

# Natural Fibres for Sustainable Development in Fashion Industry

Sanjoy Debnath

**Abstract** Ample numbers of natural fibres are available in nature from plants, animals, insects, and minerals. Each fibre is different from others, and that causes difference in their properties. Accordingly, these fibres alone, or in admixture with other fibres, are used in the design and development of specific fashion products. With time, different fashion industries have been developed all over the world for manufacturing different fibre-based fashion products. There is a huge potential of value addition in these fashion industries with the intervention of newer product design. Again, in this fashion industry, apart from newer design, avoiding the use of common natural fibres (cotton, wool, silk, etc.) commands more profit. Recent trends also show the use of these natural fibres for sustainable growth in this fashion industry. This chapter also deals with future aspects of the use of uncommon natural fibre for sustainable fashion industry.

**Keywords** Fashion industries • Natural fibres • Plant fibres • Sustainable development • Known plant fibres

## 1 Introduction—*Natural Fibres, Sources and Application* —*An Overview*

Nature has gifted humankind with a wide range of fibrous material. Based on the source, natural fibres are primarily classified into two categories: plant fibre and animal fibre. These plant fibres further classified into various categories such as leaf fibre, bast fibre, seed fibre, fruit fibre, etc.; on the other hand, animal fibres are also categorized as hair fibre, insect-secretion fibre, etc. Almost all animal fibres are protein-based, and plant fibres are cellulosic. Apart from the protein and cellulose as

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S. Debnath (✉)

Division of Mechanical Processing, ICAR-National Institute of Research on Jute & Allied Fibre Technology, Indian Council of Agricultural Research, 12, Regent Park, Kolkata 700040, West Bengal, India  
e-mail: sanjoydebnath@yahoo.com; sanjoydebnat@hotmail.com

major components for animal and plant fibres, respectively, these fibres contain many other components. Because all of these natural fibres come from biological sources, renewability or sustainability is not a big issue. For the fashion industry, along with manmade fibres, developments in the progress of the product and process of natural fibre are parallel.

Nowadays, people are more conscious about natural fibres and their uses (Debnath 2014a) due to their environmentally friendly nature because the disposal/degradation after use is not questionable. For this reason, many fashion products are now being stressed for development with natural fibres. In this chapter, most of the natural plant fibres used in the fashion industry will be covered. These fashion products are of two types: wearable and nonwearable. People are looking more for the use of uncommon/unexplored natural fibres in fashion products. Elite-class people are ready to pay more money for fashion products made out of natural fibres rather than products made out of common plant fibres such as cotton, wool, etc. Sometimes some manmade and natural fibres are blended with these known fibres to improve the functional properties of the final products (Basu and Roy 2008). The long plant fibres used most in fashion are jute, flax/linen, ramie, pineapple, sisal, nettle, coir, etc.; these fibres are sometimes blended with unconventional fibres such as cotton, viscose, polyester, acrylic, etc., to improve the look and feel of the final fashion product.

In the fashion industry, apart from manmade fibres, long plant fibres are generally extracted from different parts of the plant, viz., bark/bast/stem, seed, leaf, etc. are converted into textile yarn and fabric, which are used for fashion applications. There are many such plants in nature whose sap extracted from root, stem, leaves, barks, fruits, and seeds are used to extract natural dye used to colour fashion products. The natural fibres are cultivated; hence they are annually renewable in nature. This fact should be given more emphasis so that fashion products can be diversified. The fashion industry can be sustainable if the proper market and value of the fashion products are paid. Nevertheless, the present term “sustainable” also means taking care of mother Earth so that fibre can be green, production processes can be green, and fashion products can be free from synthetic materials. Minimal use of toxic chemicals and maximize utilization of plant extracts would sustain the fashion industry for the long term. This present chapter will cover to a great extent sustainable fashion textiles with reference to plant fibres other than cotton.

## **2 Fibres for the Fashion Industry—Natural and Man-Made Fibres, Blending of Fibres for Fashion Textiles, and the Importance of Using Known Fibres**

Jute fibre has been a fibre known for more than a century for its industrial applications such as sacking/package, geotextiles, and carpet backing (Debnath et al. 2009). However, in last few decades, there have been lots of works wherein jute has

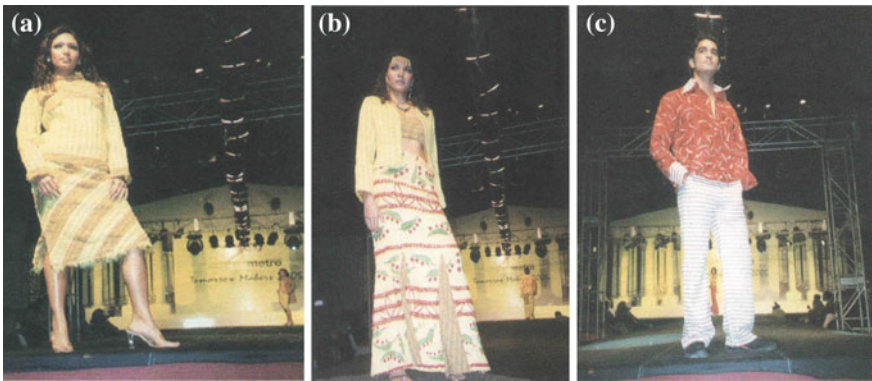
been used as fashion products in different wearable and nonwearable fashion products. The demand for conventional products has declined due to the easy availability of low-cost synthetic materials. Export demand has also been reduced due to stringent norms due to presence of band residual chemical traces. Hence, many industries are now concentrating on the development jute-diversified products for fashion and jute bags for the packaging of agricultural produce. It has been found from the literature that jute with ornamentation—using suitable modifications in spinning (Debnath 2013b, 2014c), weaving, and knitting as well as nonwoven, handloom fabrics with an attractive look of elegance—can be made (Anonymous 2006a). Fashion design aspects have been considered at the fabric-manufacturing stage and others in dress making with designed fabric (garment manufacturing). Figure 1 shows a fashion shawl made from jute-based material (Anonymous 2006a). A jute-based fashion jacket and blazer are shown in Fig. 2a, b, respectively. Furthermore, jute-based fashion garments were exhibited in fashion shows at GIFTEX Stationex and Jutex 2005 in August 2005 at Mumbai (Anonymous 2006b). Models wore jute-based decorative fashion garments in the fashion parade (Figs. 3a through c). The literature also reveals that apart from these conventional products, jute can be used for the development of value-added green textiles. Some of these jute-based green textiles are fashionable, and some are of industrial application in nature. Fashionable green products from jute-based materials (Debnath et al. 2009) include fashion garments (Debnath 2013a, 2014b, 2015b) such as bulked yarns for sweaters, jute slippers, decorative and fashion products

**Fig. 1** Jute-based fashion shawls





**Fig. 2 a** Jute-based fashion jacket as winter garment. **b** Jute-based fashion blazer



**Fig. 3 a** Jute-based fashion ladies' garment worn in fashion show. **b** Fancy jute-based ladies' wear worn in fashion show. **c** Male fashion apparel from jute used worn in fashion show

from handmade paper, fashionable shopping bags, fancy curtain materials, etc. These uncommon products are being marketed to some extent at prices that fetch good revenue.

The earliest example of preserved linen appears to be a needle-netted linen headpiece from Nahal Hemar Cave in Israel from 8500 years ago, and Swiss Lake Dwellers used a native flax to make cloth 5000–6000 years ago. Linen was the

preferred textile of the ancient Egyptians who used it for clothing, bed linen, shrouds for mummies, and ships' sails. The earliest Egyptian linen cloth dates from the Old Kingdom, but flax appears to have been grown for linen approximately 5000 years ago in the Early Dynastic period. In today's scenario, when we talk about flax fibre, it is well known as linen fashion as well as formal apparel for both males and females. Many leading manufacturers of linen-based products exist all over the world. Different blended linen products (Basu and Dutta 2014) are linen/cotton (warp cotton, weft linen or warp cotton, weft cotton/linen blend yarn), linen-based/cotton (warp cotton, weft linen/jute, linen/ramie, linen-pineapple, or linen/silk waste, etc.), linen/synthetic (warp polyester/cotton or polyester/viscose blend, weft linen, linen/jute, or linen/cotton, etc.), etc. Apart from these, there is huge scope to develop many other blended materials from linen. Elite men as well as women currently prefer linen-based apparel mainly for comfort apart from its esthetic look. Linen fibre material can absorb moisture quickly from body perspiration, and this provides cool and comfort in humid conditions. As far as the properties of the fibre are concerned, linen fibre material swells and thus improves the strength under wet conditions. This is one of the reasons linen/flax blend is normally preferred to spin under wet rather than dry conditions. As far as the international market is concerned, many pure/blended linen products are available such as ramie/linen *Kurti* for women for casual wear, linen blend trousers (50 % viscose, 35 % cotton, 15 % linen. The White label (65 % viscose, 25 % cotton, 10 % linen) by Joanna Hope, linen-mix trousers and shorts (55 % linen, 45 % cotton) by SOUTHBAY, single-breasted linen mix blazer (55 % linen, 45 % cotton; lining: polyester) by Williams and Brown: All of these are examples of lightweight fashion fabrics will keep you cool but stylish in the warm weather. Apparel (54 % cotton, 46 % linen) by Black Level Jacamo, linen mix 3/4 pants (55 % linen, 45 % cotton) by Southbay, ladies fashion linen-bow decorated straw-braid summer sun hat (linen 100 %), linen women's summer wide-brim sun hat style "Wedding Church Sea Beach" (linen 100 %) by Kentucky Derby, ladies sexy pleated criss-cross fashion linen dress, women's white linen dress (100 % linen), female slim blazer/short jacket/linen blazer/ladies coat, ladies linen thongs and underwear/briefs (85 % linen, 12 % nylon, 3 % spandex), women's linen socks (85 % linen, 15 % nylon), etc. all show that there a good fashion market exists internationally.

Pineapple leaf fibre (PALF) is another unexplored natural fibre extracted from the green pineapple plant leaf, which is normally considered an agricultural product (Banik et al. 2011). Pineapple leaf fibre also has immense potential for use as a fibre source in the arena of sustainable fashion textiles (Debnath 2016). This fibre is very strong, lustrous, and creamy in colour. It found during a review (Anonymous 2015a) that pineapple leaf fibre is considered to be more delicate in texture than any other vegetal fibre. One kilo of leaves may provide  $\leq 15$  to 18 pieces of white, creamy, and lustrous silk-like fibre approximately 60 cm long, and it easily retains dyes. These leaf fibres are scraped by means of a broken plate or coconut shell, and a fast scraper can extract fibre from  $>500$  leaves/day, after which the fibres are washed and dried in the open air. Then they are waxed to remove tangles, and the

fibres are knotted and bound into yarns for the next process of weaving it the yarn to fabric. Pineapple fabrics are mainly used for creating Barong Tagalog and other formal wear. It is also used for other products where a lightweight but stiff and sheer fabric is needed. It is sometimes combined with silk or polyester to create a textile fabric. The end fabric is lightweight, easy to care for, and has an elegant appearance similar to that of linen. Pineapple silk is considered the “queen” of Philippine fabrics and is considered the fabric of choice of the Philippine elite. In the Philippines, PALF-based fabric is also popularly known as *pina fabric*. Different fashion products (both apparel and nonapparel) are available in the market made up of PALF. Figure 4 shows Filipino shirts that are national dress, worn by everyone from the Filipino president to brides and grooms, made from piña, a type of fabric made from pineapple fabric (Anonymous 2015b). Because the pineapple leaf fibre is lustrous, the cloth made out of this fabric is very lustrous even after it is dyed, and thus garments become even more eye-catching (Fig. 5).

Although pineapple fabrics were first created in the Philippines, the pineapple plant actually originated in South America around the region of Paraguay. In the 16th century, Spaniards invaded the Northern Philippines and planted pineapple plants, which they had discovered can grow successfully in their hot and moist island tropical climate. As far as the global market is concerned, Anonymous (2015d) is one of the commercial sellers of different types of pineapple leaf fibre based fabric globally. As far as blended pineapple leaf fibre material is concerned, Ghosh and Sinha (1977) is a pioneer in textile product development from PALF fibre. In their study, they used a special technique to spin pineapple in jute-spinning machinery. They found that fine pineapple leaf fibre could be spun into in yarns of 70- to 170-tex linear densities, which are prerequisite for fashion textiles. However,

**Fig. 4** Fashion shirt made from pineapple leaf fibre used during wedding in the Philippines (Anonymous 2015b)





**Fig. 5** Pineapple fabrics and their lustrous eye-catching luxury and beauty as made by couture designers (Anonymous 2015c)



in admixture with jute, 10–15 % pineapple fibre will improve the performance of jute-blended yarn, and fine jute/pineapple blend yarn can be produced. These fine pineapple and pineapple/jute blend yarns, plain and twill woven cloth, have been developed for sustainable fashion fabric development. Furthermore, these lightweight fashion fabrics are used to design fashion bags, curtains, furnishing fabrics, etc. Finally, the authors concluded that for sustainable fashion textiles, pineapple leaf fibre or jute/pineapple leaf fibre blend products have huge potential. Along the same line of research, Ghosh et al. (1982) carried out the processing of pineapple leaf fibre in a cotton-spinning system. Before processing in the cotton-spinning system, they studied and compared the physical and mechanical properties of cotton, jute, and pineapple leaf fibres. It was observed in their study that the 100 % pineapple leaf fibre is not at all possible to spin into yarn in cotton-spinning machinery. Hence, they tried to process PALF of different proportions (50, 33, 20 %) with cotton. From this study they optimized a blend of pineapple and cotton (50:50). Although the spinning performance is poor in cotton/pineapple blended fibre, a huge amount of cotton can be saved, and thereby value-added green products can be made out of this blended yarn. In the same area of blending pineapple leaf fibre evidence exists to study the performance of blended pineapple leaf fibre/acrylic fibre in jute-spinning systems (Ghosh et al. 1987; Dey et al. 2009). These authors studied the fibre properties of pineapple leaf fibre and acrylic fibres and compared their similarities and dissimilarities. Five different blends of

pineapple leaf fibre and acrylic fibre have been tried, viz., 87:13; 67:33; 50:50; 33:67, and 13:87. From all of these blends, fine yarns of 84 tex were spun in a wet-spinning process where the rove was passed through a temperature bath (80–100° C) before spinning. They also spun the same yarns through a dry-spinning process. Finally, they compared the dry- and wet-spinning process and found that in wet spinning the breaking stress was reduced but the breaking strain was improved by 6 times. The optimum blend composition found from their studies is 67:33 pineapple/acrylic blend yarn (Basu and Roy 2008). The wet-spinning performance is much superior to that of the dry spinning method. Finally, the authors also concluded that there is ample scope for the development of green fancy apparel products out of these pineapple/acrylic blended yarns (Dey et al. 2009; Basu et al. 2006). In their papers, Ghosh and Dey (1988), Ghosh and Sinha (1977) showed different prospects and possibilities of pineapple leaf fibre based textiles for fashion apparel. Their study also confirms the types of fashion apparel/outerwear applications and fashion shopping bags, table cloths, etc. That can be made from PALF-based material.

Dogan et al. (2008) reported that the stem and fibre of stinging nettle are used to prepare traditional handicrafts in several Balkan countries. This nettle fibrous material in Bulgaria, locally known as *Kopriva*, is used for the sustainable development of cloth, sack, cord, and net manufacturing applications. In Romania, nettle is known as *Urzica*, and it is used as a substitute for cotton in fishing net and paper making. It is known as *Kopriva* in Serbia, where nettle fibre is considered to be one of the major textile fibres used in the spinning industry to produce textile products. Overall, there is a wide range of possible handicraft products (doormats, flower vases, wall hangings, door chains, carpets, hand bags, table mats, beach umbrellas, lamp shades, etc.) that can be made out of nettle either from fibre or yarn, fabric, or combination of these. All of these products have huge profit margin due to their high cost-to-benefit ratio. Most of the handicraft products fall under the category of fashion items. Similarly, Dunsmore (2006), in her findings, explained how different handicraft products are made out of nettle fibres and hand-spun yarn from Nepal. This study also elaborates on the sustainable rural livelihood earned through the cultivation of nettle to handicraft development of nettle products. This handicraft-making from nettle fibrous material by rural hill people created an alternative source of income during the lean period of agricultural activities. Economic development to the nettle-processing community of Nepal has been created through proper marketing strategy and exporting fashion textiles and handicraft products to Europe and America (Dunsmore 1998). Bacci et al. (2010) also reported that for sustainable handicraft products made from nettle, it is essential to use enzymatic retting to obtain the best quality fibre. Deokota and Chhetri (2009) reported in their research that handloomed products and handicrafts are sold side-by-side to promote nettle-based products in Nepal. These include coarse hand-woven cloths, sacks, bags, fishnets, and *namlo* (head straps to carry load), which are sold in the local market or in some cases are bartered for food or other necessary items in some rural communities. They have also demonstrated various sustainable fashion products made out of nettle and its blends such as hats, jacket,



room decorations, and various handicraft products. Many of such products are available in the international market. An internationally known company, Swicofil (Anonymous 2015e), has used the juice of the nettle stem, and leaves have been used to produce a permanent green dye, whereas a yellow dye can be obtained from boiling the roots of nettle plant and used for dyeing fashion clothes. Both of the colours have been used extensively in Russia for fashion garments. Furthermore, an Italian fashion company, Savage Designs, introduced an environment friendly alternative to contemporary textiles and dyes. A light nettle jacket (Fig. 6) made of 70 % hand-spun and -woven wild nettle blended with 30 % organic cotton, unisex wild nettle pants (Fig. 7a, b), black-colored wild nettle jeans (Fig. 8), and a fashion ladies dress and shawl (Fig. 9a, b, respectively) are some of the commercial products made of nettle that are available in the global market.

Similar to nettle, ramie is also another bast fibre extracted from the bark of the ramie plant. Literature (Anonymous 2015f) reveals that ramie is also known as China grass, grass linen, rhea, and grass cloth. It is said that ramie fibers are one of the oldest natural vegetable fibers and have been used for thousands of years for fabric and clothing including ancient Egyptian mummy wraps and shrouds. The fiber is white, lustrous, and fine like silk. However, it is somewhat stiff and brittle, which is great for coarser products such as twine, rope, wallpaper, and nets. Ramie is often used as a substitute for cotton. When spun wet, it produces a high-luster softer yarn. Dry spinning results in a harsher, hairier yarn. The versatility of ramie fiber allows it to be made into fine yarn for all types of garments ranging from dresses and suits to sportswear and jeans. Fabrics made of 100 % long and fine ramie fibers are lightweight and silky. The fibers are uneven, which gives ramie fabric a similar appearance to linen. To produce fabrics with various improved characteristics, ramie is often blended with other fibers such as cotton. By doing so, the creation of fabrics from fine linens to coarse canvas gives ramie fibers almost unlimited potential. By blending with wool, the fabric is lighter, and shrinking is

**Fig. 6** Coloured jacket made out of nettle fibre





**Fig. 7 a, b** Self-designed fashionable nettle unisex pants

minimized. Cotton blends result in increased strength, color, and luster, whereas rayon blends result in a higher wet strength. Ramie is also commonly used as a substitute for flax/linen and can also be blended with silk fibers. Ramie/China grass fibers are commonly used in blends for sewing threads, fashion sweaters, fancy clothing, and linens. Due to the fashion industry becoming more and more eco-conscious, the popularity of ramie will continue to rise. Interest in ramie is being rekindled, and it is appearing more often in the fiber content of clothing and textiles. Because of the trend toward natural fibers, expect to see ramie become even more popular. Ramie fabric is used for apparel including suits, skirts, jackets, dresses, shirts, blouses, pants, and handkerchiefs. It is also commonly used in home-fashion articles such as draperies, upholstery, linens, and thread (Anonymous 2015f). Industrial uses of ramie include parachute fabrics, fire hoses, and canvas. High-quality paper goods, such as bank notes and cigarette papers, are produced from the short fibers. Research findings show the processing technology of cotton/ramie blends (Anonymous 2002a, b) on short-staple spinning system (cotton spinning). Because both of the fibres are of natural plant origin, the final products are environmental friendly. Different fashion items, such as *Lisingphee*, fancy ramie/cotton woven towels, fancy designed fabrics, etc., are some of the novel fashion products developed from cotton/ramie blended yarns. However, less effort has been documented in the sustainability of the product. The main problem associated with ramie fibre is its gum content. Ramie fibre usually contains as high

**Fig. 8** Blue-coloured ladies jeans



as 30 % gum. Two processes are normally used to extract the removal of gum of the fibre: One is chemical (alkaline treatment), and the other is microbial/enzymatic process. Although the microbial process is more sustainable, it is associated with greater cost and is a time-consuming process. China is popular for the development of eco-friendly sustainable ramie-based textile products for fashion products. Different international reputed companies (Joanna Hope linen blend trousers) are marketing ramie/linen *Kurti* for women’s fashion wear.

Banana fibre is another unexplored natural fibre used in the fashion industry for sustainable product development. These fibres are extracted from the pseudo-stem of the banana plant. The fibres are bleached and blended with jute fibre aiming for a diversified, value-added fashionable product (Debnath and Das 2012). The authors focused on different fashion products made from banana-based textiles. Sinha (1974a, b) is pioneer in making the effort to blend banana-based fibre for different product development. This work elaborates the use of white jute, tossa jute, and kenaf, which were blended at different proportions for the development of different sustainable products. Anonymous (2012a) reported conventional hydrogen



**Fig. 9** a Women's fashion gown made from nettle. b Women's fashion shawl made from nettle

peroxide bleaching, which is used to bleach the fibre, after which further dyeing is carried out. Trials have been performed on jute/banana fibre in different blend ratios (100:0, 75:25, 50:50, 25:75, and 0:100), and the properties of the yarn were compared. Due to the coarseness and brittleness of the banana fibre, 100 % banana fibre shows poor results when spun. Furthermore, Anonymous (2012b) disclosed further that bleached and dyed jute-banana fibre blended yarns can be used to develop ornamental fibre using a jacquard attachment on a handloom. The decorated fabrics are used for the development of fashion jackets and other garments. Hence, there is immense potential to design and develop green banana fibre based textiles (Basu et al. 2006; Basu and Roy 2008). Apart from these, in commercial market, a banana fibre cardigan by People Tree (Fig. 10), hand-crafted in Nepal using banana fibres with an open gauge finish, features a deep V neckline, raglan-style long sleeves, twin pockets at the hips, and a single button fastening at the front (Anonymous 2015i). In Denmark, pants designed with a logline fit (Fig. 11) are made from silky banana fibre based material. They are available online in Denmark from Edwin Milano Baker. Apart from these fashion garments, sarees (Fig. 12) made from silk/banana fibre blend material are also available in the global market (Anonymous 2015k). Banana fibre also found importance in the fashion footwear industry (Fig. 13), wherein every component of the fashion footwear can be made different parts of the banana plant. Overall, there is an immense scope for using banana fibre in the fashion industry for sustainable development. This remuneration is due to extra utilization, and hence income, from the unused part of

**Fig. 10** Fashion banana-fibre cardigan for women (Anonymous 2015i)



**Fig. 11** Logline-fit pants made from banana fibre (Anonymous 2015i)





**Fig. 12** Banana/silk blend fashion saree (Anonymous 2015k)



**Fig. 13** Banana-fibre fashion footwear (Anonymous 2015k)





the banana plant after the banana crops are harvested. Nowadays, there exist some online marketing industries that deal with banana fibre based fashion textiles globally (Anonymous 2015j, l).

Sisal is one of the unexplored fibres extracted from the leaf of the sisal plant. Brazil is a pioneer in cultivating this fibre for rope twine, paper, cloth, wall coverings, dartboards, etc., as well as for different fashion applications (Anonymous 2015m). The literature also reveals that different commercial manufacturers worldwide are involved in producing sisal-based fashion products (Anonymous 2015g, h, m, n). A Thailand manufacturer/exporter/wholesaler of natural handmade handbags based in Bangkok provides sustainable and trendy sisal ladies' handbags, shopping bags, cosmetic bags and cases, gift bags, promotional gifts, shoulder bags, hats, handmade baskets, etc., and other various products at very attractive prices. Apart from the green-fashion area of sisal fibres, this fibre is also blended with wool and nylon for manufacturing fashion carpets and rugs (Anonymous 2015n). One of the important fashion as well as utility product made from sisal is sisal-based body scrubber. Basu et al. (2012) highlighted different prospects including fashion aspects of Indian-variety sisal. Anonymous (2004) developed an innovative processing technology of sisal/jute blends for the production of body scrubbers that have potential to replace the existing shoddy nylon scrubber. Overall, there is huge potential to develop sustainable fashion product from sisal.

Coconut/coir fibre is extracted from the outer shell of the coconut fruit. White and brown coconut fibres are the two main types of fibre available. White fibres are extracted from the green (tender) coconut, and brown fibres are extracted from mature coconut; the latter takes 3–6 months of retting in brackish water (Bhattacharya and Basu 2009). There are evidences about the processing of coconut (coir) fibre (*Cocos nucifera*) in small-scale jute-spinning systems (Anonymous 2002b). Anonymous (2006a, b) developed different types of lightweight handbags of fancy designs that go nicely with fashion garments. Further, Anonymous (2012c) reported that jute (60 % plus 40 % coconut) can be blended further for the development of value-added jute/coconut fibre blend yarn. The blended yarn is further used for the development of ornamental woven fabric can be used for fashionable ladies slippers, decorative handbags, etc. Furthermore, work has been performed to soften the coir fibre for better flexibility, and attempt have been made to develop dyed jute/coconut fibre blend yarn. It has also been documented that ornaments such as fashion necklaces (Fig. 14) have been designed by artists in Papara, Tahiti, and French Polynesia wherein the hybridization of coconut fiber, coconut shell, and black pearl is used for the development of fashion items (Anonymous 2015o). Furthermore, fashion footwear (Fig. 15) also uses sustainable coconut fibre.

**Fig. 14** Fashion necklace made from the hybridization of coconut fiber, coconut shell, and black pearl



**Fig. 15** Unisex fashion footwear made from coconut fibre



### **3 Sustainable Fashion Industry—*Fashion Fibres, Fibres for Fashion Products, Product Diversification, Technology Gap, Economics in Using Known Natural Fibres in Fashion Industry, Problem Associated with the Fashion Industry***

Apart from cotton, silk, and wool, many other known plant fibres, such as jute, banana, sisal, flax, ramie, coir, etc., have immense potential in sustainable fashion-product development. Most of these fibres plants do not need specialized attention during the production of the fibre (coir, jute, nettle, banana, pineapple, etc.). Because of this, many of these fibres have been used together for several centuries before much development was made in science and technology. The main advantages of these natural fibres are that they come from plant sources and the process of producing them, from production to fibre extraction, is sustainable (Debnath 2015a). With advances in fibre technology, many synthetic/artificial fibres have been developed and used for past 60 decades. However, in the last 15–20 years, special attention has been given to using lesser quantities of synthetic fibre, and more emphasis has been placed on the use of natural fibres in different

areas of fibre application. With this, the production of natural fibre obtained special attention, and application of these fibres in different textile fields, including fashion, also increased. Due to the scarcity of agricultural land and urbanization in limited areas, greater amounts of fibre are being produced (for example 85–90 lakh bales/year of raw jute were produced during 1990–1995, and there was an increase in the production of 115–120 lakh bales/year during 2010–2013). However, along with this improved productivity, more importance is being placed on the sustainability of production systems.

In cottage and small-scale industries, fashion products are being produced directly from raw plant fibres without much use of chemicals and machinery. Some fancy items are also being produced in decentralized sectors. However, large industries, including composite plants, are used to producing fashion products in huge quantities. Many common products can be made from unexplored plant fibres such as sacks, both for packaging, agricultural applications (Debnath 2014a), etc. However, there will be huge value addition if we switch to the production of diversified fashion and lifestyle items from conventional products. Many of the industries processing natural fibres worldwide are now concentrating on value addition in product design. For instance, jewelry made from jute fibres/coconut/sisal fibres require a lower quantity (a few grams) of such fibres, and the value gain in final fashion products made of such fibre is a few hundred times. Hence, product diversification from conventional products is order of the day for sustainable development in the fashion industry.

In many cases, these natural plant fibres require tedious processes, including human drudgery, to extract the fibres from the plant component (Basu and Dutta 2014), and different chemicals and energy consuming processes (Debnath 2014c) are being used to convert those fibrous materials into yarn, fabric, and, finally, fashion products. These processes are compensated by extra profit when marketing those fashion items. With time, people are becoming aware about environmentally friendly/green chemicals and processes. Hence, more effort should be given, and in-depth research should be performed, to using more environmentally friendly chemical processing (Basu and Dutta 2014). It is also essential to use energy in an economical mode to form an overall sustainable process. For instance, in the jute industry, jute-batching oil is used to process the jute fibre during spinning. This oil is extracted during the petroleum-refining process and has been found to pose carcinogenic effects to human health. A substitute hydrocarbon-free oil has been developed, which is from vegetable origin and can be used to address this problem (Basu et al. 2009). However, this green-processing oil technology is somewhat less cost-effective and in some cases leads to technical problems during processing. Because some fashion products come into direct contact with the skin during their use, the eco-friendliness of the product—as well as the processes of its development—plays an important role.

Natural plant fibres have various advantages as reported by Anonymous (2015f). For instance, ramie fibre is highly absorbent, has a natural ability to resist stains, has a lustrous appearance, is strong and durable, is naturally resistant to bacteria, molds, and mildew, has low elasticity so it does not shrink easily, can withstand higher water temperatures, has good dimensional stability, is resistant to light, rot, and

insect attack, dyes easily, and the fiber can be bleached plus it absorbs heat and releases moisture making it comfortable to wear in warm weather, etc. The clothing and textile fashion industry recognizes ramie as a premium product because it is one of the strongest natural fibers. Ramie fibre can be up to 8 times stronger than cotton and has the quality of being even stronger when it is wet. Ramie is a member of the nettle family, so it is well suited to growing in tropical climates. This hardy perennial can be harvested up to six times a year with a useful crop life of 6–20 years, and it produces premium long vegetable fibers. It is a highly sustainable fiber source, which makes it a wonderful eco-friendly alternative to synthetic fibers. High yields of biomass are often produced, but ramie is susceptible to pests and disease. Fiber extraction is an expensive process, which leads to a higher price for ramie fibers (Anonymous 2015f). Unlike ramie, jute is also a highly sustainable fibre crop. It absorbs huge amount of carbon dioxide and makes the environment clean and pollution free (Bhattacharya 2013). Many of the unexplored fibre crops are also sustainable due to multiple use of the plant components such as coconut plant apart from the fruit, coir fibre, pineapple fruit and fibre from its leaf, banana fruit and fibre from the plant, linseed oil from the plant and fiber from the plant stem, etc. However, emphasis must be put on the extraction process to get a better economic return due to difficulties in fibre extraction (Basu and Dutta 2014; Bhattacharya and Basu 2009).

## 4 Conclusions and Future Prospects

Natural fibres are the ultimate resource for future fashion industries. Due to scarcities of natural reserve resources, synthetic fibre production will decline in near future. Optimum use of energy will produce a good amount of natural fibres, which as yet remain unexplored. Greater application of eco-friendly processing technology and product diversification will sustain the fashion industry. It can also be concluded from this chapter that there are many fashion/utility materials based on natural plant fibres (not explored much) that have immense potential with proper marketing, advertising, and appropriate technologies to convert those fibres into yarn and, finally, fashion products. Minimum use of man-made chemicals and maximum use of natural chemicals (natural dye) will lead to green process and a sustainable fashion industry. Finally, each and every fibre has unique properties, and thus blending them with different natural fibres or blending them with a minimum quantity of synthetic fibre will also provide diversified end uses as far as sustainable fashion is concerned.

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