

Breeding and processing of wool specially hair fibres: evaluation of animal fibers for use in textile products

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ABSTRACT

Textile products are composed of a range of materials and fibers. The natural protein fibers that are currently used in textile production such as wool, mohair, and silk can be very costly to the manufacturer and consumer. A non-traditional protein animal fiber, such as dog hair, can prove to be a cheaper, environmentally friendly, and very suitable substitute for the traditional protein fibers used today in textile processing. The use of this abundant protein fiber is very possibly a promising new avenue for the textile industry. Results show it would be reasonable to consider dog fiber as a possibility for conversion into staple yarns. With strength, percent strain, and modulus, as a basis, dog fibers would perform equally as well as traditionally used animal fibers, and possibly better in certain instances.

Keywords: Wool, Fiber, Animal Fiber, Mohair, Yarns, Garment

Fibre has been of great importance to man and rank second only to food in their usefulness. Animal fibres are largely those which cover mammals such as sheep, goats and rabbits, but also include cocoon of the silk-worm as well as feather from poultry. Globally natural Fibres contribute about 48% to the fibre basket with 38% from cotton, 8% from bast and allied fibres and 2% from wool and silk fibres. India is a vast country with 44 distinct sheep breeds spread over a wide range environmental conditions. The Indian sheep breeds produce wool differing in fineness from 25 to 60 μ . As per economic survey, Government of India, the country produced about 45 m kg of raw wool (2007). Out of the total production of raw wool about 10 % was apparel grade, 70 % carpet grade and 20 % coarse grade. Specialty hair fibres obtained from Angora rabbit, Pashmina and Yak are popular for its superb whiteness, high warmth and softer feel.

Wool is consumed mainly in suiting and knitted garments for men's wears while for women's wear, shawl, coating and dress material are major products. In addition, one of the important end use of non-apparel wool is in hand knotted, tufted and woven carpets. Woollen industry in India is small in size as compared to cotton and synthetic fibre based industry, wool and woollen activities in rural areas are having important position. The woollen industry including carpet sector contributes about Rs. 5000 crore in export earnings. Moreover the industry provides employment and source of sustenance to about one million people mostly

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belonging to low income group. In addition the expansion of the industry particularly the Khadi, handloom and carpet segments will create more job opportunities in future.

SCENARIO OF WOOL AND SPECIALTY HAIR IN INDIA

Wool Production

India is a vast country with 44 distinct sheep breeds spread over a wide range environmental conditions. The Indian sheep breeds produce wool differing in fineness from 25 to 60 μ . These wools are mainly utilized for the manufacture of hand-knotted, tufted and handloom woven carpets. As per economic survey, Government of India, the country produced about 45 m kg of raw wool (2007). Out of the total production of raw wool about 10 % was apparel grade, 70 % carpet grade and 20 % coarse grade. The annual growth of wool production is marginal and wool production has remained static for last 10 years. Wool yield per sheep in India is about 800-1000 g/year. The country can be divided into 4 agro climate regions with reference to wool production. The sheep population is more or less equally spread in North Western parts of the country covering the states of Rajasthan, Gujarat, Punjab and Haryana and Southern Peninsular region consisting of State of Andhra Pradesh, Maharashtra, Tamilnadu and Karnataka. However, wool production is more in North western region than Southern Peninsular region. The wool produced in North-Western region finer than Southern Peninsular region.

The production of wool in the country is not satisfactory mainly because of dominance of medium fine wool, carpet wool and coarse wool/hairy sheep breeds. Moreover, for most part of the year the animals are subjected to under feeding mainly due to over stocking far exceeding the carrying capacity of the land and unfavourable agro-climatic conditions. In order to avoid prevailing harsh agro-climatic conditions and loss of production, the sheep farmers resort to short and long distance even inter-state migration with their stock and return back to their native tract in the favourable season. With the onset of summer, the sheep farmers of western India migrate to neighbouring states namely, Uttar Pradesh, Madhya Pradesh, Haryana and Punjab while those from the sub Himalayan region migrate to Alpine meadows. Continuous drought during last decade has changed the breed composition, production response and marketing structure of sheep produce in the dominant sheep producing regions of the country.

Speciality hair fibres

Angora rabbit hair, Pashmina and yak wool are main important speciality hair fibres are found in our country. The fineness of Angora rabbit hair ranges between 12 -14 micron. In our country, rabbits are reared in Himachal Pradesh. Central Sheep & wool Research Institute also has got its station in Himachal Pradesh at GARSa where different varieties of Rabbits i.e. British, German and Russian are reared. German rabbits are the best. Pashmina or Cashmere is obtained from Changthangi and Chegu breed goats that are famous for their softest, finest and warmest commercial natural animal fiber. The average diameter of pashmina produced in most of the countries is ranging in between 11-18 micron.

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Table 1: Animal Fibres: Production, Quality and Products

Name of the fibre	Source	Production Lakh kg	Fineness Micron	Product
Wool	Sheep	456	22-60	Carpets, blankets, Felts, shirting, suiting etc.
Pashmina	Cashmere goat	0.4	10-15	Shawls and knitwears
Rabbit hair	Angora Rabbit	0.5	10-14	Shawls and Knitwears
Yak fibre	Yak	0.1	15-25	Shawl and knitwear

Wool Marketing in India

The single weakest link after production of wool is marketing of wool in the country. Wool marketing in India is essentially in the hands of private wool merchants and traders. The producer of wool rarely takes the wool to the markets. A substantial proportion of wool is purchased by village merchants. The merchants/commission agents in wool market sell wool on behalf of village merchants or purchase the wool for themselves. There is a common practice of wool producers selling their wool per animal basis well before the shearing season by taking money in advance. The reasons for village level selling are ascribed to distant locations of wool mandies causing transportation problem. The unscientific wool marketing practices are completely against the interest of woolgrowers that have stunted production of wool over the years. To ensure remunerative price to woolgrowers, to provide protection to them against exploitation by the middlemen, to make available good quality and well-graded raw material to wool industry, it is imperative that effective market intervention is made by government agencies.

The availability of animal fibres except sheep wool is very meagre and therefore, their marketing is not at all organized. These fibres are sold locally and used locally. However, with the efforts of some developmental agencies, the production of rabbit hair has increased in the states of Himachal Pradesh and Uttarakhand. The price of rabbit hair is also not constant and fluctuates with the price of rabbit hair in international market. Further, with the globalization and open market approach the survival of this species and its products have to face a stiff competition in the times to come. Presently, India produces about 100 tons specialty hair fibres per year (50 ton Angora rabbit hair, 10 ton yak fibre and 40 ton Pashmina wool). The value of these fibres is approximate Rs. 10 crores which fetch a value of 200 crores after processing and value addition. Among animal hair fibres, the share of speciality hair is very small.

TRADITIONAL ANIMAL FIBERS

Society has used animal fibers for clothing, shelter, rugs, and many other miscellaneous items for decades. Animals have been part of everyday survival since long ago when they were hunted for food, and then the skin and hair served many other purposes. The most well known and most used of these exotic fibers today are wool, mohair, cashmere, and camelhair. Each fiber has its own distinguishing characteristics, and serves unique purposes.

Wool

Wool, the hair of a sheep, has been used for clothing, upholstery, and carpeting for many years. It possesses many fine qualities such as warmth and water resistance, but also has its downsides, such as being a very dirty fiber initially and having problems with shrinkage.

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Properties: Innumerable minute projections and indentations, known as serrations, appear along the whole surface of the shaft of the fiber. Because of this, when wool fibers come together, the serrations grip one another and assist in the production of a strong yarn. These serrations also serve to protect the fiber during manufacturing processes. These scales face towards the tip of the fibers, and cause a directional effect, which is important in the frictional behavior of wool. One of the outstanding qualities of wool is its elasticity and resilience. It has the ability to return to its natural length after being stretched. The elasticity of wool is very important when determining the comfort of close-fitting garments. Elasticity is also important in the performance of carpets causing them to recover when crushed. A wool fiber can be stretched 25 to 30% its natural length depending on the wool quality. Because of this elasticity, wool is often said to have two lengths, the apparent length and the true length. The apparent length represents the length of the fiber before stretching to the extended length. The true length is only revealed when the fiber is measured when stretched under just enough tension to pull out the crimp. Wool appears to have somewhat of a three dimensional crimp, which means that it 'rolls' as it crimps, similar to a ribbon. The average length of a wool fiber is 1 to 8 inches. Because of wool's great resilience and good elastic recovery, it has superb wrinkle recovery]. An average diameter for wool is 8 to 70 microns (0.0018 to 0.003 inches) according to Schwarz.

The cross-section of wool has an oval to circular shape and consists of three different parts. The outer part of a wool cross-section is called the cuticle, the middle layer is called the cortex, and the inner part, or core, is the medulla.

Scale patterning is a close look at how the scales arrange themselves along the length of the fiber. This patterning is seen by making a scale cast. A scale cast can be made by using a few drops of a 20% solution of polyvinyl acetate in benzene to drive off the benzene leaving a thin layer of plastic. The fibers are placed on the plastic layer and covered with a clean slide. The slides are then heated under a pressure of about 10 pounds until a test piece shows that the plastic has softened. After cooling, the slides are separated and the fibers are removed, leaving casts in the plastic. This scale cast shows if the scale pattern changes along the length of any of the fibers. Cross-sectional and whole mount views are microscopic views of a cut fiber and the complete length of the fiber. The table has this information for different sizes of the fiber, which are fine, medium, coarse, and kemp fibers. Descriptions of the scales, whole mounts and cross-sectional views are given for each fiber size.

For the whole mount, wool has an irregular diameter no matter what the fiber size. There is either no medulla or it is considered very fragmental for most wool fibers. Wool's pigment distribution is mostly none too dense. The cross-section of wool is usually circular to oval. An irregular mosaic, yet smooth scale pattern is observed on most wool fibers.

The coloring of wool fibers is mainly light cream, but can be found in brown or black. Wool's density ranges from 1.33 to 1.35 grams/cc. Also, wool has some luster, but the finer the scales, the duller the fiber. During processing, when fine fibers are spun into combed yarns with fibers laid nearly parallel, a subtle luster is evident. An example of this type of luster is seen in fine suiting materials.

Despite the fact that wool has a low tensile strength ranging from 1.28 to 1.59 grams per denier, it can be made into very durable fabrics with good abrasion resistance, which can be restored to good looks over a long wear life. Also, pilling is not a very big problem with

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wool fabrics because the pills can be easily removed with a stiff bristle brush.

Wool's ability to absorb moisture is another one of its attributes. It is considered the most hygroscopic of all of the protein fibers used in textiles today. Wool can hold as much or more than 30% of its own weight in moisture without feeling wet, and gives up moisture slowly.

Wool does not readily conduct heat; therefore, wool garments act as an insulator and help to keep the body at an even temperature during excessive hot or cold weather. When manufactured into garments, wool fibers create millions of tiny pockets that trap the air and keep it almost still, thus keeping the body at an even temperature [4]. Also, wool does not readily burn when exposed to an open flame. The burn that it has is like a bead-like ash that is cold which basically extinguishes the flame. This non-flammable characteristic makes wool a very safe textile fiber.

Wool also has an incredible ability to felt and entangle to form compact fabrics or tissue. A high degree of felting enables the production of a very dense, compact material after fabric shrinkage. Felting is mainly a physical action because it results from the small projections or serrations of neighboring fibers interlocking with each other until the component fibers become united to form a close, compact tissue of fabric. Fiber fineness, crimp, and elasticity are other factors that contribute to high felting capacities.

Wool is one of the most durable textile fibers. Its irregular and non-solid structure allows it to be twisted and bent out of its usual form without being broken, giving wool its long-lasting qualities. The coarseness of the wool fiber is what makes wool garments resistant to wear and tear. Drape is another outstanding property of wool. This aspect is very important when considering outerwear garments, upholstery fabric, and drapes.

Processing : The most important characteristic of wool from a manufacturer's view is the length. The length of the wool fiber determines the method of preparation for spinning the fiber into yarn. Generally, the longer the wool fiber, the higher the wool value because of the ease of manufacturing. Because of the dirty nature of wool, a rigorous scouring process must be done before any other processing stage. Wool is scoured in warm water with soap and a mild soda ash solution. Scouring baths are equipped with automatic rakes to stir the fibers, and rollers between the vats. Wool can also be put through a carbonizing bath of dilute sulfuric acid or hydrochloric acid to burn out the foreign matter.

After the scouring process, the wool fibers go through a drying process to remove excess water. Wool can still contain up to 40% moisture after completing the scouring process. The wool must be dried for storage purposes. If it is not dried properly, it may be attacked by mildew. However, if the wool is over dried, the fibers are damaged and may become discolored and electrically charged. The charge could make the fibers fly away from each other and cling to machinery in the manufacturing facility. The two most commonly used mechanical driers are the tier dryer and the drum drier. For effective operation, a constant temperature must be maintained in either type of drier, and the moist air from the drier must be exhausted into the outside atmosphere.

Crimp is thought to be an important factor in the manufacturing process, as well. During combing, the crimp is combed out, but during the finishing process, the fibers tend to return

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to their natural shape, thus tightening up and strengthening the material. The serrations that wool exhibits also assist in the production of a strong woolen yarn. During processing, wool fibers are stretched to their true length and the subsequent return to their original length causes the yarn and the finished material to bind strongly together, thus adding to the strength and wearing capabilities of the fabric.

End Uses : Wool is preferred to other materials for children's clothing; especially sleep wear, and elderly clothing because of its non-flammable nature. Sometimes the coarse guard hair from wool, called kemp, is used as effect fibers in fabric such as tweed because it has poor dye uptake.

Wool is a very popular fiber used in winter clothing, such as sweaters, because of its great warmth. The thicker, harsher wool fibers are usually restricted to use in outer garments, where the finer and softer fibers can be used in top weight garments, such as sweaters. Many men's suiting fabrics are wool, or contain a percentage of wool. Winter coats, socks, and scarves are often made from wool fibers. Because of wool's durability and natural resilience, it is also used in carpeting, rugs, and upholstery. Wool possesses many qualities, which make it a versatile fiber.

Mohair

Mohair, the lustrous fleece of an Angora goat, has been regarded as one of the most luxurious and best quality fibers available to man. Mohair is the number one produced fiber out of all of the specialty animal fibers today, but represents less than 0.05% of the total world fiber production. Mohair's tremendous versatility is one of its main advantages. It can be used for clothing and furnishing, and within these sectors, its end uses are endless. The average price of mohair can fluctuate anywhere from \$13/kg in 1979 to \$8/kg in 2000. Mohair's affinity for dyes and its ability to absorb them completely makes the dyeing process easy during manufacturing.

Properties : Generally, mohair is a straight, smooth, and naturally lustrous fiber. Mohair exhibits the capability to be dyed deep, brilliant, and fast colors, where in contrast, it can also produce very distinctive muted tones. Naturally, mohair is white, however, occasionally; there are varieties of brown, black, and pink/red assortments. Good quality mohair is virtually free of medullation and kemp, which makes it a relatively clean fiber.

Mohair has low flammability, felting, pilling, and good durability. Because of its strength of about 13 grams/denier, it is classified as the strongest hair fiber. Further attributes of mohair are its elasticity, luster, resistance to soiling, setting ability, abrasion resistance, drapeability, shapeability, moisture and perspiration absorption and release, insulation, and comfort. Mohair is almost non-crushable, therefore having great resilience. In addition, mohair fibers shed soil well by brushing clean easily.

Mohair's scale structure gives it the attributes of smoothness, low friction, low soiling, good soil shedding, and low felting. The scales are usually thin, flat, and relatively long. These relatively large, plate-like scales also give mohair its luster. Mohair's epidermal, or cuticle scales are faintly visible and hardly overlap. They are anchored much more closely to the body of the fiber, giving the fiber a very lustrous smooth appearance.

Mohair has somewhat of a circular to oval cross-sectional shape and a regular diameter. Its

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pigment distribution ranges from none to occasionally very sparse. The scale patterning of mohair is fairly consistent from the root region of the fiber to the tip, which has a smooth, irregular mosaic pattern.

The average length of mohair fibers is from 9 to 14 centimeters. Its diameter ranges from below 24 μm to 40 μm . Mohair fibers tend to be more even in diameter along their lengths than wool. Generally, mohair is practically circular, having a ratio between the major and minor diameters of 1.12 or lower. Wool, on the other hand, has a ratio that is 1.2 making it more oval than mohair. Lower grades of mohair fibers are stated to be generally less circular than the better grades.

Processing : Mohair is not an easy fiber to process, especially in drawing and spinning. Many companies are secretive about the processing of mohair because it provides them with a competitive edge. Because of mohair's low cohesion, it often necessitates that the fibers be supported during processing. Its generation of static electricity also poses a large problem in processing. Blending mohair with other fibers, such as wool, greatly reduces these processing concerns, as well as using lubricants and additives, and the appropriate processing machinery and conditions.

Fabrics made of mohair are very light in weight and have excellent insulation. Mohair fabrics are warm in the winter; yet comfortably cool in the summer. Mohair blends beautifully with other fibers, which of course reduces the cost of a fabric made partly of mohair.

End Uses: Mohair is used in apparel as well as non-apparel items. It has proven to be relatively unsurpassable in many non-apparel applications such as furnishings, blankets, and upholstery. It is particularly suitable for household textiles such as velour upholstery fabrics, curtains, and carpets. Because of mohair's ability to shed dirt easily, it is used for paint roller covers because it releases the paint easily as well. The fiber is often used in boucle loop yarn to give fabric a light, airy, and warm feeling. Mohair's wiry property makes it suitable for use in braids and tailor's canvas. It is often blended with wool for top quality blankets where the mohair content makes the fabric warmer, and at the same time lighter.

Cashmere

Cashmere is the under down of the domestic goat of central Asia and goats which are now raised in North America. Cashmere is a very soft and luxurious fiber, which comes from the coat of a cashmere goat. It adds warmth, luster, and visual charm to garments and carpeting. There is a long history of cashmere hair, the thick outer protective coat of the animal, being used for cloth and carpets in Asia. Cashmere fibers were also used for weaving cloth for making tents for the nomadic herdsmen, who traveled with their goats seeking new pastures. With natural fibers increasing in popularity in the fashion world, new interest in cashmere fiber is occurring in many areas of the world. This unique, exotic fiber is finally getting the recognition it deserves.

Properties: There are three key factors that explain why cashmere is regarded so highly. These factors are its extreme fineness and softness that give cashmere its tactile and visual appeal; its scarcity in relation to other fibers; and its image or charm. Because of this prestige, cashmere has a very high price in the textile world. The price of cashmere ranges anywhere from about \$40/kg to \$110/kg, as compared to wool ranging in costs from about

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\$8/kg to \$25/kg. As compared with wool and mohair, cashmere is a much finer fiber. The finer the diameter of cashmere, the higher the price for the down. Cashmere also possesses a lot of crimp.

Cashmere fibers have an oval to circular cross-sectional shape. These fibers have a fairly thin cuticle. The scale patterning of cashmere that is a regular waved mosaic pattern with slight ripples.

Cashmere also has a fairly regular diameter throughout the length of the fiber. The diameter of cashmere ranges from 12.5 to 16.0 microns, where a standard diameter is considered to be about 15.5 microns. When considering length, the longer the cashmere fiber the better the quality. The Chinese Commodity Inspection Bureau (CCIB) specifies that a cashmere fiber should be longer than 32 mm, and a fiber length of 46 mm is considered long. White cashmere fiber is the preferred color because it is easiest to dye and produces the purest colors. Grey and brown are colors seen in cashmere fibers also.

Cashmere's medulla ranges from being not present, to being interrupted, to being continuous. The pigment distribution ranges from sparse to dense and even. The scale patterning of cashmere is basically a regular waved mosaic pattern.

Processing : The processing of cashmere is no easy task. Historically, the fibers were sorted by hand in factories called sorting sheds into grades and colors by women with trained eyes. Today, sophisticated laboratory equipment performs this sorting process, while also testing fiber properties. After sorting, the fibers go through a process known as willowing. This process removes any dirt and grit by feeding the fiber through a revolving machine that shakes out the grit and dust. Next, the fibers are scoured and then dehaired.

Dehairing separates the coarse guard hair from the precious inner down. Dehairing is a mechanical process involving several stages that must be performed in a controlled temperature of 80 to 85 degrees Celsius. This technique is kept secret because of the quality of cashmere that it produces. Only the under hair or 'down' is used for apparel applications. The hair that is removed, or the waste, has other end uses.

Before the dyeing process, the cashmere fiber should be scoured. This scouring process is very similar to the scouring process of wool. The fiber is cleaned using a mild detergent, dried, and is then ready for dyeing. The dyeing of cashmere fibers is carried out in its 'loose' state. When dyeing the actual fibers, the cleaned fibers can be lowered directly into the dye bath without the fiber being handled.

After dyeing, the fibers are teased into roughly the same direction and oil is added to give resilience for the spinning process. When dyeing a cashmere yarn or finished garment, the dyeing process is a bit easier and safer because there is less chance of felting.

Higher quality cashmere fibers are usually spun into knitting yarns, and the lesser quality fibers go into weaving yarns. The weaving sector of the textile industry is a much smaller customer for cashmere than the knitting sector. Blending cashmere with a small amount of silk strengthens the yarn without downgrading the cashmere fiber quality. The higher the percentage of cashmere when blending with another fiber, the easier the spinning process becomes. Production of cashmere was estimated at 5,000 tons per year in 1988.

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End Uses

The coarser cashmere fibers, 16.0 to 17.5 microns, are used primarily in knitwear and weaving, with fibers ranging from 17 to 21 microns chiefly used for weaving. Overcoats are usually made of the coarser cashmere hairs. The fine cashmere hairs are used in sweaters [3]. The hair that is removed during the dehairing stage, is used in carpets, under felts, and interlinings for men's suits and jackets.

Camelhair

Camelhair holds a very prestigious quality image in the United States, and comes high in the league of luxury fibers for woven cloth. Just as the name indicates, this fiber comes from the coat of a camel, and is usually in shades of brown and grey. The price of camelhair can range from \$9/kg to \$24/kg in the United States.

Properties: The most common color of camelhair is a reddish brown with variants from brown to grey. The white fleece is the most valued, but is very rare. Camelhair and cashmere share many of the same properties except for the fact that camelhair is a bit coarser. Camelhair has two basic qualities, the coarse outer hair and the inner down fiber. The fine down fibers range in diameter from 19 to 24 microns and have a length of about 2.5 to 12.5 cm. The coarse fibers have a diameter of 20 to 120 microns and a length of up to 37.5 cm.

The cuticle of the fiber is somewhat less dense compared to the rest of the length of the fiber. The pigment distribution is sparse near the medulla in the finer fibers, yet dense near the medulla in the coarser fibers.

Other characteristics of camelhair are its strength of 1.79 grams/denier, luster, smoothness, water repellency, warmth, fineness (9.55 denier), and camelhair is lightweight also.

Processing : Very little information can be found in the literature on the actual processing of camelhair. The development of better dyeing techniques for camelhair has helped make it a practical substitute for cashmere. However, it does require an extra processing step because of its light tan coloring; therefore, it must be bleached before dyeing. On the other hand, cashmere is white and does not require bleaching. Unfortunately, no further information on the processing of camelhair is available in the reviewed literature.

End Uses : The trend for softer tailoring and lightweight fabrics has helped to maintain the demand for exotic fibers such as camelhair. The greatest interest in camelhair lies in the United States, and is likely to remain in the US market. The US camelhair market accounts for 70% to 75% of fabric production.

In production, only the soft under wool or down hair is used in making yarns for apparel applications. The longer fibers, which are removed by a dehairing process, are used in other non-apparel related applications such as rugs and carpeting.

Primarily, camelhair is used in woven cloth for men's coatings and jackets. The coarse hair that is up to 37.5 cm in length is used in making felt, carpet backing, cords, low quality rugs, and winter coats that are very warm and completely waterproof. Traditionally, the outer hair is used in bedding because it is said to be beneficial in relieving pain associated with rheumatism and arthritis. The strong springy hair from the camel's mane is used for interlinings. The finer camelhair is usually made into worsted yarn and used for knitwear and

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light wovens. Some other end products of camelhair are tailored jackets and blazers, as well as sports jackets. Blends of wool and/or silk with camelhair are used for both men's and lady's jacketing.

CONCLUSION

Compared to mohair and camelhair, wool can be fine, yet quite strong. Also, mohair and camelhair require less force to deform them than does wool.

Despite the fact that wool is the most widely used protein fiber in manufacturing today, other protein fibers have many attributes as well. There are definitely other advantages to mohair, cashmere, and camelhair that wool fibers do not possess. The main advantage that these fibers hold when compared to wool is their softness and tactile appeal. Wool tends to be scratchy and a bit uncomfortable to the bare skin. Camelhair has a breaking extension very similar to that of wool, but is much stronger.

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Conflict of Interest

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