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Edited by Qiu Yiping

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PREFACE

Since the first Sino-Africa International Symposium on Textile and Apparel in 2015， the One Belt-One Road Program has gained new momentum in promoting the social-economic development of the developing countries along the ancient silk roads. Progress has been made in our collaboration with these countries in terms of research and student exchange as well as education collaboration. In this symposium， we intend to present more recent results of research in the field. A total of more than 60 research papers have been accepted for the proceeding and the quality of the papers has also been improved. These papers cover a wide spectrum of topics such as textile engineering， nano technology， textile materials， apparel design and technology， textile management and marketing and textile history. The authors of the papers come from more than 15 countries and quite a few of them are fromAfrica. This indicates that the symposium SAISTA 2016 has attracted much more attention both in Africa and around the world than the previous one. The symposium is attended by educators and professionals from Kenya， Sudan， Zimbabwe， Tanzania， Uganda， and South Africa as well as China. About 20 presentations are given in the symposium. I believe that this symposium represents the latest progress of the great success in the collaboration and exchange in textiles and apparel education and research between China and Africa.

Yu Jianyong

Professor YU Jianyong

Academician of Chinese Academy of Engineering

Contents

The Prediction and Analysis of Fabric-evoked Prickle Properties of Different Textile Woven Fabrics using Artificial Neural Networks (ANNs) Method

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Abstract: This paper aims to discuss the design and development of an artificial neural networks (ANNs) model to understand human perception of the tactile prickliness properties of textile wear fabric materials and create an objective system to express those prickle perceptions in terms of measurable mechanical properties. The objective and also subjective hand measurement of the textile materials used for wear fabric has been check up on with consideration given the aspects of both dermatitis and comfort. In this work, we tried to predict the prickliness (itchiness) of wear fabric by their physical properties using a back-propagation network and a stepwise regression. Handle properties of fabrics were measured by universal test equipment (KES-F) and total prickle score (TPS) values of the wear fabrics were determined by a group of panelists consisting of some textile experts. The optimum construction of neural network was investigated through the change of layer and neuron number. The results showed that the back-propagation network could predict the (TPS) values of wear fabric with a meaningful difference. These wear fabrics were used to show that the results of neural network were in good agreement with subjective test results.

Key words: wear fabrics; prickliness; ANNs; tactile comfort; human sensory; KES-F

1 Introduction

Fabric-evoked prickle is defined as the discomfort feeling when worn garment next to human skin. It is the combination of physical, biological and psychological processes[1-3]. According to this definition, the nociceptors are the sensory receptors which are responsible for sensing the prickle pain when a garment is worn[4-8]. Many studies have been conducted to analyze the relationship between various fabric parameters and tactile prickle comfort properties by using statistical methods[9-11]. However, the statistical methods used have some limitations. One of the most common problems faced in statistical modeling is the non-linear relationship of different fabric parameters with tactile prickle comfort properties. Furthermore, most of the fabric parameters which directly influence the prickliness properties such as thickness, fabric weight, bending, etc., are related to each other and are derived from basic fabric specifications such as fiber length and diameter, yarn linear density, etc. Hence, it is difficult to study the effect of one parameter without changing the other. Therefore a system is required which can predict the tactile prickle comfort parameters of the fabric by considering the collective influence of all the fabric parameters at the same time. This is where artificial neural network can be effectively put to use. Therefore, in this paper an artificial neural network is used to predict the tactile prickle discomfort sensation behavior of different wear fabric, when the fabric weaving and construction handle parameters are given as inputs. The ANNs system consisted of one network with one output. The networks were trained with a training data set and then tested with a set of untrained values of fabric parameters. The total prickle score (TPS) values obtained from the network were compared with actual values obtained from the subjective evaluation score result of total prickle score (TPS) values.

2 Experimental

2.1 Materials

Fifty six samples of several fabrics such as cotton, cashmere, linen, hemp, ramie, jute, wool, wool/cotton, cotton/ polyester and wool/polyester, woolen fabrics were used for thepresent study. The samples were collected from different sources, including markets and factories. It involved a wide range of end users, and thus they differed a lot in fiber content, density, thickness, weight and fabric weave type.

2.2 Characteristic Parameters

The characteristic parameters of input layers are the major factors for determining the recognition rate. We worked on the proposed method with KES-F instruments, which measure the handle properties of the wear fabrics[12]. The KES-F system consists of subsystems which have the function of measuring different handle properties such as surface property, compression property, bending property, thickness and weight properties. For this study we choose five parameters from KES-F parameter namely, bending, competition, surface, thickness and weight.

2.3 Wear Fabric Mechanical Properties

Fabric mechanical properties namely; surface (friction), compression, bending, thickness and weight were measured by test methods which were discovered by Kawabata S and Niwa M[12]. Mechanical properties were measured under the conditions of high sensitivity. All measurements were performed at $(65 \pm 2)\%$ relative humidity and (20 ± 1)℃. For each sample, 5 measurements were performed. In order to evaluate total hand value of the samples, paired comparison methods were carried out.

2.4 Wear Fabric Subjective Evaluation

Subjective evaluation of prickliness felling score was performed via forearm experiment to test the samples covered in a box which could not be seen by the evaluators. A total of 31 students who had textile education (age: 19～38), participated in the evaluation. The human perception score of prickliness was measured by the 1-7 prickle rating scale. This scale was developed by TMT research group in Donghua University, the range of prickliness values varied between 1 and 7, where 7 corresponds the least prickle value, and 1 to the most prickle value. The range of mechanical properties as measured using the KES-F module and total prickle score (TPS) values is given in Table 1.

Table 1 Range of the mechanical properties as measured using KES-F module and TPS measured by subjective evaluation test

Property	Minimum value	Maximum value
B	0.031	0.500
2HB	0.026	0.704
MIU	0.124	0.248
MMD	0.010	0.059
SMD	5.890	14.29
LC	0.130	0.350
WC	0.121	1.200
RC	50.00	85.70
T	0.557	1.870
W	13.60	55.80
TPS	1.645	6.871

2.5 Architecture Artificial Neural Networks (ANNs)

A typical artificial neural networks (ANNs) structure and a neuron within a neural network of the 56 wear fabric samples, 41 samples(≈75%) were chosen as the training set, while the rest 15 samples(≈25%) were chosen for the testing set at random as shown in Fig. 1. A nonlinear hyperbolic transfer function $[f(x) = e^x - e^{-x}/e^x + e^{-x}]$ served in the hidden layers, and a linear transfer function $f(x) = x$ was used in the input and the output layers to avoid limiting the output value to a small range. The details of the architecture and the set parameters for training and testing phases are as shown in Table 2.

Table 2 Details of the neural network architecture

Parameter	Value
Learning algorithm	Feed forward back propagation
Number of input neurons	10
Number of hidden layers	1
Number of hidden neurons	10
Number of output neurons	1
Number of Epochs	2000
Mean square of error (termination criteria)	0.01
Activation function	Hyperbolic tangent
Total data set	56(11 fabrics×5 samples)
Training data set	41 (<75 percent of 55)
Training data set	15 (<25 percent of 55)

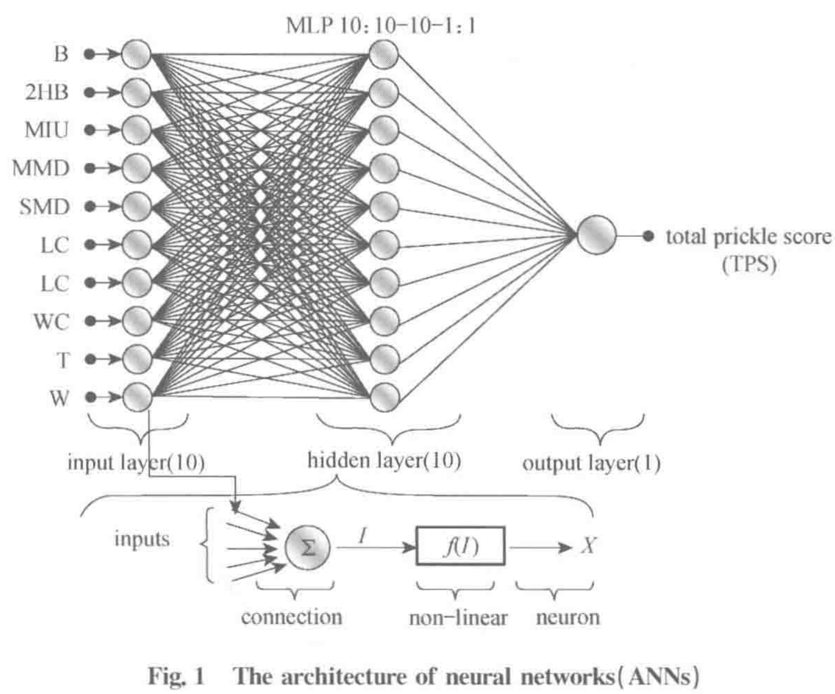

Fig. 1 The architecture of neural networks(ANNs)

3 Results and Discussion

3.1 Predictions of Total Prickle Score(TPS) Values

The whole data was split into two parts, namely, training set and testing set. The proportions of these data sets are 75% and 25%, respectively. Following the training phase, the neural network is tested for its performance using the test data. The data of input layer was entered into the established BP neural network using MATLAB program for simulation trainingvalue. The comparison between output value and subjective evaluation value were shown in Fig. 2. The data in

Fig. 2 illustrates that relative errors between output value from neural network and subjective evaluation value is below 5.0%. Therefore, the BP neural network method is considerably accurate for evaluating prickle instead of subjective appraisal. Therefore, from the results, we had seen that no significant difference between actual and predicted values of total prickle score TPS, refer to good training performance process of ANNs designed with low error as shown in Fig. 2.

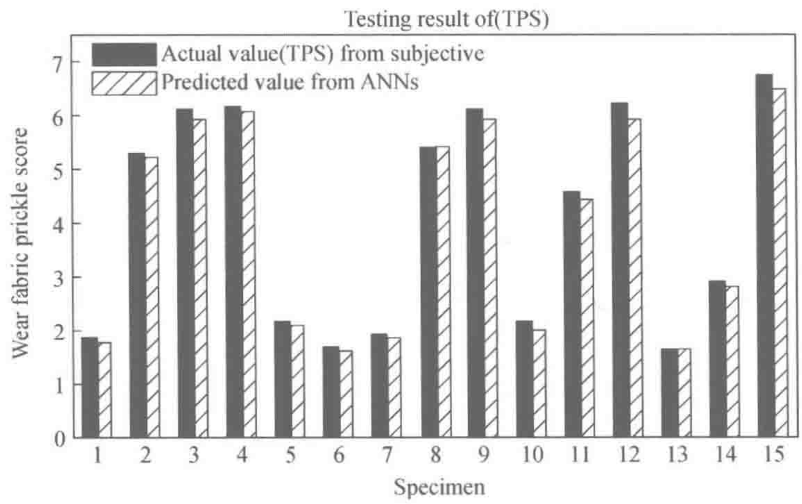

Fig. 2 Compression between prediction and actual data of total prickle score(TPS) using ANNs engine

3.2 Neural Network Analysis

To examine the significance levels of each variable taking place in the network, sensitivity analysis were performed[13]. Sensitivity expresses the relative contribution of each variable to the overall prediction of the network. Therefore this analysis gives an idea about the significance levels of each variable in the network. The sensitivity is calculated as the ratio of the error with missing value substitution to the original error. If this ratio is high, the deterioration will be high which means that the network is more sensitive to that particular variable. After all sensitivities of all variables have been calculated, the variables can be ranked by their importance. The ranks indicate the order of variables by the magnitude of the quotient. The variable ranked first is the most important. The results of the sensitivity analysis carried out for seven input quantities based on the neural network are summarized in Table 3.

Table 3 Sensitivity analysis of the neural networks

Input quantity	B	2HB	MIU	MMD	SMD	T	W
Quotient	2.38	2.11	5.36	2.71	5.11	4.54	3.42
Rank	6	7	1	5	2	3	4

From the obtained results it has been found that all of the input quantities significantly influence the values of the input quantities of the three-layered perception. The most important parameter affecting on the total prickle score values of the wear fabric as a result of the neural networks is coefficient of fabric surface friction (MIU). The second one is geometrical roughness (SMD) of the wear fabric in that order from Table 3. Based on our study, we can recommend that wear fabric physical properties can be used to predict total prickle score value with the application of the ANNs predictive model that can closely simulate human sensory perception and judgment processes.

4 Conclusions

It has been indicated that the technique of neural networks showed better agreement with the forearm subjective evaluation test method when evaluating the total prickle score (TPS) value. Our neural networks method revealed a good coincidence with the results of subjective test assessment. Another advantage of our automatic total prickle score (TPS) evaluator is that it is simple in application, and is applicable to different textile markets or areas of survey and for a wide range of textile materials. Therefore, it can be stated that the neural network approach suffices an effective tool for simulating the overall hand feeling of textile materials especially prickliness feeling score. Using the dimension reduction algorithms, the numbers of attributes that contribute effectively to the output are chosen. The seven attributes fall under four groups of human tactile sensations such as bending rigidity of the material, compressibility and friction, and the subset evaluation scheme was able to identify these influencing parameters. Thus, the ANNs approach provides a successful platform for cognitive perception analysis of tactile prickling feeling.

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Study on Kenya Wool Resource and its Application

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Abstract: Kenya is one of the African countries with enormous livestock populations composed of sheep, cattle, goats, and etcetera. Agro-industry and the trade of semi-processed and fully processed agro-derived products such as wool are a major foreign exchange earner for many African countries. The means to this natural wealth is for countries to develop full economic benefits whereas renewing quality, conserving, as well as increasing their livestock resource cores. In future, market trends may favor a swing back to wool products, a shift towards smarter, more tailored products at work. Energy crisis, sustainability, new environmental regulations, social awareness and green chemistry are guiding the development of the next generation of materials, products, and processes. Most farmers in Kenya rear sheep for production of meat, and wool as a by-product. Agriculture, commerce and Industrialization are the key pillars of wealth creation in any country and therefore this paper explores wool fibers in Kenya as an economic natural raw material resource viable for both local and foreign exchange income as well as to provide the fundamental data for their possible conventional and non-conventional textile applications. In this study, the findings showed that utilization of natural wool is necessary in fostering economic and industrial development. Kenya is not a member of the International Wool Textile Organization, which would require, among other things, the ability to certify wool and fibers to internationally-accepted standards and therefore this research focuses in providing standard information on sorting, testing and application of Kenyan wool for stakeholders to make sheep farming more viable and profitable to farmers and stakeholders for wool trade. With the current availability of technologies to produce functional textiles based on advanced engineering strategies, new directions for utilization and studies of natural fibers can be considered.

Key words: Kenya; wool resource; IWTO; fiber properties and testing; research and application of fibers

1 Introduction

Agro-industry, of which Livestock production is one of it, is an important part of the economy. It contributes a significant quota of the national income in several Sub-Saharan African countries such as Kenya. Africa is a large and topographically varied land mass, which has endowed the continent with a wide range of natural resources with a great potential beneficiation. Yet in the midst of this great wealth Africa is a paradox of poverty. Agriculture is very important in Kenya as 75% of the Kenyan population is dependent on it for food and income, and it contributes 26% to the Gross Domestic Product (GDP) and 60% to foreign exchange earnings[1-2].

The research institutions such as universities play a part in national and international development. Whether directly through research, innovation, production of knowledge, or through private benefits, cumulatively, they contribute to economic growth[3]. Therefore, research and development on natural resources, so as to understand the extent of their uses and benefits, is vital for both local and global economic growth as well as providing solutions for the current global economic and environmental challenges.

The research and good policies in the developing countries such as some Latin American and African countries may benefit from the expansion of China's imports of foods, agro-derived goods and agricultural raw materials[4].

The smallholder and pastoral/extensive production systems of small ruminants in the tropics, taking Kenya as an example, provides tangible and intangible benefits to the farmers. Most of them put first the keeping of sheep either for regular cash income or as an insurance against emergencies. This knowledge of the reasons for keeping small ruminants is a prerequisite for deriving operational breeding goals[5].

The benefits of wool research and analysis, provides confidence to Wool Growers that the buyers' assessments are accurate, reduces the need for a risk margin, gives equity in pricing provides information for farm management decisions, increases competition from buyers and captures the real value which can be lost if characteristics are underestimated. It also help the wool Processors to allow the specification of the raw materials in precise, enables processing performance to be predicted, enables machinery settings and processing performance to be maximized and reduces the potential for disputes and claims. The sound data provides shearing and wool handling advices to wool Traders. It also enables clear market signals to be established and ensures maximum value for wool grower customers. It helps the Wool Exporters for it will facilitate confidence in bidding[6]. In addition, it may lead to development of the next generation of materials, products, and processes. Globally, consumers are increasingly demanding the eco-friendly goods. Green manufacturing is considered to be the fastest growing. For instance, the green apparel consumer market is estimated at 15%~24% of developed markets' consumers, with an annual market size of US$2.7 billion in the United States alone. This represents a significant opportunity for Kenya to market towards green buyers. Importantly, other countries in the region have not taken advantage of the green opportunity, and Kenya is well-poised to act now in order to gain the first-mover benefit[7]. With increasing concerns regarding the effect of the synthetic textile materials are having on the environment, more and more textile researchers, producers, and manufacturers are looking to biodegradable and sustainable fibers as an effective way of reducing that impact. New environmental regulations and social awareness have triggered the search for new products and processes that are compatible with the environment. Studies of natural fibers promise a number of potentially useful lessons for textile physics, chemistry and processing scientists.

A worldwide platform for business contacts in sectors and all kinds of organizations related to wool products and the wool business in general, is offered by The International Wool Textile Organization (IWTO) which has been the recognized global authority for standards in the wool textile industry since 1930. IWTO represents the interests of the wool textile trade at the global level. By facilitating industry strategy and ensuring standards in manufacturing and sustainability, IWTO fosters connection between members and all stakeholders through mutual support of opportunities for wool[8]. Kenya is not a member of the International Wool Textile Organization, which would require, among other things, the ability to certify wool and fibers to internationally-accepted standards and therefore there is a need in providing standard information for wool stakeholders to make sheep farming more viable and profitable to farmers and commercial standards for wool trade.

1.1 Wool Resource in Kenya

1.1.1 Pasture and carbon isotope

Kenya has climatic and ecological extremes with altitude varying from sea level to over 5 000 m in the highlands. The mean annual rainfall ranges from 250 mm in semi-arid and arid areas to 2 000 mm in high potential areas[9]. Kenya possesses well over 500 species of grass. One hundred and two of these are C_3 carbon isotope and 428 are C_4 carbon isotope. The difference in photosynthetic systems represents a general difference in plant growth form and distribution. In Kenya, open grasslands at low altitudes or at low indices of available soil moisture consist of C_4 species which is adaptive in arid areas. In contrast, open grasslands at high altitudes consist of C_3 species[10]. Many C_4 plants possess higher temperature optima (30~45 ℃) for net CO_2 exchange than C_3 plants (10~25 ℃). The carbon isotope of sheep wool can be interpreted in terms of the carbon isotope ratio of herbage on the grazing grounds of a flock; Wool integrates the carbon isotope signal of consumed biomass[11].

1.1.2 The wool sheep rearing regions

Sheep are being reared for production of mutton for the food industry and wool for the wool industry. There's a huge market for the mutton consumption due to life style changes around eating habits. Rearing of sheep is not capital intensive and they are not highly susceptible to many diseases that attack livestock. Again the sheep are not heavy feeders as cows are[12]. The country, by the year 2000, had sheep totaling 7 855 911 heads. The population for wool sheep was about 13% of the total population standing at 1 010 771 heads of sheep. This is a 30% growth from the year 1999, indicating that there was a positive growth in the wool industry. Rift Valley province led with 713 791 heads of wool sheep while Central Province had 247 379[13]. In the census of 2009, total number of sheep was 17 129 606. This was a significant increase[14]. Kenya had a tradition of wool production in Nakuru, Uasin Gishu, Keiyo, Marakwet, West Pokot and Nandi in Rift Valley region. Other potential areas include highlands such as Nyandarua in the Aberdare Mountain Ranges, and Mount Kenya regions in central and eastern provinces. Wool production in these regions declined some years ago and herders dropped out of the market in reaction to marketing problems and unattractive prices[15].

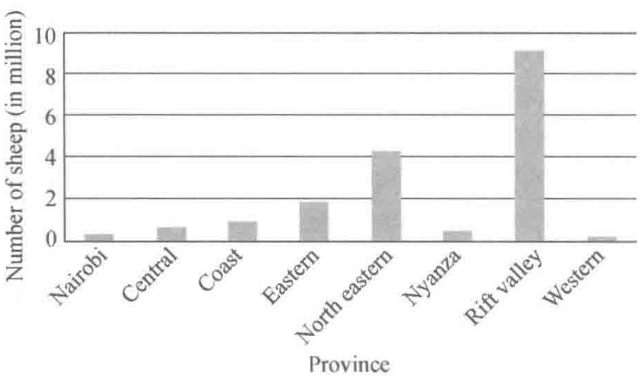

Fig. 1 The number of sheep in all provinces as per the livestock population: Kenya population census 2009

In the past, the sheep industry has received relatively little attention in terms of research and development when compared to large stock. This has resulted in the huge potential of sheep to the industry not having been fully exploited. The current government priority development policy strategy is geared towards poverty reduction. Among the strategy for small holder farmers in the high potential areas will be the dual purpose sheep production[16].

Table 1 Livestock population: Kenya population census 2009[14]

Province	Exotic cattle	Indigenous cattle	Sheep	Goats	Camels	Donkeys
Kenya	3 355 407	14 112 367	17 129 606	27 740 153	2 971 111	1 832 519
Nairobi	25 536	29 010	34 717	46 837	20	12 824
Central	800 227	325 678	664 237	531 209	231	35 516
Coast	74 119	74 119	885 846	467 439	1 570 728	51 045
Eastern	373 307	1 886 854	1 890 898	4 729 057	248 634	304 249
North eastern	80 422	2 694 786	4 264 155	7 886 586	1 700 893	382 345
Nyanza	221 670	1 527 000	495 055	961 269	59	60 793
Rift valley	1 560 222	5 919 585	9 079 380	11 750 521	968 192	988 647
Western	219 904	843 608	233 725	263 946	2 037	16 229

1.1.3 Sheep breeds and wool production

The colonial settler community introduced wool sheep in Kenya as from 1920's and in subsequent years, continued to import better breeds mainly from New Zealand, Britain, Australia and South Africa for fiber production. In 1950's, Kenya farmers association established a wool center so as to sort, grade, pack and market the wool. The large-scale farms in high prospective areas did wool production years before 1970s but most of these farms were sub-divided into small-scale farms due to human population pressure. Today small-scale farmers in the high potential areas keeping small flocks of wool sheep and do bulk of the wool production[13].

The ministry of agriculture, department of livestock, has classified Sheep breeds in Kenya into two main categories. First, is the Exotic sheep which comprises of Merino, Corriedale, Hampshire, Suffolk, Dorset Horn, and Improved hair sheep. The second category comprises of Indigenous sheep which includes; Thin tailed, Fat tailed e. g. Maasai sheep (Red Masai), and Fat rumped e. g. Blackhead Persian, Somali sheep[18]. The major wool breeds in Kenya include Merino, Corriedale, and Romney Marsh. Other breeds include Hampshire Down and cross breeds between two or more of these breeds. There is a lot of inbreeding in the wool flocks due to shortage of breeding stock. This is attributed to lack of serious wool sheep breeders in the country. The world mean yield of wool per animal per year is 4.5 kg. The mean yield for Kenyan sheep is only 2.18 kg per year. There is big potential to increase both the wool yield per animal and the overall population of the animals. The wool is processed locally or exported to world markets[19].

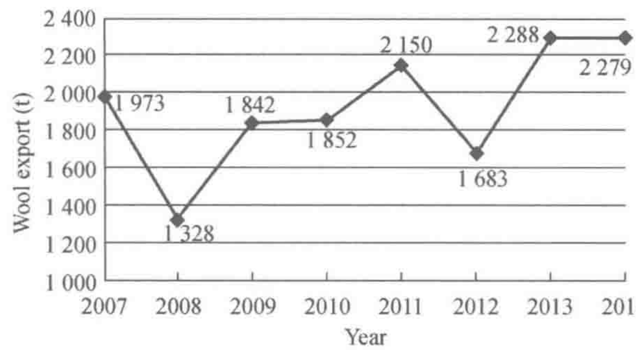

Fig. 2 Trends in Kenya raw wool export in 2007—2014

Table 2 Domestic exports in 2007—2014 (Quantity)[20]

Year	2007	2008	2009	2010	2011	2012	2013	2014
Raw wool(t)	1 973	1 328	1 842	1 852	2 150	1 683	2 288	2 279

2 Experimental

2.1 Samples

Sources of variation in the characteristics of the raw wool in each batch are: between breeds, between flocks, between fleeces within flocks, between positions within fleeces, between staples within positions, between fibers within staples and along the fibers[21]. The wool fiber samples used were sourced from Kenyan farms in Nakuru County, Rift Valley Province, which is one of the major regions that have been having tradition of wool production. The samples were shorn from dual purpose crossbreed then sorted and labeled according to the sheep body parts where wool were shorn from and are presented as bellow:

RBS—wool shorn from flanks, shoulders, lower neck, and hips;

BCK—wool shorn from the back area;

NLS—wool shorn from upper neck and head, belly and legs;

SKN—greasy wool shorn from pelt (sheepskin) of a mature sheep.

3 Results and Discussion

3.1 Scouring of the Wool Fibers

Thorough skirting was done to the greasy wool and then the fibers were conditioned for 24 h at (20 ± 2)℃, (65 ± 3)% RH. Latter, samples weighing 120 g were prepared. Using Liquor Ratio 1∶50, the liters of water required was determined and then heated to 60 ℃. 1~3 g/L of nonionic detergent were measured and mixed with the water in the scouring bath, to form an aqueous solution. The greasy wool fibers were immersed into the scouring solution and Soaked for 20 min. Another trough with wash water was prepared and water heated to 60 ℃. After soaking for 20 min, the greasy wool fibers were removed from scouring bath and then pushed gently into the wash water. Left to stand in the wash water for 10 min then wash water was drained out. A second scouring bath with the same liters of water, same temperature and quantity of detergent as in the first bath was prepared. The fibers were then immersed to the second scouring bath and soaked for 20 min. Wool fibers were immersed into the rinse water of temperature 60 ℃ and then left for 10 minutes and then drain the rinse water. The rinse water was checked if is it very dirty and if so, another rinse was run repeating the rinsing step. The wool fibers were then dried in an oven at 60 ℃. The dried scoured wool samples were then conditioned at (20 ± 2)℃, (65 ± 3)% RH for over 24 h and then Weighed to obtain their final weight.

The results showed that NLS had the highest percentage of waste, 40.4%, because they constituted of wool shorn from belly, legs, upper neck and head. The average waste percentage was 33%.

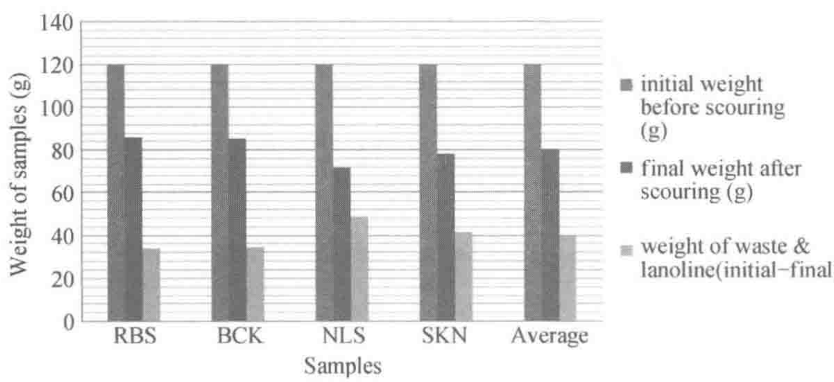

Fig. 3 Weight of scoured wool and percentages of waste and lanolin

3.2 The Moisture Regain for Scoured Samples

The oven testing method was used as specified by IWTO-33[22,30-31]. The scoured wool samples were first conditioned at (20 ± 2)℃, (65 ± 3)% RH for over 24 hours and then the samples were weighed and split into sub-samples. These sub-samples were accurately weighed to the nearest 0.005 g and dried in a suitable oven at 103 ℃. The subsamples were reweighed after further drying at intervals at no less than five minutes until their weight was constant and the following formula was used to obtain the Moisture Regain = [(Original Weight − Oven Dry Weight)/Oven Dry Weight]×100%[30-31]. The results showed that the moisture regain was between 13.636% and 14.705%.

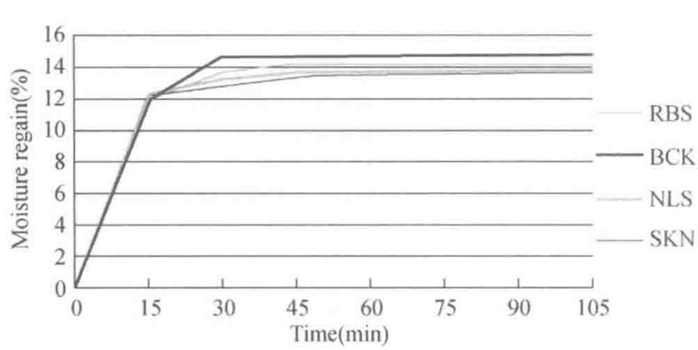

Fig. 4 Moisture regain of the scoured wool

3.3 Carbonizing the Fibers

Subsamples of raw wool, Scoured with non-ionic detergent, were weighed 40 g each. The LR = 1∶25 was used for the amount of water, (40 × 25 = 1 000 mL) required the carbonizing solution was prepared for each subsample by adding 5%～7% (w/v) sulphuric acid and 1～2 g/L of nonionic detergent into each 1 000 mL of water. The wool samples were then Soaked for 2 to 3 hours at 20～30 ℃ and then rinsed and drained. Samples