CROSSBREEDING OF DAIRY CATTLE IN POLAND

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***Abstract.** Crossbreeding involves mating specimens from different hereditary lines, breeds and populations. It allows to utilise desired traits of the particular breed to achieve production targets. The heterosis, present in the first generation (F1), makes the two or more way crossbreds biologically superior, better adapted to the environment and of higher longevity. Parental crossbreds also become more efficient which in turns improves econimic yield.*

In Poland, the most common crossbreeding breeds are: HF x Swedish Red (SRB)/ Montbeliarde (MO)/ Norwegian Red (NRF)/ Simmental (SIM)/ Brown Swiss (BS) or Jersey (JE). Reaserch shows that crossbreeeding of the specimens from different hereditary lines, breeds and populations, improves the quality of milk in terms of fat and protein content. Crossbred animals live longer and are biologically superior. For example, their udders are resistant to mastitis and their hoofs and legs are stronger. Thier reproduction traits also benefit from crossbreeding as they are better at withstanding consecutive lactation periods, experience easier labours, higher number of surviving offspring, shorter recovery time between pregnancies and deliveries. Also, smaller amount of semen is needed for the effective fertilisation.

Considering the yield and composition of milk; MO, BS, NRF and SRB prove to be most valuable breeds for crossbreeding purposes as they have no negative effect on quantity of milk produced while significantly improving fat and protein content.

Implementing of the crossbreeeding practises has an incredibly positive influence on the age of obtained crossbreds which increases their economic longevity and health. Crossbreeding does not have to be limited to commercial farming. There are considerable economical benefits of crossbreeding herds kept for evaluation and monitoring purposes.

Crossbreeding gives great opportunities to improve a herd. Farmers are more interested in implementing the crossbreeding strategies and they can take an independent, optimized decision for their farm about crossbreeding cattle.

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Introduction. Crossbreeding is all about breeding of individuals of different lines, races or populations and provides great herd refinement possibilities. Animals derived from breeding of one or more races are more vital, biologically stronger, adjust to the actual environmental conditions better and gain more in terms of their performance [Żółkowski, 2014].

The effect of heterosis connected with crossbreeding solves inbred-related breeders problems. It increases health, fertility, longevity and thanks to this it has an impact on the profitability of production [Osten-Sacken, 2015b, Lewandowski 2014]. Research and experiments in crossbreeding show that heterosis appears in relation to features which have the biggest impact on the dairy cattle breeding economy. A significant effect is observed in longevity and functional features as well as in milk performance, however being slightly lower [Gołębiewski, 2015]. Crossbreeding gives new opportunities and allows to make conscious decisions in choice of races and acquired improved in many characterisics individuals. Thanks to such actions the herd will be close to expectations and needs of breeder.

Interracial crossbreeding is present not only in theory – many breeders introduce such action on their farms and topicality still has an impact on its development. Crossbreeding positively influences some of the production characteristics of the first generation hybrids, it also increases heterozygosity, thus decreasing breeding value [Litwińczuk and Szulc, 2005]. Interracial crossbreeding does not have to be used in utility herds only. In herds using utility value assessment of cattle it is also desirable, if we are economical, not implementing breeding programs [Osten-Sacken, 2015b, Gołębiewski et al. 2015].

The aim of the work is an analysis of the crossbreeding impact on performance and milk composition as well as some functional characteristics of dairy cattle use basing on the available literature.

State of dairy cattle livestock in Poland. According to data (all farms of legal persons and individuals not having legal personalities as well as randomly drawn individual farms: 40 thousand farms – sample of about 2%) the livestock of cattle in June 2016 amounted 5 938,7 thousand pieces pointing at 0,4% decrease in the scale of year. The decrease of cattle population was a result of a 4,6% decrease of adult cattle livestock at the age of over 2 years old, including the 4,6% decrease of cow livestock.

Table 1 – Status of cattle population in Poland [GUS, 2016]

Specification	Cattle	Calves at the age below 1 year	Young cattle at the age between 1-2 years	Cattle at the age of 2 years and more	
				sum	incl. cows
in thousand pcs.	5938,7	1728,1	1575,8	2634,9	2332,0
June 2015 = 100	99,6	103,6	103,1	95,4	95,4

December 2015 = 100	103,1	106,9	102,9	100,8	101,3

In June 2016 the cattle population was 5938,7 thousand pieces and was 22,0 thousand pieces higher, which was 0,4% lower than a year earlier and when compared to herd population in December 2015 – it was 176,2 thousand pieces higher (3,1%). Whereas in comparison to last year's June the population of calves below 1 year old increased to the level of 1728,1 thousand pieces, so it was a 3,6% increase, whereas in comparison to December 2015 the 6,9% increase was noticed. Young cattle herd at the age of 1-2 years noted the increase of 3,1% as well when compared to the last year, whereas in comparison to last year's December the increase of 2,9% and reached 1575,8 thousand pieces level. Overally cow population had a 112,5 thousand pieces decrease in comparison to June 2015, which is 4,6% to the level of 2332,0 thousand pieces, whereas when compared to December it was 29,2 thousand pieces higher which is 1,3%.

In the structure of cattle population the share of specific age-usability groups in June 2016 was as follows: 29,1% - calves at the age below 1 year, 26,5% - young breeding and slaughter cattle at the age of 1-2 years, 39,3% - cows, 5,1% - remaining adult cattle (breeding and slaughter) at the age of 2 years and more.

In comparison to the structure of cattle herd in June 2015 the population of calves noticed 1,1% increase as well as young cattle at the age of 1-2 years reported an increase of 0,9%. Whereas the share of the remaining adult cattle at the age over 2 years reported an increase of 0,3% and population of 1,7%.

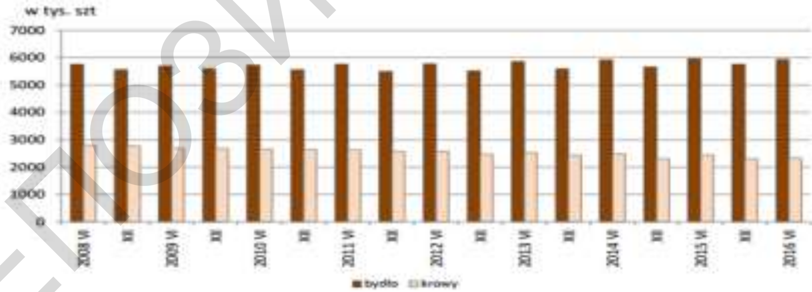

Chart 1 – Cattle population, including cows in years 2008-2016 [GUS, 2016].

The increase of calves and young cattle at the age of 1-2 years old reported in June's study draws attention to the persistent interest of breeders in fattening cattle. The average purchase price of 1kg of bovine livestock for 6 months amounted 5,94 zł/kg and was 3% higher than the one reported in the convergent 2015. As far as the milk is concerned, its average purchase price for 6 months in 2016, amounting 104,79zł for 100l, was 10,3% lower than the one reported in 2015 [Satora, 2016].

Hybrids coloring. The black color is dominating the red, therefore from the mix of black and white holstein-friesian with swedish red, norwegian red or montbeliarde bulls the black and white calves are born. The exception is the HF cow, which is a carrier of the red-white coloring gene (red factor) – then in the F2 generation, i.e. (SRB x HF) x MO or (MO x HF) x SRB, half of calves will be black while the second half red and white. Mixing of holstein-friesian red and white variant will always be the cause of birth of red and white offspring (recessive feature). The use of those 3 races in rotational crossbreeding will limit the possibilities of coloring of hybrids to only two color variants mentioned above. Occasionally, after mixing with swedish red bulls, black or sometimes red calves may be born. Whereas in two-race rotational crossbreeding i.e. SRB x HF or MO x HF and then F1 x HF, then F2 x SRB or F2 x MO etc. alternately: beginning from F3 generation, red and white calves might appear alongside the black and white [Gołębiewski et al. 2015, Osten-Sacken 2015a, Żółkowski 2014].

The impact of crossbreeding on chosen features. The impact of crossbreeding on milk performance is connected with a slight decrease of such performance in lactation, while positively influencing the composition of milk.

It is obvious while looking at Table 2 that both Jersey, SRB, brown swiss, simental or montbeliarde races hybrids (listed accordingly to the percentage content of protein and fat – from the best) achieve better results in the percentage content of protein, as well as fat than the purebred holstein-friesian cows. In simental and montbeliarde races the hybrids surpass the purebred counterparts of this race in milk content. It is a proof of good impact of crossbreeding on milk content with small decreases in performance in comparison to pure-bred holstein-friesian cows. The F1 generation (SRB x HF) is characterised by the performance similar to purebred HF cows, wherein the percentage of dry weight in their milk is higher.

Table 3 shows that in case of brown swiss race hybrids (BS x HF) they have achieved only slightly smaller milk production for one lactation and were characterised by significantly higher content of milk components, whereas somatic cells level has decreased significantly: from 20 even to 45% (the observations of Italian farms in the summer of 2007 in comparison to pure-bred contemporaries of holstein-friesian cows).

When selecting the montbeliarde race bull to crossbreeding it is needed to clarify whether the bull is clearly of dairy type. Bulls of this race may differ depending on type. Some of them are characterised by a clear domination of meat features over dairy features – such thing disqualifies their use in the rotational scheme of crossbreeding in the dairy herd [Osten-Sacken, 2008b, Gołębiewski et al, 2015, Damasiewicz and Damsz, 2015].

Table 2 – Parameters of productional features for holstein-friesian (HF), jersey, montbeliarde, brown swiss, simental races and F1 generation of these races [Damasiewicz and Damsz 2015]

Race	Cows [n]	Lactation [days]	Milk [kg]	Fat [%]	Protein [%]	Fat [kg]	Protein [kg]	Dry weight [kg]
Purebred								
Holstein-friesian. (HF)	601038	305	8,785	4,27	3,47	375	305	680
Jersey (JE)	644	305	5,474	5,85	4,06	320	322	642
Montbeliarde (MO)	1178	305	7,194	4,21	3,50	303	252	555
Brown Swiss (BS)	260	305	6,978	4,69	3,65	327	255	582
Simental (SI)	960	305	6,558	4,30	3,51	282	230	512
Hybrids								
Jersey x HF	998	305	7,229	4,92	3,69	356	267	623
Montbeliarde x HF	7473	305	7,782	4,29	3,50	334	272	606
Brown Swiss x HF	5520	305	7,754	4,46	3,57	346	277	623
Simental x HF	15128	305	7,514	4,38	3,54	329	266	595
Swedish red (SRB) x HF	4538	305	7,638	4,53	3,56	346	272	618

Table 3 – Parameters of productional features for holstein-friesian (HF), brown swiss (BS) races and F1 generation of these races [Freyer et al, 2008]

Race	Productional features		
	Milk [kg]	Fat [%]	Protein [%]
HF	7894	4,14	3,37
BS	6440	4,18	3,59
HF X BS	7525	4,16	3,48
Heterozja [%]	5	0	0

None of the races used for crossbreeding with holstein-friesian race in Poland (montbeliarde, brown swiss, NRF, SRB, simental, jersey – listed in the order of performance – from highest to lowest) can match holstein-friesian race with potential or results. It should not be expected to increase results in this sector due to crossbreeding. It is needed to remember about the economy and the fact that the goal is not to reach the highest production level but to make a profit.

Races: MO, BS, NRF and SRB have the highest milk performances among races used for crossbreeding (Table 4). The constant increase of inbred, which occurs in the population of holstein-friesian cows (+0,1% per year), in close future may lead to crossbreeding being almost necessary for milk producers. Further increase of production potential should not stand in the foreground – it is satisfactory and its use is limited by nutritional and environmental conditions. Breeder must only plan the scheme of crossbreeding and fulfill it [Osten-Sacken, 2008a, Gołębiewski et al. 2015].

Considering the performance feature and milk composition, four races: MO, BS, NRF and SRB are the most demanded in crossbreeding. They do not have a fundamental negative impact on milkiness, at the same time having a positive impact on remaining parameters.

The impact of crossbreeding can be seen in hybrids' health as well - they are stronger and less susceptible to diseases in comparison to the parent generation. It is the result of heterosis appearing in the F1 generation. Studies concerning health of crossbred hybrids were performed in 6 productive herds (both purebred cows as well as hybrids were in these herds) in California from June 2002 to January 2009 [Heins et al., 2012].

Table 5 shows mortality and all losses in the herd during the first lactation for hybrids and purebred as well. The differences appearing between the groups of hybrids and purebred animals are significant [Gołębiewski et al. 2015]. We can conclude from Table 5 that only 2,6% of hybrids were lost during the first lactation, in comparison to the purebred results – 5,3%, which points at higher hybrid survivability. Losses before the first lactation were: 3,6% - for purebred HF cows and 1,4% in hybrids. In summary, during the first lactation 12,2% of hybrids and 21,2% of purebred animals were lost or died, whereas before the first lactation it was 4,7% and 12,3% appropriately. There is a very noticeable difference here and the confirmation that crossbreeding positively influences health.

Table 4 – Average performance of several chosen races in Poland in years 2012-2014 [Osten-Sacken, 2015a]

	2012	2013	2014
	milk[kg]/fat [%] /protein [%]/fat+protein [kg]	milk[kg]/fat [%] /protein [%]/fat+protein [kg]	milk[kg]/fat [%]/protein [%]/fat+protein [kg]
HF	7533/ 4,13/ 3,35/ 563	7588/ 4,15/ 3,35/ 569	7742/ 4,07/ 3,35/ 547
Simental	5826/ 4,14/ 3,45/ 442	5862/ 4,18/ 3,45/ 447	6030/ 4,12/ 3,46/ 457
Jersey	5711/ 5,20/ 3,83/ 516	5746/ 5,19/ 3,83/ 518	6009/ 5,10/ 3,84/ 538
Montbeliarde	7205/ 3,99/ 3,51/ 541	7224/ 4,03/ 3,50/ 544	7203/ 3,97/ 3,49/ 537
Brown Swiss	6756/ 4,58/ 3,56/ 550	7125/ 4,50/ 3,55/ 547	7076/ 4,30/ 3,54/ 555
SRB	7483/ 4,40/ 3,58/ 597	7511/ 4,44/ 3,58/ 603	7029/ 4,34/ 3,59/ 557
NRF	7114/ 4,59/ 3,51/ 577	7426/ 4,60/ 3,51/ 603	7052/ 4,34/ 3,51/ 554

Table 5 – Mortality and all losses of a herd during the first lactation for montbeliard x holstein-friesian (MO x HF), swedish red breed x holstein-friesian (SRB x HF) hybrids as well as purebred holstein-friesian cows [Heins et al. 2012]

Specification		HF (N=416)		MO X HF (N=251)		SRB X HF (N=321)	
		n	%	n	%	n	%
Deaths	before the first test milking	15	3,6	5	2	3	0,9
	until the 305th day of lactation	22	5,3	10	4	5	1,6
Diminutions	before the first test milking	36	8,7	12	4,8	7	2,2
	until the 305th day of lactation	66	15,9	35	13,9	20	6,2

Hybrids of the swiss brown were characterised by a higher health of udders, whereas the ones treated to mastitis recuperated much faster. In research, more cases of lameness during first lactation in F1 hybrids cows were reported, whereas in case of the second lactation no major differences were noticed, therefore it does not have any meaning in the health context [Gołębiewski et al, 2015].

Table 6 data show that from the functional features of BS race – namely hybrid rejection indicator – decreased significantly in comparison to the purebred holstein-friesian cattle. The positive impact of crossbreeding is observed in shortening of calving interval from 367 to 398 days (thus 31 days). The calving rate indicator also gained and increased from 91,7% to 99,4%.

Table 6 – Parameters of functional features for holstein-friesian (HF), brown swiss (BS) races and F1 generation of these races (HF x BS) [Freyer et al, 2008]

Race	Functional features			
	lifetime production [numer of lactations]	rejection indicator [%]	calving interval [days]	calvings interval [%]
HF	2,48	35,7	398	91,7
BS	3,11	25	411	88,8
HF x BS	3,07	27,4	367	99,4
Heterozja (%)	9	9	9	5

The productive potential of animals increases with an improvement of body features, their longevity and health improving as well. Cows which have high-hanging udders, strong and well-structured legs as well as a proper rump width are distinguished by a higher survival rate. A proper udder structure is connected with a lower tendency to mastitis. Udder which is low-hanging is more vulnerable to penetration of microbes through the teats or various injuries. With such structured udder a negative impact on productive life of a cow is observed.

Daughters should receive high rating for the udder after the bull chosen for breeding, with particular emphasis on udder's middle ligament, placement of the udder and teats arrangement; high notes should also concern legs and hooves. Such features directly affect longevity and productive efficiency of cow's udder. Presently, great attention is attached to teats arrangement – it has an impact on the process of mechanical milking, thus decides of the use of milking robots for milking of a specific cow [Gołębiewski et al. 2015].

Interracial crossbreeding and its beneficial influence is noticeable in hybrids' breeding as well (Table 7). Survey research [Gołębiewski, 2015] reported that cows' fertility and health as well as their survivability are the issues which drew the attention of scientists to crossbreeding. In Heins and Hansen studies (2012 – Table 7) MO x HF and SR x HF hybrids were characterised by the earlier age of first calving in comparison to purebred individuals of holstein-friesian race. What is more, in such hybrids the effectivity of fertilisation was higher throughout the duration of five lactations and the service cycle (days betweens the first and the last mating) was shorter. In MO x HF and SR x HF hybrids the pregnancy interval decreased (days from calving to the effective mating) by 19 to 27 days, whereas the date of first mating decreased by 3 to 7 days in comparison to the results achieved by purebred HF, which were kept together with hybrids (six Californian herds) [Heins et al. 2006b, Gołębiewski 2015]. The average pregnancy interval in the first lactation in hybrids was even 14 to 21 days shorter than in purebred cows. Depending on lactation the divergences in the length of this cycle are noticeable, in individual races combinations. In MO x HF the tendency to shortening of parturition interval was reported together with an increasing number of lactations. For SRB x HF the pregnancy interval length was on the same relative level, having the highest predominance in fifth lactation in comparison to the HF hybrids, however quite a big increase of the parturition interval in the fourth lactation can be observed, whereas the third lactation was characterised by the shortest parturition interval [Gołębiewski et al. 2015].

Dechow et al. (2007) research shows that the parturition interval's heterosis in USA is on the level of 1,4% - 15,1%. In order to determine results of heterosis for the vitality of calves and the ease of calving in dependence of mother's race, the data of calving of: 676 HF heifers, 370 MO x HF heifers and 264 SR x HF heifers mated with BS, MO and SR races bulls were subdued to an analysis [Heinsi et al., 2006a]. Both in the case of multiparous as well as primiparous cows of chosen races (Table 8), the percentage of difficult parturitions and stillborn calves is lower. When it comes to difficult parturitions it was between 3,7% for the SRB race and 7,2% in the MO race and 17,7% in HF (Table 8) as well as 5,1%, 6,2% and 14% for stillborn calves appropriately.

Table 7 – Average pregnancy intervals for purebred holstein-friesian cows and their hybrids, counted until the fifth lactation with the use of the smallest squares method [Heins and Hansen, 2012]

Lacta-tion number	HF			HF x MO			HF x SR		
	n	Average pregnancy interval	SE	n	Average pregnancy interval	SE	n	Average pregnancy interval	SE
1	360	148	6	477	131	5	305	134	5
2	274	144	5	396	120	4	254	133	5
3	180	146	6	302	130	5	181	132	6
4	97	147	8	195	120	7	116	146	8
5	37	157	12	72	110	11	33	139	14

Another example may be the result of the hybrids of SRB x HF cows in which difficult parturitions occurred less when compared to the HF race (Table 9) – they decreased from 16,4% to 5,5% in primiparous and from 8,4% to 2,1% in multiparous cows. The indicator of stillborn calves in cows of these hybrids was also lower and decreased from 15,1% in purebred holstein-friesian cows to 7,7% in primiparous cows of the SRB hybrids. On the other hand, in multiparous cows this indicator decreased from 12,7% to 4,7%. In such crossbreeding with swedish red cattle (Table 9) as an example, 10,9% decrease in difficult parturitions and 7,4% decrease in stillborn calves are gained, whereas in primiparous cows of these hybrids difficult parturitions decreased by 6,3%, stillborn calves decreased by 8,0% and appropriately for the MO race: -3,0%, -7,7%, -4,8%, -3,4% and BS race: -3,5%, -7,1%, -3,9% and -3,5%.

Presented studies show that milk producers may lower the occurrence of difficult parturitions and stillborn calves in the herd thanks to crossbreeding. As an effect, with high probability it can be expected that cows obtained from such crossbreeding will be characterised by easier parturitions in comparison to the purebred holstein-friesian cows. Besides that, it can be expected to achieve the higher number of alive calves [Gołębiewski et al. 2015].

Table 8 – Difficult parturitions and stillborn calves in HF primiparous cows and crossbred hybrids mated with BS, MO and SR bulls [Heins et al 2006a]

Animal race	First calving		
	n	Difficult parturitions [%]	Dead births [%]
HF	676	17,7	14,0
MO x HF	370	7,2	6,2
SR x HF	264	3,7	5,1

Table 9 – Difficult parturitions and stillborn calves in primiparous and multiparous HF cows mated with bulls of different races [Heins et al 2006a]

Father's race	Primiparous			Multiparous		
	n	difficult parturitions [%]	dead births [%]	n	difficult parturitions [%]	dead births [%]
HF	371	16,4	15,1	303	8,4	12,7
BS x HF	209	12,5	11,6	524	4,9	5,6
MO x HF	158	11,6	12,7	2373	5,4	5,0
SRB x HF	855	5,5	7,7	515	2,1	4,7

Another aspect, which the crossbreeding concerns is the longevity. The use of crossbreeding is very beneficial to the age of obtained hybrids. For many years there have been a tendency of a regular shortening of dairy cattle productivity period, which is unfavorable. Whereas increasing the longevity thanks to their selection is difficult and long-term and it is connected with low-inheritance of this feature. The longevity of the assessed holstein-friesian cattle in Germany decreased from 4,9 to 4,6 years throughout 10 years (1996 – 2006). At the same time their performance increased from 7013 to 8672 kg (for 305-day lactation) [Freyer et al. 2008]. Thanks to high longevity heterosis, longer usage of hybrid cows is possible [Trela and Choroszy, 2010]. Thanks to the studies from 2003 (Van Raden and Sanders) the significantly lower heterosis was proved in comparison to an earlier American research from 1988 and 1992. Heterosis parameters presented there were higher than the estimations from 2003. The USA results [Heins et al., 2012] show that F1 hybrids are significantly more long-lived when compared to the purebred holstein-friesian cattle.

According to studies from 2012, 25% of purebred holstein-friesian cows before the second calving and only 11-15% of hybrids were rejected, whereas during the third calving 71-75% of hybrids and 51% HF were rejected and in the fourth calving only 30% HF. This can be confirmed by the studies from 2006 (Hare et al.) which inform about the survivability of the holstein-friesian race on the level: for the second lactation – 73%, for the third lactation – 50% and fourth lactation – 32% appropriately.

In studies from New Zealand – Table 10, concerning the percentage of cattle survivability in subsequent lactations (observations have been undertaken for 10 years in the herd consisting of 300 cows) – it was concluded that the crossbred cows (HF x SRB) live longer than purebred HF cows. The percentage of survivability for subsequent parturitions was significantly higher for the SRB x HF hybrids than in the case of purebred HF cows. In the sixth calving this difference was almost double – 30% to 18% (Table 10). Prolongation of cow usage time is an effect of the increase of indicators deciding of cow's health [Osten-Sacken, 2008b).

In the opinion of Gołębiewski et al. (2015) the difficulties during calving and reproduction, as well as the increase of inbred and other health issues are considered as factors of weak survivability. Basing on the above materials, longevity heterosis – important from the economic point of view, might reach 10-15%. Quoted experiments and studies of crossbreeding indicate that heterosis appears in relation to the features most crucial economically in breeding of dairy cattle. The highest effect is revealed for the longevity and functional features, lower for mastitis immunity and milk performance, which do not change significantly [Gołębiewski et al. 2015].

Table 10 – The percentage of cow survivability [Osten-Sacken 2008b]

Race of cows	Survivability until next calvings [%]				
	Calvings				
	2	3	4	5	6
HF	81%	59%	49%	34%	18%
HF x SRB	88%	74%	61%	48%	30%

The examples of features enhancement in the offspring generation in case of the use of better race in respect of given feature. Jersey race and its use for obtaining of JE x HF hybrids definitely positively influences milk composition and udder's health (Table 11). Crossbreeding of these races allows to increase fat content in milk by 0,63% and protein by 0,27% in comparison to the purebred HF cows. Additionally, the number of somatic cells decreased from 199 thousand to 131 thousand – so it dropped by full 68 thousand. It can be clearly stated that crossbreeding of these two races brings very good results. Here we are dealing with the use of an individual with better genotype in respect of given feature (milk content here) than the owned herd (comparison to HF race here), therefore quick improvement with respect to this feature in the offspring generation may be expected [Gołębiewski et al., 2015, Wójcik 2012].

Table 11 – Chosen production parameters [Wójcik, 2012]

Specification	HF	JE	JE x HF
Fat [%]	4,38	5,75	5,01
Protein [%]	3,55	4,12	3,82
Body weight [kg]	481	-	446
Number of somatic cells [unit]	199 000	-	131 000

Norwegian scientists state that HF x NRF hybrids have better fertility, less problems with hooves, less cases of clinical mastitis, easier parturitions, less amount of stillborn calves, their better survivability and rearing. Milk production by HF x NRF does not differ significantly from the one of purebred holstein-friesian. Since the beginning of work on the NRF race all activities have been focused on healthiness and fertility, not on performance improvement. At this moment, it is not more than 39% of selective index of this race. Focus on the economical aspects in the work on this race results with the fact that 50% of population is hornless and it is estimated that in the next 10 years this race will be completely hornless. Scientists, basing on the work of Norwegian breeders, confirm that the correlation between fertility and occurrence of clinical mastitis actually exists [Pedrotti and Pedrotti, 2009].

Breeders owning F1 generation confirm that, despite HF x NRF hybrids are characterised by lower performance than their holstein-friesian counterparts, they are characterised by milder temperament, lower use of semen for the effective fertilization as well as easier parturitions. Owners of such herds of hybrids also observe higher immunity to mastitis, therefore its rare occurrence [Grala, 2009, Brzozowska, 2013].

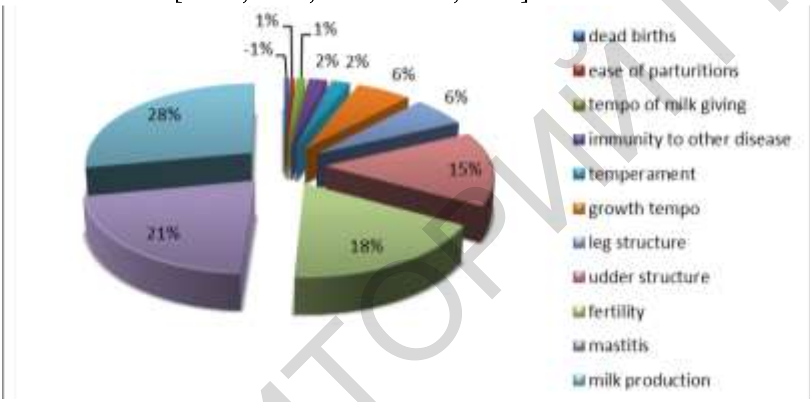

Chart 2 – Percentage content of NRF race index [Pedrotti and Pedrotti, 2009]

Summary and conclusions. Studies show that crossbreeding of individuals of different lines, races or populations has a positive impact on milk content (fat and protein content). Hybrids live longer and are biologically stronger. Benefits are observed in udder's and hooves' health as well as immunity to mastitis. Hybrids are distinguished by higher survivability in subsequent lactations and better reproduction parameters (easier parturitions, higher amount of surviving calves, shorter pregnancy and calving intervals as well as lower amount of semen used for the effective fertilization).

Interracial crossbreeding brings huge possibilities of herd improvements. Every breeder is allowed to make an independent, optimal breeding decision concerning crossbreeding for its farm.

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THE EFFECT OF OREGANO (*ORIGANUM VULGARE L.*) OLEORESIN AND GREEN TEA (*CAMELLIA SINENSIS*) EXTRACT ON SELECTED QUALITY ATTRIBUTES OF COLD-STORED PORK

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Abstract. *The objective of this study was to compare the effects of natural antioxidants on lipid peroxidation, and the physicochemical and sensory properties of ground pork. The experimental materials comprised samples of m. longissimus dorsi collected from the carcasses of crossbred [♀(Polish Large White x Polish Landrace) x ♂Duroc] pigs. The samples were divided into 5 groups: fresh meat before storage, control – without additives; with the addition of 0.02% encapsulated oregano oleoresin; with the addition of an aqueous extract made from 5 g of dry green tea leaves; with the addition of an aqueous extract made from 10 g of dry green tea leaves. Samples of fresh meat were immediately subjected to laboratory analyses, whereas the control sample (without additives) and the remaining samples (thoroughly mixed with the additives) were vacuum-packaged and evaluated after 14 days of cold storage.*

It was found that control samples (without additives) and pork samples supplemented with oregano oleoresin and cold-stored for 14 days were characterized by lower pH and lower water-holding capacity compared with samples supplemented with 5 and 10 g of green tea extract, and fresh meat samples analyzed before storage. The tested natural antioxidants influenced meat color. Meat without antioxidants, evaluated before storage, was darkest (L) and had the lowest contribution of redness (a*) and yellowness (b*). Oregano oleoresin contributed to the highest increase in color lightness, and green tea extract contributed to the highest increase in redness (a*). Oregano and an aqueous extract made from 10 g of dry green tea leaves most effectively inhibited lipid peroxidation (TBARS) in pork. The concentration of green tea extract was correlated with its antioxidant activity. Meat samples with the addition of 5 g of green tea extract received the lowest score for aroma desirability, which most probably resulted from the highest rate of lipid peroxida-*