SZENT ISTVÁN UNIVERSITY

Studies for the marketable mutton production

PhD Thesis

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1. Background and goals of the study

In Hungary income for sheep breeding is based almost only on selling lambs. A prognosis shows a slow decrease in mutton production in the European Union, which enhances the market possibilities of the Hungarian products. The main market is still Italy, where there's a demand for merino lambs. Good quality fattened lamb available in sufficient quantity for the traders are the basic criteria for broadening the sale market.

My study was focusing on the different factors of marketable mutton production, as these factors are diverse, I analysed factors in correlation with lamb fattening, meat quality and reproduction and based on the test farm data provided by the Research Institute of Agricultural Economics the composition of the members of the sheep branch, based on size and the tendencies in profitability.

2. Aims of the study

- Analysing the fattening and growth traits of different sheep breeds (Hungarian merino, German mutton merino and German black-headed mutton)

- Evaluating the fattening production of German mutton merino ram lambs in connection with temperament and some blood parameters

- Evaluation of the traits after slaughtering and some meat quality traits (colour, pH, sheer force, nutrient content) of lambs belonging to different genotypes (Hungarian merino, German mutton merino)

- Analysing reproduction traits of Hungarian merino and German mutton merino ewes based on their life production

3. Material and methods

I collected my data between 214 and 2015 in Törtel, Hungary, in the nucleus-breeding farm of Mihály Sebők. The owner is dealing with sheep for fifty years, breeding German mutton merinos, Hungarian merinos and German black-headed muttons. He won the main price for breeding several times in the National Agriculture and Food Exhibition and many other prices.

3.1. Life production based on lamb production of ewes belonging to different genotypes

Ewes included in this study were born between 2004 and 2005 in Törtel. The German mutton and Hungarian merino ewes were involved in breeding at 15-20 months of age. Only artificial insemination was used. They've used test rams (raczka, czigaja breeds) for detecting the ewes in oestrus. I was analysing the production data between 2006 – 2013. Hungarian merino (n=335), and German mutton merino (n=188) ewes and lambs born from them took part in the study. After the first lambing both breeds were lambed every 8 months in average. Keeping and feeding was the same for the two breeds, two weeks before mating dams got rye (300 g/day) as supplemental forage (flushing).

I was analysing the reproduction traits, the ratio of twin lambing due to accelerated lambing and life production. I was using the method suggested by VERESS et al. (1995) for evaluating reproduction traits (number of lambs born, lambing percentage, number of ewes lambed).

I used SPSS 20.0 package for the statistical analysis. Applied the statistic tests bellow.
Verified the normal distribution of data by Kolmogorov-Smirnov test. As I concluded that data show a normal distribution, used parametric test during in the following.
I've used F test (for comparing standard deviations) and t tests for comparing two independent samples.
In case of three groups checked the homogeneity of data by Levene test before conducting ANOVA. I've performed one factor analysis of variance. In the number of data was similar in the groups I've applied LSD tests, if different, Tukey tests.
I've used Pearson correlation and regression analysis among the correlation tests. Have used the trend function for illustrating the weight gain of the breeds studied.

3.2. Analysing the fattening traits and growth intensity of lambs belonging to different breeds (Hungarian merino, German mutton merino, German black-headed mutton)

We started to fatten the ram lambs of the three breeds (Hungarian merino, German mutton merino, German black-headed mutton) according to the Farm Production Control, described in the Sheep Production Control Codex by the Hungarian Sheep and Goat Breeders Association in 2015 spring.

10-10 animals from each of the three genotypes were chosen randomly at the start of fattening (which was the weaning time as well, 60th day of age), at the end of the 40 day fattening time, and 15 days after that for individual scaling. We measured life weights individually at the start of fattening, at 70, 90, 100 and 115 days of age, with 0,1 kg accuracy.

Lambs were kept in small groups, divided by breeds during the fattening, room for an animal was 1 square meter.
I've calculated the daily weight gain of the lambs in different ages and analysed the correlations between different fattening parameters and breed.

Statistical analysis (average, standard deviation, Chi^2 test) was performed by SPSS 20.0. I made a trend function for analysing the growth intensity of the three breeds. The model from of the trend function is: y=a+b*t+c*t^2, where t means the number of days, y the weight gain of the breed.

3.3. Analysing fattening traits of German mutton merino ram lambs in correlation with their temperament and certain blood parameters

I was analysing the fattening performance of 16 German mutton merino ram lambs in correlation of their temperament and given blood parameters. This study was performed in Törtel, Hungary in the nucleus breeding stock of Mihály Sebő in the spring of 2014.

We started to fatten 40 German mutton merino lambs (at 76 days of age), fattening lasted for 40 days. Fattening lambs were fed *ad libitum* (150 g/kg raw protein, 7.20 MJ/kg NEm, 4.80 MJ/kg MEg) by commercial mixed feed during the study and licking salt and drinking water was also provided.

Lambs were kept in small groups, in deep litter, $1m^2$/lamb room provided. Health status of the lambs was good during the experiment.

I've measured the lams during the farm performance test next the days of weaning and grouping, and in the middle and at the end of fattening. I've chosen the individuals for further from the lamb group randomly involved in the study analyses based on results of the scale test for measuring temperament, those, who showed extreme reactions: 8 calm (1-2 scores) and 8 nervous (4-5 scores) animals, I've recorded their weight and temperament scores. Those lambs remained in the same groups and under the same circumstances during the rest of the study.

Scale test

Animals are kept of the scale for 30 seconds during the scale test (TRILLAT et al., 2000). During this period I gave scores for their behaviour according the system bellow:
- Score 1: calm, no movement;
- Score 2: calm, some accidental movements;
- Score 3: calm, a bit more movements, but does not shake the scale;
- Score 4: sudden, episodic movements, but does not shake the scale;
- Score 5: permanent, sudden movements, shakes the scale.

Escape speed test

I've also performed escape speed test based on the recommendations of BURROW (1988). In this case I've measured the time needed for running a 1,7 m distance after the scale with a timer.

Right after taken out of the scale I collected 10-10 ml blood from *v. jugularis* in tubes containing heparin against clotting and in normal tubes as well, samples were cooled to 4°C immediately and transferred and I started their analysis in 2 hours.

Laboratory analyses

I've measured haematocrit values, blood glucose levels from the blood samples right after being taken, and the following parameters after dividing plasma and serum by centrifuge and

frozen to -20 °C: total protein, albumin, globulin, calcium, aspartate-aminotransferase (AST/GOT), carbamide, kreatinin, cholesterol, triglyceride, serum fructose amine.

I've performed the measurements at the Department of Animal Physiology and Health of Szent István University, Hungary with macro method on *Metertech UV/VIS SP 8001 Spectrophotometer*, using a narrowed plastic cuvette, with chromatographic kits (Diagnosticum). The spectrophotometer can be connected to a computer, so I've recorded the data by *UV Mate* laboratory computer programme, then copied the results to Microsoft Office Excel tables for statistical analysis.

I've ascertained the full protein content from blood serum with a colometric kit based on Biuret-reaction.
Albumin content was also defined by spectrophotometry from serum, using a colometric kit based on bromine-cresol-green reaction.

I've measured glucose content of the blood from venous blood - kept in heparin tubes against clotting - using *Fine Test POCT glucometer*. I've used Fine Test automatic blood sugar measuring equipment for determining glucose level in the blood samples. Kinetic UV test based on enzyme reaction (Diagnosticum) was used for determining AST activity.
I've determined the carbamide level of the blood by commercial kinetic enzymatic test.
Commercial colorimetric test, the so-called determining method according to Jaffé or alkalic picrate in an other name was used for determining creatinine levels.
I've applied enzymatic colorimetric test for measuring the triglyceride concentration of the serum.
I've measured cholesterol levels by an enzymatic, colorimetric test.
We've applied the micro method developed at the Department of Animal Physiology and Health, SZIU, Hungary (OPPEL et al., 2000b).
I've used SPSS 20.0 package for the statistical analysis of the data (test for normal distribution, F test and t probe). I've applied Kolmogorov-Smirnov test for checking the normality of the data, and as they've showed normal distribution used parametric tests further. I've checked the homogeneity of the data with F test before applying t probes. The α value was 0.05.

3.4. Analysing meat quality of lambs belonging of different genotypes

8-8 randomly chosen individuals among the Hungarian merino and German mutton merino lambs were slaughtered and qualified after the fattening period. I've measured the slaughtered weight, the weight of warm/cold the carcasses, the pH value and counted the slaughtering percentage. For calculating slaughtering percentage I've taken as the base the weight measured in the slaughterhouse, before slaughtering. Age at time of slaughtering was the same as for those lambs taking part if the fattening experiment (115 days). Slaughtering and qualifying was done in Hetes, Hungary at a slaughterhouse belonging to Kapos Ternero Kft.

After slaughtering short chops (in caudal distance from the 12-13th ribs) were taken out from the right carcasses fro further analyses. Laboratory analysis took part in the Department of Animal Feeding and Nutrition of Szent István University.
We've measured the following traits:

The pH value

The pH value was defined in the 45th minute after slaughtering, then after pre-cooling, before cutting in the 24th hour by an electronic pH measure with a piercing electrode l (pH-STAR, Firma Matthäus, Germany).

Colour

I've defined the colour of the meat samples by reflectance spectrometry method, with a Minolta Chromameter® CR 410 type colour measuring equipment in the L*, a*, b*colour system; in the fresh cut surfaces of the meat samples. The L* value refers to the lightness of the meat (0=black; 99=white), the a* value the reddishness of the meat (towards +60red, towards -60 green), the b* value refers to the yellowness of the meat (towards +60 yellow, towards -60 blue).

The measurement in these colour system are not enough, there's a need for qualifying colour form the consumers point of view as well. The ΔE*ab value helps in that, which can be counted by the formula bellow:

$$\Delta E^*_{ab} = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}.$$

Based on it the differences of the results are comparable and visually perceivable (**Table 1**).

Table 1: **Categories for defining differences in meat colour**

Value intervals	Perceivable difference by sight
ΔE*ab ≤ 0.5	Not visible
0,5 < ΔE*ab ≤ 1.5	Almost not visible
1,5 < ΔE*ab ≤ 3	Visible
3 < ΔE*ab ≤ 6	Well visible
6 < ΔE*ab	High

Source: Lukács, 1982

Melting and roasting loss

I've put the chop samples into hermetic plastic packing after measuring and deep-frozen them for a month. After the one-month passed melted them on room temperature, then unpacked and wiped the dry and measured all samples again. I've registered the weigh loss in case of every sample, then fried the chop slices in a contact grill oven (Cucina HD 2430, Philips, Germany) to 72 ºC core temperature, which I checked by a core thermometer (TESTO 926, TESTO AG., Germany) pricked into the middle if the meat slices. I've measured the fried samples again, so compared to the previous weights got the roasting loss values.

Analysis of friability

I've cut two square based column probe shapes with 8x8 mm side length by a sharp knife from the chops cooled to room temperature. I've removed the crust layer formed after grill frying then made five-five cuts on them. I've conducted the measures by TA. XT Plus texture analyser equipped with a Warner Bratzler blade (60° angle, 1 mm thick, pre-pushing 250

mm/min). I've counted the such defined sheer force value by a computer software Texture Exponent 32, based on the given force/time (kg/s) diagram.

Analysis of nutrient content

I've analysed the nutrient content (dry matter, protein and fat percentage) of the meat based on the NIR method by INSTALAB® 700 NIR analyser. The near infrared (NIR) spectrums are giving important information about the quality of the analysed material, so NIR spectroscopy methods are getting more and more widespread nowadays in analysing agricultural and food industrial materials rapidly, without using a diluting.

I've cut 100-100 g out of 8-8 samples (*m. longissimus dorsi*) and homogenised it with a shredder equipped with knife, then put them into the sample holder of the NIR analyser.

I've used SPSS 20.0 package for the statistical analysis of the data (test for normal distribution, F test and t probe). I've applied Kolmogorov-Smirnov test for checking the normality of the data, and as they've showed normal distribution used parametric tests further. I've checked the homogeneity of the data with F test before applying t probes. The α value was 0.05.

3.5. Analysing competitiveness of the Hungarian sheep sector based on the database of the Research Institute of Agricultural Economics

I've studied and analysed the farm and enterprise sizes, the cost-income ratios and the changes in the sales prizes of the Hungarian sheep sector based on the Test farm system database of the Research Institute of Agricultural Economics.

4. Results

Life production of ewes belonging to different genotypes based on lamb production

I evaluated the life production of ewes belonging to different genotypes based on lamb number.
I could conclude that due to accelerated breeding life production of German mutton merino dams was significantly higher than one of Hungarian merino dams, next to appropriate keeping and feeding.

There's no significant difference between in the time spent in production between Hungarian merino and German mutton merino ewes, notable culling was after the 6th lambing, which is in concordance with the literature data, that the optimal production of sheep is between the 5th and 6th lambing. This has an importance regarding rearing costs, and additionally, has an effect on the final cost of the end product.

Analysis of fattening traits and growth intensity of different sheep breeds (Hungarian merino, German mutton merino, German black-headed mutton)

During the 3.2 experiment I defined, that Hungarian merino lambs showed almost equal production than German mutton merino lambs when reared intensively (*ad libitum* feeding,

commercial full value lamb rearing mixed feed). Production of the German black-headed muttons exceeded those of the merino breeds.

Measured average daily weight gain in Hungarian merino lambs (338 g/day) exceeded the data published by SZÉKELY and DOMANOVSZKY (1999), according to which average daily weight gain of Hungarian merino ram lambs during fattening was between 284-319 g/day in 1996-1998.

Hungarian authors measured 336-378 g/day (ram), and 282-320 g/day (ewe) daily weight gain for German mutton merino (SZÉKELY and DOMANOVSZKY, 1999; SZÉKELY et al., 2004). In my study the average daily weight gain from the start of fattening till the 100th day of German mutton merino ram lambs was 362 g/day, so higher then the Hungarian average.

Average daily weight gain of German black-headed mutton lambs was extraordinary, 381 g/days, highly exceeding the data published by DOMANOVSZKY and SZÉKELY (2000), the 299,51 g/day daily weight gain. Lambs in my study even achieved better results than published for the breed in the database of the Hungarian Sheep and Goat Breeders, MJKSZ (2015).

Kept in appropriate farm conditions Hungarian merino lambs can be fattened to a higher weight than the low-weight suckling lambs mostly done nowadays, which can broaden the European market.

Analysis of the fattening production of German mutton merino ram lambs in correlation with their temperament and certain blood parameters

I determined that lambs with different temperament showed highly different production during fattening. Lambs with calm temperament had higher weight at the end of fattening (38.1 kg) and higher weight gain during fattening (466.7 g/day), than those with noervous temperament (332 kg, 345.4 g/day; P<0.05). So nervous ram lambs reach lower body weight tat the end of fattening, than calm ones. As known, individual traits of lambs are mostly visible after weaning if keeping system and feeding gives a chance to these differences.

These results are in concordance with previous studies (PAJOR et al., 2008), which analysed weight gain during fattening, and proved calm animals reaching higher weith at the end of fattening and higher average daily weight gain, than those belonging to the nervous group.

I also measured some blood parameters (serum fructose amine and carbamide level) of the two temperament groups as well.

According to my results, carbamide level was significantly, with 43,52% higher in the group with nervous temperament, than in the group with calm temperament. High carbamide level in the nervous temperament group suggest higher protein division in the body, which means that animals can build in a smaller proportion of proteins consumed.

Serum fructose amine level was also significantly, with 41,58% higher in nervous lambs, which again suggest the repeated, increased working of energy producing processes.

I suggest measuring blood serum fructose amine and carbamide levels for defining temperament in sheep next to the scale test, as that way calmer, better producing individuals can be defined easier.

Comparing the meat quality traits lambs belonging to different genotypes

I compared the slaughtering and meat quality traits of Hungarian merino and German mutton merino lambs.

There was no significant difference between the two breeds according slaughter weight, but in case of fattening terminal weight, slaughtering percentage and cold carcass weight German mutton merino lambs had better results.

Slaughtering percentage I've measured can be considered excellent in case of Hungarian merino (52.05 %), as other authors reported 48.64–49.9 %- (PAJOR et al., 2004, 2009), and 44-48 % (JÁVOR et al., 2006). Ratio of the carcass in sheep species can vary between 33-58% , but in healthy fattening lambs 40-58% (VERESS and JÁVOR, 1990; JÁVOR and MOLNÁR, 1997). The value of the slaughtered end product is defined by extractive percentage, the weight and quality of the slaughtered body (MUCSI, 1997).

I didn't find a significant difference in the drip loss – meaning the water loss due to gravitation - of the two breeds while analysing meat quality. Water extracting capacity doesn't important in case of mutton, as it's industrial processing is minimal. The measure for chewability (Warner value), was different in the two breeds analysed, Hungarian merino being more favourable.

Meat colour of Hungarian merino lambs was paler (L-average) 41.56 in the meat colour analysis.
According to JÁVOR (2014) meat colour, friability, water retention ability, taste and smell are important to the consumers. Consumer habits, the quality and taste they got used to have a major impact on the market value of the lambs. Their importance can be even higher, than of the one of objective quality.

Analysing competitiveness of the Hungarian sheep sector based on the database of the Research Institute of Agricultural Economics

Based on the test farm data of Research Institute of Agricultural Economics (AKI) my anaysis revealed that small farm size is present both in individual and common enterprises, which is against competitiveness. From the marketability's point of view breeding farms keeping 300-500 ewes are viable. Increasing sheep population is also justifiable for utilizing pastures. Increasing farm sizes in well founded, viable, modern, effectively working enterprises are needed instead of the unviable small ones. In case of acceptable mutton quality and quantity even broadening the market is possible.

5. New scientific results

1. There's no significant difference between in the time spent in production between Hungarian merino and German mutton merino ewes, notable culling was after the 6th lambing, which is in concordance with the literature data, that the optimal production of sheep is between the 5th and 6th lambing. I suggest reproduction and life production being taken in consideration more seriously during the selection of Hungarian merino and German mutton merino, and take into breeding the ram- and ewe lambs of the dams with the best life production, especially the lambs born after the 8th lambing in German mutton merino breed.

2. Slaughter production of Hungarian merino lambs can reach the level of mutton-wool breeds in case of appropriate keeping and breeding conditions. Slaughter percentage measured by me can be considered an excellent (52,05 %) in Hungarian merino breed.

3. Meat colour of Hungarian merino lambs – which is one of the main factor influencing consumers - is favourable. I've measured 41.56 (L average) for the meat colour of Hungarian merino lambs during my study.

4. There was a significant difference in chewability (friability) of the meat between the two breeds (Hungarian merino, German mutton merino) in the test (2.11 kg and 2.73; P<0.05), for the favour of the Hungarian merino breed.

5. The carbamide level was significantly, with 43,52% higher in the group with nervous temperament, than in the group with calm temperament. High carbamide level in nervous temperament group suggests higher protein division in the body, which means that animals can build in a smaller proportion of proteins consumed.

6. Serum fructose amine level was significantly, with 41,58% higher in nervous lambs, which again suggest the repeated, increased working of energy producing processes. I suggest measuring blood serum fructose amine and carbamide levels for defining temperament in sheep next to the scale test, as that way calmer, better producing individuals can be defined easier.

6. Discussion

6.1. Life production of ewes belonging to different genotypes based on lamb production
I suggest fertility and life production taken into consideration more seriously in selection of German mutton merinos and Hungarian merinos, and involve in breeding the progeny of the dams with the best life production, especially lambs born after the 8th lambing of their dams in German mutton merino breed.
It would worth to consider intensive keeping system for the best use of the dams. In this case production would be more expensive and demanding more equipment, so keeping the dams would need demand sources, but the number of marketable lambs would be higher.

6.2. Analysis of fattening traits and growth intensity of different sheep breeds (Hungarian merino, German mutton merino, German black-headed mutton)
Hungarian merino lambs showed almost equal production than German mutton merino lambs when reared intensively (*ad libitum* feeding, commercial full value lamb rearing mixed feed) according to my research. Production of the German black-headed muttons exceeded those of the merino breeds.
Kept in appropriate farm conditions Hungarian merino lambs can be fattened to a higher weight than the low-weight suckling lambs mostly done nowadays, which can broaden the European market.

6.3. Analysis of the fattening production of German mutton merino ram lambs in correlation with their temperament and certain blood parameters
Fattening production of lambs with different temperament showed significant difference during fattening. Calm lambs reached higher end weight (38.1 kg) and had higher weight gain during fattening (466.7 g/day), than nervous lambs (33.2 kg, 3454 g/day; P<0.05). So nervous ram lambs have a lower weight at the end of fattening than calm ones. As known, individual traits of lambs are mostly visible after weaning if keeping system and feeding gives a chance to these differences.

I suggest serum determining fructose amine and carbamide levels next to the scale test for measuring temperament, as with applying these calm individuals with better production traits can be chosen more accurately.

6.4. Comparing the slaughering and meat quality traits of Hungarian merino and German mutton merino lambs

There was no significant difference between the two breeds according slaughter weight, but in case of fattening terminal weight, slaughtering percentage and cold carcass weight German mutton merino lambs had better results.

Hungarian merino lambs showed more favourable meat quality traits, such as meat colour and friability.

I have to stress, that meat colour, friability, water retention ability, taste and smell are important to the consumers. Consumer habits, the quality and taste they got used to have a major impact on the market value of the lambs, their importance can be even higher, than of the one of objective quality.

6.5. The economical background of marketable mutton productions

I've analysed the economical background of marketable mutton production and enlightened many factors impairing competitiveness. These are the following:

- ✓ Small size farms are unviable, farmers having 200-500 ewes could form the base of sheep keeping,
- ✓ The purchase price of lambs is low, it doesn't even follow the inflation,
- ✓ State intervention for helping and organizing in the sector is minimal,
- ✓ Production costs are causelessly high, so have to be reconsidered.

Publications by the author in topics connected to the study (grouped as described by the PhD school)

Póti P., **Bokor B.**, Pajor F., Weidel W., Fazekas Z. (2011): Húshasznosítású merinó állományok értékelése különböző tartási és anyajuh használati körülmények között. AWETH Vol 7.4. 172-173.

Morlin Zs., Póti P., **Bokor B.**, Kerti A., Pajor F. (2013): Előzetes eredmények német húsmerinó hízóbárányok vérmérsékletének és egyes vérparamétereinek összefüggés-vizsgálatából. AWETH Vol. 9.3. 255-261.

Bokor B., Abayné Hamar E., Tóth G., Tőzsér J., Pajor F., Póti P. (2015): Különböző genotípusú juh fajták egyes hizlalási tulajdonságainak összehasonlítása. AWETH Vol 11.1. 42-47.

Beáta B., Zsófia M., E. Hamar Abayné, A. Kerti, Cs. Szabó, P. Póti, F. Pajor (2016): Effect of Temperament on Some Blood Biochemical Parameters and Growing Traits of Lambs During Fattening. Journal Of Animal Research 6:(3) pp. 367-370.

Bokor B., Abayné Hamar E., Morlin Zs., Póti P., Kerti A., Szabó Cs., Bárdos L., Pajor F.: A vérmérséklet hatása a német húsmerinó bárányok hízékonyságára és egyes vérparamétereire. Állattenyésztés és Takarmányozás 66:(2) pp. 133-140. (2017)