Biological influences on the quality properties of wool

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Although only 3,9% of the total world wool production is produced here, South Africa is well known for the high quality of its wool and its classing. In this article quality differences of a biological nature are identified (breeding, feeding and management) and the relationship between certain physical and chemical fleece and fibre properties and their monetary value are examined.
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Hoewel slegs 3,9% van die totale wolproduksie van die wêreld hier gelewer word, is Suid-Afrika bekend vir die hoogstaande wolgehalte en die klassering daarvan. In dié artikel word kwaliteitsverskille van biologiese aard geïdentifiseer (teling, voeding en bestuur) en die verband tussen sekere fisiese en chemiese vag- en veseleienskappe en hulle monetêre waarde ondersoek.
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Introduction

The importance of the wool industry is clearly reflected in the fact that farmers who farm with woolled sheep own 80% of the land which is used for agricultural purposes in South Africa. In the extensive parts of the country, particularly, where the alternatives are extremely limited, farming with woolled sheep can still be profitable. Wool is one of only a handful of agricultural products which can be exported profitably by South Africa. It is a regular and strong net earner of foreign exchange.

Although South Africa is the fourth largest wool producer in the western world and fifth in the world ranking, we nevertheless produce only 3,9% of the total world wool production. South Africa is much better known for its high quality of wool and its classing, than for the quantity it produces. Indeed, wool production could be extended by 50% with great advantage to the country. It could even be doubled without leading to world over-production and downward pressure on prices. The total market for fibres is still growing. Throughout the world there is strong consumer preference for natural fibres. Owing to natural limitations, total world wool production cannot keep pace with demand, and provided that wool maintains its competitive position, there is no danger of over-production.

It is thus essential that wool with outstanding textile properties be produced to meet the requirements of the manufacturer. The aim of this article is to identify quality differences of a biological nature, i.e. due to breeding, feeding and management, and to measure certain physical and chemical fleece and fibre properties in monetary terms.

By quality of wool is meant, specifically, physical properties such as tensile strength, length, fibre diameter or fineness, quality, condition or clean yield, and its appearance (colour, staple formation and tip).

Causes of differences in quality

Various factors can lead to differences in quality, the most important being genetic, nutritional and environmental factors.

Genetic

Notwithstanding the fact that Fraser (1934) stated clearly that the maximum quantity and optimum quality of wool produced by the sheep was determined by its genetic composition, the full development of these properties are dependent on the nutritional status and environment.

Heydenrych (1975) found in the Tygerhoek flock that raw wool production had a heredity of 0,398 ± 0,081, while the heredity for clean wool production was 0,309 ± 0,081. He drew the conclusion that the Tygerhoek Merino flock should react satisfactorily to mass selection for raw and clean wool production.

Fibre properties such as fibre diameter (fineness), length and the crimps per unit of length, which together give substance or bulkiness, are, genetically, reasonably strongly hereditary with a high incidence of repetition (Bosman, 1958; Young, Turner & Dolling, 1960; Beattie, 1961).

According to Hugo (1950), the number of follicles is determined genetically, and nutrition has no influence on it. Better nutrition only activates the follicles to produce thicker and longer fibres.

Nutrition

Nutrition has a big influence on most of the quality properties of wool. Poor nutrition weakens the fibres, which might be damaged further by weathering. Ample evidence of increased raw wool production through better nutrition is provided by various researchers (Venter, Cloete & Edwards, 1969; Venter, Steenkamp & Edwards, 1973). However, nutrition also influences related wool properties separately, as a consequence of which the quality of the wool is strongly susceptible to changes in nutrition.

The influence of specific nutrients on the morphology and physical and chemical properties, as well as the structural composition of wool, was also investigated. Uys (1966) quotes a series of studies into the importance of trace elements. Imbalances or shortages of certain elements impair fibre formation through which the quality of the wool is seriously reduced. Copper, one of the best known mineral shortfalls in certain regions, not only impairs the crimp but also leads to faulty or incomplete keratinization of the fibre, by retarding the speed with which the cross-bonds are formed in the fibre crimp in the keratinization zone. Because of this impairment, the development process is incomplete by the time the fibre appears above the skin.

Another mineral which influences the crimp and appearance of wool is cobalt (Moule & Young, 1950; quoted by Uys, 1966). An excess of molybdenum causes the same symptoms as a shortage of copper (Dick, 1953; quoted by Uys, 1966). According to Uys (1966), Rider established that an excess of fluorine leads to shorter and thinner fibres with fewer crimps per unit length, and poorer colour.

Environment, climate and external factors

It has been proven irrefutably that nutrition influences the growth of wool, but there is still considerable lack of clarity on the interaction of non-nutritional factors. According to Snyman (1960), climate and environment are amongst the most important factors in the degree of weathering. Damage to wool is often found in the form of different colourings, as described by Botha (1945), e.g. bacterial infection such as green and red rot, canary stain and gilding, as well as external colourings caused by urine, plant material, soil types, etc.

Economic implications of differences in quality

Apart from clean fleece mass, wool price tendencies over the past three seasons have demonstrated that the most important economic properties of wool are fibre diameter (or fineness), staple length and tensile strength. Quality and appearance have a less important influence on wool prices.

Clean wool mass

Genetic and nutritional factors largely determine the quantity of clean wool produced per sheep. They also make, by far, the greatest economic contribution. On average, a kilogram of South African Merino clean wool is worth R7,70 in the current season (R4,61 per kg of greasy wool).

The wool buyer bases his price per kilogram on the true quantity of wool keratin, and takes impurities into full account. The nature of the contamination determines subsequent processing costs in respect of the required scouring and combing processes (Marais, 1971). Dolling (1970) argues that an increase in any of the most important components of clean wool mass, such as staple length, fibre diameter and the number of fibres per unit of surface area, will increase the clean wool mass. Estimates of the heredity of clean wool mass range between 0,309 (Heydenrych, 1975) in South Africa and 0,30 to 0,50 (Turner, 1977) in Australia.

Fibre diameter (fineness)

To the wool processer and manufacturer, average fibre diameter is the most important fibre property. Von Bergen (1963) puts the relative importance in manufacturing as follows:

Average fibre diameter	80%
Length	15 – 20%

Other properties, including crimping, are important only if they diverge abnormally. Because of the unreliability of crimping as an indication of fibre diameter, wool is now sold on the basis of its fibre diameter (fineness) measurement. According to Nel (1975) problems are being experienced in Australia in achieving significant increases in clean wool production because breeders are trying to prevent a drop in crimp counts. This problem is well known in South Africa.

Assertions that the South African clip is becoming stronger are not supported by statistical evidence. Objective measurement was introduced in South African in 1974/75. In Table 1 the weighted fibre diameter is stated in microns for Merino wool as well as fleece wool derived from other woolled breeds.

These data demonstrate that the South African clip has in no way become stronger since 1974/75. This holds good for Merino wool and wool derived from other woolled breeds.

Fibre diameter plays a surprisingly big role in wool prices. In Table 2 the price of 12-month wool of the good top-making type is given for three seasons since 1982/83. Based on the assumption that 5,5 kg of greasy wool measuring 21,1 to 22,0 μm can be produced per sheep under extensive conditions such as in the Karroo, and 7,7 kg of greasy wool under semi-intensive conditions as in the Southern Cape, the mass of greasy wool of various fibre diameters (finenesses) which will yield the same gross monetary return, is calculated.

Table 1 Average fibre diameter of SA clip in microns (μm)

Season	Average fibre diameter of Merino wool	Average fibre diameter of other woolled breeds	Average weighted fibre diameter for Merino and other wool
1974/75	22,13	24,07	22,20
1975/76	22,35	23,78	22,43
1976/77	21,92	22,91	22,01
1977/78	22,27	23,04	22,35
1978/79	21,89	22,21	21,93
1979/80	21,97	22,33	22,02
1980/81	21,90	22,24	21,95
1981/82	22,28	22,46	22,30
1982/83	22,10	22,46	22,15
1983/84	21,84	22,66	21,93

Table 2 Relationship between fibre diameter, clean wool price, greasy wool price and the estimated production to yield the same return under extensive and semi-intensive conditions

Fineness	Fibre diameter (μm)	Clean wool price (c/kg)	Greasy wool price (c/kg)	Estimated production to yield the same amount of money (kg of greasy wool)	
				Extensive	Semi-intensive
Superfine 74's	17,6 – 18	1427,6	923,4	2,7	3,8
Superfine 70's	18,1 – 19	1182,1	777,6	3,2	4,5
Fine 66's	19,1 – 20	874,0	567,8	4,4	6,1
Medium 64's	20,1 – 21	749,2	489,9	5,1	7,1
Medium 62's	21,1 – 22	685,5	451,9	5,5	7,7
Strong 60's	22,1 – 23	633,5	418,2	5,9	8,3
Strong 58/60's	23,1 – 24	591,7	394,0	6,3	8,8
Overstrong 56/58's	25,1 – 26	535,2	358,0	6,9	9,7

Overstrong-woolled sheep (56/58's) thus had to produce 1,4 kg more greasy wool, and strong-woolled sheep 0,8 kg more, under extensive conditions to yield the same amount of money as medium woolled sheep (64's). Under semi-intensive conditions superfine-woolled sheep (74') with 3,9 kg less wool, will yield the same wool income as medium-woolled sheep (62's), while strong-woolled sheep (58/60's) will have to produce 1,1 kg more wool.

It looks as if little, if any, progress has been made over the past 20 years in respect of greasy wool production per sheep. There are, however, many individual flocks which have demonstrated what can be achieved through breeding and good nutritional and management practices.

South Africa is known for the 20, 21, 22 and 23 μm wools of good quality it produces. Efforts to increase wool production must aim at doing so without simultaneously increasing the fibre diameter. The same clean wool mass with a finer fibre measurement will earn a greater return.

Length

Staple length is important to the textile industry, and according to Von Bergen (1963), a longer staple length results in less combing waste and a higher yield of combing wool. Excessive staple length, however, causes an increase in combing waste, and Turpie (1973) argues that a greater incidence of fibre breakage is also found in longer wool.

Fibre growth increases up to 18 months, after which it declines every year because of the age of the sheep, the wearing of its teeth and the consequent retarded metabolism.

The average price differences in respect of length for fine, medium and strong wool in the good topmaking types for three seasons since 1982/83 are presented in Table 3. The researchers' findings are clearly reflected in the price differences, e.g. the lower price for excessive length (warp). Wool longer than 50 mm is processed by means of the worsted system, and wool shorter than 50 mm by the woollen system. The price difference at the dividing point is 35,6c/kg of greasy wool.

Table 3 Price differences in c/kg of greasy wool over three seasons

Trade length (months)	Staple length (mm)	Greasy wool price (c/kg)	Price difference between length grades (c/kg)
Warp	90 +	470,6	–
12	75 – 90	471,3	(– 0,7)
10/12	60 – 75	458,5	12,8
9/11	50 – 60	445,7	12,8
8/10	45 – 55	410,1	35,6
7/9	35 – 45	372,0	38,1
6/8	30 – 40	352,9	19,1
6	25 – 30	331,3	21,6
4/6	15 – 25	310,9	20,4

From a breeding point of view, selection for a higher fleece mass will automatically lead to an increase in length.

Tensile strength

The manufacturer of apparel material requires a sound wool fibre with a tensile strength over its entire length and as little weathering as possible. There is a noteworthy positive correlation between fibre diameter and breaking strength ($r = 0,95$) and a negative correlation between fibre diameter and tensile strength ($r = -0,48$).

Tender wool can be prevented by maintaining a good level of nutrition. Work by Jacobs (1972) indicates that loss of bodymass of 16 – 23% represents the critical point for tender wool production. Better fleece density (Le Roux, 1958) and thicker staple formation (Veldsman, 1965) can limit weathering. Ropy wool or thin staple are in general less resistant to climatic factors and dust penetration due to their lack of bulkiness and substance (Venter, 1964). Better fleece density and particularly more fluid wool yolk and a reasonable amount of suint with a high pH in the tip areas increase the wool's resistance to weathering (Truter & Woodford, 1955).

The degree of weathering in the tip of the wool from the various parts of the Karroo is generally high, according to Venter, leading to possible loss in length of 25% to 30%.

Quality

The scorecard for Merino sheep defines quality as softness of handle, the definition and evenness of crimp and the presence or absence of deviating fibres. Venter (1976) found that the staple length and straight length of good quality wool was significantly longer ($P < 0,01$) than that of poor quality wool. However, he also found (1971) the tip of good quality wool to be significantly more weathered than those of poor quality wool. Wilke (1974) also found that good quality wool weathered more than poor quality wool.

Von Bergen (1963) found that average fibre diameter and length were the most important processing properties, and that other properties, including crimp, were only of importance if they deviated abnormally.

Appearance

According to the Merino scorecard, the appearance of wool comprises its colour, the thickness of its staple, and the weathering at its tip. Kruger (1964) points out that wool which is lacking in substance or bulkiness is characterized by a high level of weathering and poor or ropy staple formation.

Taking into account its seed and plant material content, quality and appearance, the wool is graded into spinners or good, average or inferior topmaking type. The price differences for 21,1 to 22 μm long wool, i.e. 9/11, 10/12 and 12-month wool (into which the great bulk of the clip falls) are given in Table 4.

Although there is a price difference on a greasy wool basis, on a clean wool basis it is very small.

Table 4 Price differences in c/kg for 21,1 – 22 μm long wool

Type	Greasy wool price	Clean wool price	Clean wool price difference
Spinners	454,8	660,5	–
Good topmaking	438,5	669,7	(–9,2)
Average topmaking	409,0	654,2	15,5
Inferior topmaking	358,5	620,0	34,2

Conclusion

Clean wool mass is an extremely important factor in determining the price of wool. Two of the most important components, namely average fibre diameter and length (in addition to which the buyer also takes note of tenderness) are, to manufacturers, important processing properties which are clearly reflected in the different prices paid by the wool buyer. Judging by price tendencies, it seems as if Von Bergen (1963) was correct in stating that other properties, including quality or crimp, are important only if they deviate abnormally.

The South African clip is known overseas for its good quality and classing. This great asset, built up over many years, must be maintained. Any possible contamination which emerges, such as by kemp and/or coloured fibre, must be rectified immediately.

Production per sheep leaves much to be desired, and shows no progress over the past 20 or more years. Clean fleece mass can be increased through purposeful breeding, selection and feeding practices. However, this must be done without increasing fibre diameter, otherwise it will not be profitable. Length and fibre diameter together with bulkiness and substance must be the most important considerations. The other properties, like quality and appearance, are satisfactory at present. They do not hold much in the way of economic considerations, and the *status quo* need only be maintained while attention is concentrated on the production properties.

The great bulk of the Merino clip falls into the 21, 22 and 23 μm range. South Africa is known amongst manufacturers for this. It is not necessary, nor is it economically justifiable to produce wool of 25 – 27 μm commercially. However, particularly in areas with a 'gentler' climate, serious consideration should be given prior to producing 24 μm and stronger wool.

Researchers have done valuable work over many years. Future research work should be concentrated on these factors that will promote efficient and economic wool production.

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