DEVELOPMENT OF SELECTION INDEXES FOR MILK PRODUCTION TRAITS IN DAIRY GOATS IN THE PHILIPPINES

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ABSTRACT

The ultimate goal of improving food security and elevating the livelihood of dairy goat raisers could be achieved by enhancing milk production through developing selection indexes. Selection indexes (SI) were developed with corresponding selection criteria based on formulated breeding objectives. Three SI were developed based on actual and possible traits in dairy goats raised under an intensive production system. Selection index I_{Php} includes milk production (MP) and lactation length (LL), II_{Php} includes MP, LL, age at first kidding (AFK), and kidding interval (KI), while SI III_{Php} includes both the actual and possible traits which were already recorded but not yet used in milk price determination which includes MP, LL, AFK, KI, percentage milk protein (%MPROT), percentage milk fat (%MFAT), and somatic cell score (SCS). Selection index III_{Php}=134.81(MP) + 6.54(LL) – 4.33 (AFK) – 4.14(KI) + 0.43(%MPROT) + 0.29(%MFAT) + 0.13(SCS) have the highest selection accuracy of 0.982, thus a higher probability to increase profit due to selection. However, in the absence of milk quality records, SI II_{Php}=184.98(MP) + 10.06(LL) – 5.58(AFK) – 4.30(KI) showed the highest MP and reproductive trait improvements.

Keywords: breeding objectives, lactation length, somatic cell score, protein, fat

INTRODUCTION

Over the past 20 years, the importation of exotic goat breeds is being done. This importation program of the government was primarily to augment the demand for goat products and improve the genetic constitution of the country's local goat population by gene infusion from exotic breeds of desirable traits to the indigenous population (Bondoc, 2008). However, despite this move, the program in improving the genetic potential of the local goat population seemed to be very slow and far below other goat-producing countries. Likewise, one of the major constraints being identified as why the dairy goat industry has not reached its full potential is due to limited quality breeders and replacement (Bondoc, 2005; Bondoc, 2002) which could be attributed to a lack of organized selection methods and strategies, mating systems, and cost-efficient breeding programs (Bondoc, 2005; Bondoc, 2002; PSA,

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2016) due to the absence of identified breeding goals and objectives as a basis for selection indexes development (Abbasi and Savar, 2015).

Thus, the ultimate goal of developing selection indexes with the highest selection accuracy is indeed vital to improve the overall performance of the dairy goat population and to elevate the profit margin of dairy goat raisers and enthusiasts. In addition, the development of selection indexes is a statistical tool that offers solutions to problems at affordable costs (Kargar *et al.,* 2017). These selection strategies are feasible and valuable by shortening the generation interval and exploiting the selected animals' response to selection (Lopes *et al.,* 2012). Moreover, selection indexes (SI) are the fastest and most efficient manner to improve the aggregate breeding value which involves the selection of multiple traits to produce a single value and predict the animals' genetic merit in the selection process (Lambe *et al.,* 2008; Cunningham and Tauebert, 2009; Lopes *et al.,* 2013).

Nowadays, most selection indexes are mainly focused on progressing milk production. For instance, SI developed in Brazil was formulated to increase milk yield and eventually the shifting towards protein yield improvement (Lobo *et al.,* 2010; Facó *et al.,* 2011) while indexes developed from North America are towards improving milk quality such as milk fat and protein yield and content (Montaldo *et al.,* 2010). Furthermore, developed SI which encompasses various economically important milk traits in dairy goats is towards promoting the simultaneous improvement of various economically vital traits (Lambe *et al.,* 2008; Nielsen *et al.,* 2005). Likewise, reports showed that the application of SI in different animal farms was a highly precise method of the breeder and possible replacement stock selection with regard to several traits. This is indeed possible since the relationship between all traits, comprising breeding value and economic weight, is taken into account (Lambe *et al.,* 2008; Lopes *et al.,* 2013).

The Philippines is gearing towards dairy goat production, and goat milk processing is a sun-rising industry, thus, developing SI for different milk traits (Lopes *et al.,* 2013) such as milk protein, milk fat, and somatic cell score, aside from milk production, that nowadays uses as the basis for milk pricing, could help dairy goat raisers to enhance goat productivity and farm profitability. Moreover, reproductive traits have been reported to have significant correlations to different milk quality and production traits (Lobo and Silva, 2005; Ziadi *et al.,* 2021) and thus, could contribute significantly to goat production revenues. Hence, this study was conducted.

The research aims to develop SI in raising Saanen and Anglo-Nubian goats under an intensive production system. Specifically, the study aims to develop selection indexes based on developed breeding objectives associated with the selection criteria including milk production (MP), lactation length (LL), age at first kidding (AFK), kidding interval (KI), percentage milk protein and fat, and somatic cell score in Saanen and Anglo-Nubian goats raised under intensive production system, and to determine the selection accuracies of the developed SI based on the identified breeding objectives.

MATERIALS AND METHODS

Source of Data

In eight (n=8) commercial (25-doe level and above) dairy goat farms using an intensive type of production system in the provinces of Kalinga, Nueva Ecija, Pangasinan, Tarlac, Bulacan, Batangas, Cavite and Laguna, a total of 5,280 records of Saanen

(2,016 records) and Anglo-Nubian (3,264 records) were collected due to availability and completeness of records. These records came from 53 sires and 1,509 dams on the farms. These are from the actual records kept on the farm and were used in the estimation of genetic parameters. Moreover, all information provided through formal interview and actual visitation by the seventeen (n=17) commercial dairy goat farm owners and/or farm managers from the abovementioned provinces were encoded, tabulated, analyzed, and summarized for the construction of breeding goals/objectives. Estimated genetic parameters and developed breeding objectives with corresponding selection criteria were the basis for the development of selection indexes limited for Saanen and Anglo-Nubian goats as dairy breeds raised under an intensive production system.

Development of Selection Indexes

The approach described by Becker (1967) was used to formulate the SI, which took into account variances estimated for each trait that was taken into consideration, as well as genetic and phenotypic variances (δ^2_A and δ^2_P for every trait considered in the selection index), genetic-phenotypic covariances (δ^2_A and δ^2_P between each pair of traits), and relative economic values (a) for each characteristic.

Collected records were limited and for SI to be more reliable, there must be at least 5000 individual records. Thus, pooled breeds (Saanen and Anglo-Nubian goats) were used for SI development to formulate more reliable and accurate indexes (Hazel, 1943).

In addition, Hazel (1943) defined the aggregate genotype, H, for a given individual as the total of its genotypes for a number of traits (presuming a different genotype for each economic attribute), with each genotype being weighted by their expected contribution to the growth of the overall aim. So-called cumulative discounted expressions and economic values are used to calculate this contribution. The frequency and timing of the future manifestation of a superior genotype resulting from the employment of a chosen individual in a breeding program are reflected in the cumulative discounted expression of a trait (Werf, 2022).

Equation 1 illustrates the principle of H or the aggregate genotypic value of the index in considering milk traits such as milk production per day (L/day), lactation length, up to the last trait which is the somatic cell score.

$$H = a_{MP}G_{MP} + a_{LL}G_{LL} + \cdots + a_{SCS}G_{SCS} \qquad [Equation\ 1]$$

where $\mathbf{a_{MP}}$ – the relative economic values of milk production per day; $\mathbf{G_{MP}}$ – the genotypic values of milk production per day; $\mathbf{a_{LL}}$ – the relative economic values of lactation length; $\mathbf{G_{LL}}$ – the genotypic values of lactation length; $\mathbf{a_{SCS}}$ – the relative economic values of somatic cell score, and; $\mathbf{G_{SCS}}$ – the genotypic values of somatic cell score

In addition, the normal simultaneous equation, Equation 2, was used to obtain the b_1's which were the partial regression coefficients needed to construct the selection index, I:

$$H = b_{MP}X_{MP} + \cdots + b_{SCS}X_{SCS} \qquad [Equation\ 2]$$

where $\mathbf{b_{MP}}$= the coefficient of milk production per day; $\mathbf{X_{MP}}$ = the phenotypic values of milk production per day; $\mathbf{b_{SCS}}$= the coefficient of somatic cell score; $\mathbf{X_{SCS}}$ = the phenotypic values of somatic cell score

To obtain a set of values for the index coefficient of the trait which maximizes the correlation between I and H, the desired solution to the index coefficient of the trait was obtained from a set of simultaneous linear equations and conveniently represented by matrix notation given in Equation 3:

$$\underset{\sim}{P}\underset{\sim}{b} = \underset{\sim}{G}\underset{\sim}{a} \qquad [\textit{Equation 3}]$$

where: $\underset{\sim}{\mathbf{P}}$ = the phenotypic variance-covariance matrix; $\underset{\sim}{\mathbf{G}}$ = the genotypic variance-covariance matrix; $\underset{\sim}{\mathbf{a}}$ = the vector of relative economic values; $\underset{\sim}{\mathbf{b}}$ = the vector of partial regression coefficients of the X's in the index.

Setting $\underset{\sim}{H} = \underset{\sim}{G}\underset{\sim}{a}$ and inverting the P matrix lead to the solution of the b's, thus: $\underset{\sim}{b} = \underset{\sim}{P}^{-1}\underset{\sim}{H}$.

The variance of the aggregate genotypic value δ^2_H and the variance of the index δ^2_I were given by Equations 4 and 5 (Konanta, 1967):

$$\delta^2_H = \underset{\sim}{a}'\,\underset{\sim}{G}\,\underset{\sim}{a} \qquad \& \qquad \delta^2_I = \underset{\sim}{b}'\,\underset{\sim}{P}\,\underset{\sim}{b} \qquad [\textit{Equations 4 \& 5}]$$

where: $\underset{\sim}{\mathbf{a}}'$ = the transpose of the column matrix a; $\underset{\sim}{\mathbf{b}}'$ = the transpose of the column matrix b; $\underset{\sim}{\mathbf{P}}$ = the phenotypic variance-covariance matrix; $\underset{\sim}{\mathbf{G}}$ = the genotypic variance-covariance matrix; $\underset{\sim}{\mathbf{a}}$ = the vector of relative economic values; $\underset{\sim}{\mathbf{b}}$ = the vector of partial regression coefficients of the X's in the index.

The selection index accuracy is vital information in the development of various selection indexes. These could indicate possible correlation (low, moderate, high) between the selection indexes and the breeding goal (Lopes *et al.*, 2012; Lopes *et al.*, 2013) and serve as proof that the developed selection indexes are reliable. The accuracy of the selection index, rTI (Werf, 2022; Konanta, 1967) was $r_{HI} = {\delta^2}_I / \sqrt{\delta^2_A}$. The single trait index, on the other hand, was calculated by multiplying the trait's phenotypic standard deviation by the trait's direct additive heritability. The square root of the direct additive heritability of the trait was used to calculate the accuracy of the index. Microsoft® EXCEL was used to perform all calculations to facilitate matrix operations.

Three selection indexes were formulated based on the available actual farm data gathered. The selection of the index formula was based on selection index accuracy for all milk production traits included in the selection indexes. To compare the best indexes, Index 1 (Equation 6) was considered as a base selection index. Selection index coefficient was computed considering Equation 7.

$$I = b'X \qquad [\textit{Equation 6}]$$

where **X**: phenotypic record and **b** is the selection index coefficient (or weight) for traits (Lopes et *al.*, 2012; Lopes *et al.*, 2013).

$$b = G'Q \qquad [\textit{Equation 7}]$$

where **G**: genetic covariance matrix for traits in the selection index, and; **Q**: desired gain for the traits included in the index (Lwelamira and Kifaro, 2010; Lopes *et al.*, 2012; Lopes *et al.*, 2013; Werf, 2022).

Data Analysis

Using the REML Method and the Mixed Procedure in SAS System (9.1.3), estimates of genetic parameters were derived for dairy goat characteristics indicated in developed breeding objectives with associated selection criteria, regardless of breed (Holland *et al.*, 2003; Holland, 2006). Identified breeding objectives and selection criteria were determined using descriptive analysis and the Wilcoxon Rank-sum Test. Data on developing index coefficients were computed using the multiple regression procedure (PROC REG) and correlation (PROC CORR) using statistical analytical software (SAS version 9.1.3). Afterwards, the selection indexes, accuracies, and response to selection were calculated through Microsoft® EXCEL.

RESULTS AND DISCUSSION

Breeding Objectives Development

The actual and potential traits recorded and used as the basis for milk price determination in 17 chosen commercial dairy goat farms are included in the breeding objectives and their corresponding selection criteria (Table 1). Actual traits include those that are currently noted and compensated for by consumers for milk production, whereas possible traits were the criteria not currently used but potentially useful for selecting dairy goats and could result in a higher price for a range of dairy products.

Table 1. Identified breeding objectives and corresponding selection criteria for dairy goats (*Capra hircus* Linn.) raised under intensive production system in Luzon, Philippines (n=17).

Breeding Objectives	Selection Criteria
Actual traits	
Breed purity/Source	ADGA/FGASPAPI Membership, Animal breeder certificate
Milk Production	Milk production and Lactation period
Precocity	Age at first kidding and Kidding interval
Possible traits	
Milk quality	Protein, Fat, and SCS

Legend***:*** *ADGA – American Dairy Goat Association; FGASPAPI – Federation of Goat and Sheep Producers Association of the Philippines Incorporated.*

The actual traits used in goat breeding include breed purity, milk production, and reproductive traits such as AFK and KI. In selecting dairy goats for overall performance, membership of the goat farm to the American Dairy Goat Association (ADGA) and the availability of breeder certificates were used as selection criteria by the dairy goat farms that indeed influence the price of the breeder animals. Likewise, to select dairy goats for increased quantity of milk produced, MP and LL were used as selection criteria. Moreover, AFK and KI were used as the basis for selecting early-maturing goats (precocity). This could be achieved since MP and LL as well as AFK and KI are all positively correlated (Lobo and Silva, 2005; Zumbach *et al.,* 2008; Menéndez-Buxadera *et al.,* 2010; Mucha *et* *al.,* 2014; Wolber *et al.,* 2021; Ziadi *et al.,* 2021).

Possible traits that were analyzed and recorded that could probably contribute to dairy goat production revenues include milk quality. Though some of the commercial dairy goat farms indeed proved that they increase their profit owing to the consideration of milk fat, milk protein as well as SCS in milk pricing, limited available marketing record is provided to prove their claim. Thus, milk quality is vital to include in the breeding objectives formulation for dairy goats that could increase their profit. To select dairy goats in relation to milk quality, the milk protein content and yield, milk fat content and yield, and SCS were incorporated as selection criteria. Therefore, selecting animals for protein yield and content (Bagnicka *et al.,* 2015; Bagnicka *et al.,* 2016; Scholtens *et al.,* 2018; Valencia-Posadas *et al.,* 2021), fat yield and content (Bagnicka *et al.,* 2015; Bagnicka *et al.,* 2016; Scholtens *et al.,* 2018; Valencia-Posadas *et al.,* 2021), and somatic cell score (Serrano *et al.,* 2003; Legarra and Ugarte, 2005; Apodaca-Sarabia *et al.,* 2009; Rupp *et al.,* 2011; Jiménez-Granado *et al.,* 2014; Bagnicka *et al.,* 2016; Amin, 2018) were possible.

Variability of Selection Criteria for Developing Breeding Objectives

The heritability and phenotypic variability of the identified breeding objectives and selection criteria which include AFK, KI, MP, milk protein and fat yield, percentage milk protein and fat, and SCS in dairy goats, regardless of breed are presented in Table 2 and were used to determine the economic values for each trait. Results showed that identified selection traits have a wide range of heritability values which could be attributed to factor combinations which may include the genetic constitution, favorable husbandry and managerial practices, and balanced nutritional environment. Thus, the variance in milk yield and composition in dairy goats is significantly influenced by genetic makeup (Bagnicka *et al.,* 2015; Scholtens *et al.,* 2018; Valencia-Posadas *et al.,* 2021). Its incorporation in selection indices is therefore essential for the genetic advancement of dairy goats to identify the most suited one to generate the greatest number of expected selection responses.

Table 2. Data structure of identified selection criteria for developed breeding objectives in dairy goats (*Capra hircus* Linn.) raised under intensive production system in Luzon, Philippines.

Traits	h^2	Mean	SD	Range
Milk production (L/day)	0.21	1.87	0.25	1.36 – 3.00
Lactation length (days)	0.08	249.14	7.19	230.00 – 280.00
Age at first kidding (months)	0.26	16.77	0.35	15.00 – 17.50
Kidding interval (days)	0.07	296.54	9.53	260.00 – 320.00
Percentage milk protein (%)	0.51	3.51	0.31	3.00 – 4.30
Percentage milk fat (%)	0.49	3.89	0.25	3.20 – 5.00
Somatic cell score (cells/mL)*	0.28	4.23	0.74	2.60 – 7.30

**analyzed as food (milk) sample and health condition of the animals were not accounted.*

Economic Value

At present, the majority of commercial dairy goat raisers mostly select MP and LL. These were proven through formal interviews and provided records. Moreover, results

(Table 3) revealed that MP and LL exhibited high economic values of Php 45.48 for 1L milk/doe and Php 20.27/day, respectively. Surprisingly, SCS, AFK, KI, percentage milk protein, and fat have economic values that are considerably significant to further increase dairy farm profit. Thus, the inclusion of reproductive traits and milk quality traits as selection criteria are taken into consideration to further increase dairy goat production profitability.

Table 3. Economic values (Php – Philippine peso) for actual and possible breeding objectives in raising dairy goats (*Capra hircus* Linn.) under intensive production system in Luzon, Philippines.

Traits	**Economic value**
Milk production (L/doe)[a]	45.48
Lactation length (days)[a]	20.27
Age at first kidding (days)[a]	9.41
Kidding interval (days)[a]	5.48
Percentage milk protein(%)[b]	1.82
Percentage milk fat(%)[b]	2.15
Somatic cell score(cells/mL)*[b]	17.53

Legend: [a]*Actual breeding objective (recorded and used as basis for milk price);* [b]Possible breeding objective (recorded but not used yet as basis for milk price); *analyzed as food (milk) sample and health condition of the animals were not accounted.

Profitability

The detailed source of variation for production expenses and revenues was provided by the 17 commercial dairy goat raisers during the formal interview and farm visitation and are presented in Tables 4 and 5.

Production expenses were calculated on a per head per year basis particularly the feed, forage, labor, veterinary drugs and biologics, and fixed costs. However, costs of the acquisition of possible replacement breeder buck and breeder doe, preferably between 8 to 12 months, were calculated on a per-head basis, regardless of weight.

Sources of production revenues included the actual and only tangible (direct cash income) products of the farm. Available products are 8-12 months old bucks and does, with or without breeder certificate, growing bucks and does, culled bucks and does, planting materials such as forage seedlings, grass cutting (i.e. napier cuttings), and goat manure. In addition, the collection of acacia pods as feeds and fermenting of a large volume of silage in silos both made from the corn stover (greens) and corn husk (*sapal*) as a source of revenue are also common in the commercial farms interviewed and visited due to the challenges of forage availability specifically during dry months (January to April). Moreover, milk products which include fresh milk, choco milk, ice cream, *pastillas de leche*, and goat white cheese are the common milk products sold by the dairy goat farms, which were based on the existing farm prices as of November 30, 2021.

Likewise, profit-cost analysis was computed, summarized, and presented in Table 6. Findings revealed that profitability based on return on investment (ROI) was 132.11%.

Results implied that for every Php 1.00 of operating cost (excluding initial capital investment), raising Saanen and Anglo-Nubian goats for milk production under an intensive production system attained an average profit of Php 1.32.

Table 4. Sources of variation for production expenses in intensive dairy goat production.

Source of production expenses	Unit	Mean Value
Buckling (8-12 months) with breeder certificate	Php/head	24,117.65
Doeling (8-12 months) with breeder certificate	Php/head	38,705.88
Buckling (8-12 months) without breeder certificate	Php/head	21,117.65
Doeling (8-12 months) without breeder certificate	Php/head	27,705.88
Feed cost	Php/head/year	1,609.94
Forage cost	Php/head/year	1,073.29
Labor cost	Php/head/year	1,863.53
Veterinary drugs and biologics	Php/head/year	38.64
Fixed cost (housing, electric, water bill)	Php/head/year	12,705.88

Table 5. Sources of variation for production revenues in intensive dairy goat production.

Source of production revenues	Unit	Mean Value
Buckling (8-12 months) with breeder certificate	Php/head	24,117.65
Doeling (8-12 months) with breeder certificate	Php/head	38,705.88
Buckling (8-12 months) without breeder certificate	Php/head	21,117.65
Doeling (8-12 months) without breeder certificate	Php/head	27,705.88
Growing buck (6 months)	Php/head	15,529.41
Growing doe (6 months)	Php/head	24,323.53
Culled buck/doe	Php/kg	222.94
Forage seedlings	Php/seedling	5.50
Grass cutting	Php/sack	265.00
Goat manure	Php/sack	50.00
Acacia pods	Php/sack	25.00
Silage (corn stalk/corn husk)	Php/kg	5.23
Fresh milk	Php/L	147.65
Choco milk	Php/L	156.25
Ice cream	Php/250g	182.50
Pastillas de leche	Php/250g	100.00
Goat white cheese	Php/100g	152.73

Table 6. The profitability of dairy goat farming raised under intensive production system.

Economic Indicators	Value
Total Revenues (Php)	69,739.39
Total Cost (Php)	30,046.02
Net Profit (Php)	39,693.36
AOC/L of milk (Php/L milk)	64.16
Average profit/L of milk (Php/L milk)	84.76
ROI (%)	132.11

Legend: Values were computed based on the provided information by the commercial dairy goat farms.

Selection Index Development

The selection indexes were created for pooled Saanen and Anglo-Nubian goats in Luzon, Philippines under an intensive production system. This is due to the limited number of records collected from commercial dairy goat farms. Moreover, the development of selection indexes for pooled breed groups rather than for each breed group provides results that are more reliable and accurate (Hazel *et al.,* 1994; Hazel, 1943).

A total of three selection indexes (I–III) were created based on the actual and possible traits included as selection criteria for the developed breeding objectives. Selection index I_{Php} includes MP and LL; selection index II_{Php} includes MP, LL, AFK, and KI, which were categorized as actual traits; while selection index III_{Php} includes both the actual and possible traits which include MP, LL, AFK, KI, percentage milk protein (%MPROT), percentage milk fat (%MFAT), and SCS.

Table 7. Selection indexes and their accuracies (rTI) in raising Saanen and Anglo-Nubian goats (*Capra hircus* Linn.) under intensive production system.

Selection Indexes	Formula	rTI
I_{Php}	282.68 (MP) + 8.05 (LL)	0.762
II_{Php}	184.98 (MP) + 10.06 (LL) – 5.58 (AFK) – 4.30 (KI)	0.828
III_{Php}	134.81 (MP) + 6.54 (LL) – 4.33 (AFK) – 4.14 (KI) + 0.43 (%MPROT) + 0.29 (%MFAT) + 0.13 (SCS)	0.982

Legend: Selection indexes I_{Php} and II_{Php} were based on the actual traits included in the breeding program of the commercial dairy goat farms, and selection index III_{Php} is based on the actual and the possible inclusion of milk quality traits in the selection index.

The selection index weights for dairy goats in Luzon, Philippines raised under an intensive production system showed moderate accuracies (Table 7) when MP, LL, AFK, and KI were included in the traits (<0.90). On the contrary, studies revealed that high accuracy

(>0.90) is obtained when milk quality traits were added to the selection index weights. Moreover, the obtained selection index accuracies (rTI) in selection indexes I_{Php}, and II_{Php} which include the MP, LL, AFK, and KI were lower than the rTI reported by Lopes *et al.* (2012) which is >0.90. However, selection index III_{Php} which includes the MP, LL, AFK, KI, and milk quality traits (%MPROT, %MFAT, and SCS) showed 0.982 accuracy which is higher than the rTI (0.95) reported by Lopes *et al.* (2012) when milk quality traits like total solids (TS) and somatic cell count (SCC) were included in the SI formulation.

Moreover, findings showed that when the number of characters included in the selection index increases, the significance of milk production declines (Table 7). Moreover, although other attributes had positive weights, the AFK and KI had negative weights. These findings demonstrate that recording milk quality traits is equally imperative as in recording milk production and reproductive traits, which in the long run could be used in selection procedures and improve the overall dairy goat farm productivity.

CONCLUSION

The selection and use of SI is based on the farm's definition and established breeding goals as well as the measurability of the selection criteria to be applied in a specific dairy goat production system. Nowadays, most selection indexes are mainly focused on increasing milk production. Thus, selection index II_{PhP} = 184.98 (MP) + 10.06 (LL) – 5.58 (AFK) – 4.30 (KI) is suggested when farm objectives are based on the improvement of both reproductive traits and milk production in dairy Saanen and Anglo-Nubian goats. However, when producing milk of better quality, selection index III_{PhP} = 134.81 (MP) + 6.54 (LL) – 4.33 (AFK) – 4.14 (KI) + 0.43 (%MPROT) + 0.29 (%MFAT) + 0.13 (SCS) must be highlighted to increase farm profit.

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