fat content in milk. With an increase of milk production of cows, the fat content in milk decreases and vice versa.

## Conclusions

Consequently, under the new conditions of breeding and exploitation of Holstein cows of Dutch and German breeding, realize their genetic potential at a high level, which is facilitated by the appropriate conditions for their keeping and feeding animals. Holstein cows imported from Holland and Germany combine high milk production are able to produce high daily average milk yields, have good health, and have also successfully adapted to the conditions of JSC „Aydyn" and SLL „Doksancom" farms.

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