PRODUCTION OF PLAIN WOVEN FABRICS FROM FLAX/COTTON BLEND YARNS AND STUDY OF THEIR PROPERTIES

BY

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DECLARATION

I hereby declare that this thesis titled "PRODUCTION OF PLAIN WOVEN FABRICS FROM FLAX/COTTON BLEND YARNS AND STUDY OF THEIR PROPERTIES" is my research work under the supervision of Dr. A.S. Lawal and Prof. P.O. Nkeonye and has not been submitted in any form for another degree or diploma at any other university or institution. All information from the literature has been duly acknowledged by means of references

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CERTIFICATION

This thesis, titled "PRODUCTION OF PLAIN WOVEN FABRICS FROM FLAX/COTTON BLEND YARNS AND STUDY OF THEIR PROPERTIES " by BAWA, Idris meets the regulations governing the award of Masters of Science Degree (Textile Science and Technology) of the Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This research work is dedicated to Almighty Allah for making the work possible.

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All Praises and thanks be to Almighty Allah (S W T), most beneficent and the most merciful. May the blessing of Allah be upon his noble prophet Muhammad (S A W), his household, companions and all those that follow his teachings to the last day.

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ABSTRACT

Blended yarns spun from different blend ratio (70/30, 50/50, 30/70, 10/90) Flax/Cotton and 100% Cotton were converted into fabrics through the integration of warp and weft yarns. The blend yarns were used as weft in the fabric construction using plain weave pattern. The properties of the produced blended fabrics were studied. The results show useful indications of the differences that exist in their physical and mechanical properties such as the fabric tensile strength, tearing strength, abrasion resistance, crease recovery, extension at break, elongation at break, fabric drape, fabric thickness, fabric crimp and fabric sett. From the study it was discovered that as the flax content in the blend is increased, both tensile, tearing, abrasion resistance, fabric thickness and fabric crimp reduces. It was apparent from the study that in order to produce material of good quality that may be used as apparel, the flax content in the blend would have to be reduced. The strength of the flax fibre was greatly affected during the cottonization process,due to the harsh treatment of the fibres during the cottonization

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CHAPTER ONE

1.0 Introduction

The properties of woven fabrics depend on the type and composition of fibres used. Thus, flax and cotton fibres are blended in order to achieve properties unachievable with single fibre type (Lawal, 2008).

1.1 Flax

Flax is a bast vegetable fibre that comes from the stem of an annual plant called "Linum ussitatissimum". The plant usually grows within the range of 40-90cm depending on the variety, soil fertility, plant density and available moisture. Other bast vegetable fibres include jute ,hemp, kenaf, ramie, sunn, and urena (Pringle,1949).

The physical and morphological structure of the plant revealed that the main portion of the flax plant is the woody trunk or boon, which is hollow in the centre. This is surrounded by the harl, which is composed of the soft bast, in which the fibres are embedded, hence the term 'bast fibre' and the outer covering or epidermis. The elementary flax fibres exhibit a polygonal shape with five to seven sides and they are assembled into bundles of 10-40 fibres. The bundles or 'compound' fibres ,run the full length of the stem and are joined to each other at intervals by insoluble gums or pectin (Pringle, 1949; Liholt et al., 1999).

The outer covering of the flax is coated with a thin, water proof, waxy skin or cuticle. The cuticle provides protection against microbial pathogens and water loss and is bound to the epidermis (Batra, 1998). The cuticle barrier is difficult to remove during retting and remains with the fibres with consequent poor quality yield leading to problems in processing and utilization. Scutching and hackling tend to break-up the

coarse bundle of fibres as they exist in the bast (Cook, 1984; Pringle, 1949), but do not separate the fibre strands into their individual fibre cells.

The flax fibres consist of highly crystalline cellulose fibres spirally wound in a matrix of amorphous hemicelluloses and lignin. They are oriented at a tilt angle of 10^0 to the axis of the fibre end, hence display an unidirectional structure (Baley, 2002). The polymer system of flax is more crystalline than that of cotton and therefore stronger, crisper and stiffer to handle, also , wrinkling more easily than cotton. The ultimate fibres are composed of micro fibrils which are spirally arranged with a diameter of about 0.5 mm. The cell wall of flax fibres is thick and polygonal in cross section and do not have the convolutions typical of cotton.

Flax plants are cultivated in various countries including Russia, China, Germany, Poland, Ireland, France, Belgium, South Africa and Holland. There are about one hundred species of flax known to botanists but of these only Linum Ussitatissimum is suitable for fibre production (Cook, 1984).

Raw flax fibre consists of natural cellulosic polymers containing up to 30 % of various non-cellulosic impurities. The impurities in the flax fibres are hemicellulosic, lignin or woody matter, pectin and small amount of fats, waxes, protein and residual ash. These impurities have negative effect on the fibre hydrophilic and absorption properties (Zhang et al., 2003; Fakin et al.,2006). There are various properties of textile fibres and they include tensile strength, fibre length, fineness, cohesiveness, pliability, uniformity, porosity, durability, etc.

The flax fibre is the strongest of the natural fibres. However, it should be noted that the strength of a yarn is not necessarily related to the strength of the fibre. This is because strong fibres badly arranged or constructed can produce a weak yarn (Pringle,

1949). The molecular structure of flax fibre is more ordered than the cotton fibre. Because of the molecular structure, the fibre is expected to have good strength, low elasticity, greater susceptibility to creasing and high abrasion resistance.The flax fibre is inferior to cotton interms of uniformity, so that flax yarns are characterized by pronounced irregularities when compared with cotton (Pringle, 1949; Kholar, 2005).

The suppleness and spinning power of flax fibre are closely related to the presence of natural wax. The removal of the wax content makes the fibre more brittle, rough and lusterless (Trotman, 1984). The flax fibres are good heat conductors with low heat retention. With these properties the fabric produced from the flax would have a cool feel during wear and would make it very suitable for summer and tropical wear. The tensile strength of flax fibres is 6.4 N/tex compared with 3.0 N/tex to 5.0 N/tex for cotton (Trotman, 1984). The breaking elongation of flax is 1.8 % for dry fibre, and 2.2 % for wet fibre. The flax yarn is about 20 % stronger when wet than dry (Trotman, 1984). Flax fibres differ from cotton fibres because of their longitudinal striations and modes (Peters, 1963)

The cohesiveness of a fibre is the ability of the fibre to cling together and is chiefly dependent on the nature of the surface of the fibres. Flax has a good cohesion in the compound states (Pringle, 1949), yet is inferior to cotton or wool in this respect, hence , these other fibres are much more easily handled than flax during processing. Flax fibres are not so pliable and elastic as cotton or wool fibres, both of which possess this property due largely to their natural crimp or waviness.

However, fabric produced from 100 % flax are noted for low crease resistance (Irish, 2005) and can be improved with newly developed wrinkle free finishes and blending with other fibres.

1.2 Cotton

Cotton belongs to the genius "Gossypium" of the natural order of malvacea or mallow family. The cotton fibres are seed hairs of the cotton plant and is regarded as the purest form of cellulose ever known (Trotman, 1984).

The plant is an annual crop grown in sub-tropical climates with different varieties cultivated according to geographical location including Nigeria. There are five different species of cotton namely: Gossypium barbadense, Gossypium herbaceum, Gossypium arboretum, Gossypium hirsutunm and Gossypium Peruvianum (Rollins, 1965; Lord, 2003). However, the fibres are classified as long, medium and short staple fibre. Important countries producing cotton include Egypt, United States of America, India, China, Russia, Brazil, Nigeria, etc.

The major constituent of cotton fibre is cellulose with up to 89.3 – 90.5 % cellulose in raw cotton. Other constituents include waxes, pectins, protein and cuticular matters. Cellulose being the major constituent in cotton is a linear polymer consisting of D-anhydroglucose units joined together by β-1, 4-glycosidic linkage.

The strength of cotton fibre may be attributed mostly to the cellulose content in the fibre and is related to a number of structural factors e.g molecular chain length and the orientation of the cellulose. From the stand point of processing, wax is the second most important constituent of the cotton fibre. The presence of wax is important for the attainment of proper spinning.

1.3 Blending

Fibre blending is defined as the process of forming a fibre mixture by combining different fibre components either of the same or different types to produce a homogenous fibre assembly (El-Mogahzy, 2004; Membree, 1959). Blending is

therefore important where the yarn is intended to consist of mixture of fibres. It should be noted that each fibre has its own known characteristics and properties. These properties may be some advantages or constraints as the case may be for a particular fibre.

However, in order to obtain the best fabric for a particular purpose at a suitable price, one often can achieve the desired result by blending fibres. As mentioned earlier, the blending of the fibres leads to the attainment of a mixture of characteristics of the individual fibres in the blended fabric.

Therefore, textile manufacturers tend to blend in order to achieve improvement in quality and processing performance. Other advantages include reduction/control of cost and to meet functional end-use requirements e.g. tensile and tear strength, abrasion resistance, drape, elongation, permeability, absorption etc. Research has shown that moisture absorption improves when flax is blended with cotton (Foulk and Danny, 2001), On the other hand, yarn strength is often lowered or reduced when flax is blended with cotton (Morrison and Danny, 2001). One of the reasons may be attributed to the brittle nature of flax fibres which lack crimp and convolution to effectively produce the necessary cohesiveness between two cellulosic fibres (Schulze, 1998).

Another research has shown that yarns with flax fibre contents have good hygienic, antistatic and UV-protective properties. These properties themselves are amenable to several applications (Czekalski, et al., 2000).

1.4 Fibre Distribution in Blended Yarn Structure

The mechanical properties of staple yarns not only depends on the physical properties of the constituent fibres but also on the yarn structures as characterized by the

geometrical arrangement of fibres in the yarn (Hamilton, 1958: El-behery and Batavia, 1971). When processing yarns from different blends of fibres, it is necessary to know how the blend component are arranged over the yarn cross section. This makes it necessary to elucidate some of the surface properties of the finished article and to determine the relationship between the distribution of the blend components and the properties of the fibres in the blend (El-behery and Batavia, 1971).

The fibre movement at the point of yarn formation and the ultimate position of fibres in the yarn structure is called the fibre migration (Ramakrishnan, 2007). The migration behavior of a fibre is affected significantly by the inherent properties of fibre such as fibre length, fibre fineness, crimp, cross sectional shape and the inherent characteristics of the adopted processing system. Factors such as fibre properties, yarn properties, spinning system adopted influences fibre migration. Physical properties such as lengths, fineness, cross sectional shape, frictional properties, fibre substance and mechanical properties such as tensile modulus, bending modulus, tensional rigidity, elastic recovery and extensibility influence fibre migration. Generally, finer and longer fibres tend to move to the core and shorter and coarser fibres moves outward and increase the yarn hairiness. The fibre arrangement in the blended yarn affects its properties, hence the properties of blended yarn or fabric cannot be explained merely in terms of the properties and proportions of the different constituent fibres in the blend, the geometrical arrangement of the fibres must be taken into account (Morton and Yen, 1952). For example, properties such as the strength, abrasion resistance and surface appearance of the blended yarn, depend not only on the ratio of the different fibres in the blend but, also on the relative position of the different constituent fibres in the yarn (Hamilton, 1958). Similarly, fabric

properties such as drape and strength are also strongly influenced by the fibre arrangement in the blend (Hamilton, 1958; El-Behery, 1968).

Fibre distribution in yarn exhibit different characteristics depending on the system used. The degree of fibre migration on open end yarn is much lower than ring spun yarn. In open end rotor spinning which was used to produced the blended yarns, fibres accumulate in rotor groove and are twisted in to yarn under very low tension variation within a strand. At its core, rotor yarn has almost the same structure as the ring yarn but the yarn surface consists of fibres experiencing different twists and almost no migration. Therefore fibres in rotor yarn take part in migration to a lesser extent than ring yarn and hence the strength realization is less than that of ring yarn (Ramakrishnan, 2007).

In view of the foregoing development, this research is intended to explore the use of the blended flax/ cotton of different ratios to produce fabric and investigate some of the physical and mechanical properties of the fabric.

1.5 Statement of The Research Problem

This research work is a continuation of the research carried out by Lawal in the area of spinning flax/cotton blend staple fibres (Lawal, 2008)

One of his major recommendations was that further research should be carried out to convert the processed yarns into fabric. (Lawal, 2008). Therefore, this research is intended to:

1. Convert the rotor spun yarns produced from the flax/cotton blend into fabrics.
2. Evaluate the woven fabric produced from the blended yarns with respect to some of the physical and mechanical properties. With these, it is expected to give proper understanding of the parameters used on the woven fabrics.

1.6 Objectives of the Research

1. Wind the blended yarns from the cone unto the pirns
2. Construct woven fabrics using the blended flax/cotton yarns as weft or filling while sized cotton yarns as warp.
3 Examine some of the physical and mechanical properties of the fabrics such as tensile strength, tearing strength, abrasion resistance, elongation etc. in order to fully assess the quality of fabrics produced from the different blends of flax/cotton yarns.
4. Recommend the areas that may require further research work.

1.7 Scope of Work

1. A brief introduction on the constituent fibres in the blended yarns.
2. Literature review on the various parameters to be examined under the research.
3. Determine the various instruments to be used in conducting the various tests.
4. Conduct a pirn winding operation using the Ishikawa-Seisakusho winding machine from the Zaria Industries Limited.
5. Carry out weaving operations using a conventional tappet loom from the Textile Science and Technology Department, Ahmadu Bello University, Zaria.
6. Analyze the results with a view to identifying the best end-use of the blended fabrics.

CHAPTER TWO

2.0 Review of Literature

2.1 Effect of Spinning Parameters on the Fabric

It is obvious that the insertion of twist in fibre assembly affects, in addition to the tensile properties, the diameter and the specific volume of yarns (Lawal, 2008). In fact there is a certain minimum value of twist below which it is impossible to spin a staple yarn (Lawal, 2008). An understanding of some certain variables having direct relationship with the analysis or evaluation of the fabric is very imperative. These include the raw material characteristics, the yarn structure (including count, irregularity, twist factor etc) as well as the fabric structural properties (Jinlian, 2004).

As mentioned earlier, the twist level may determine the spinnability of a particular fibre or blend of fibres. Lawal (2008) in his research work showed the effect of twist on the tenacity and extension of flax/cotton blended open end spun yarns. It was very clear that as the flax content in the blend increases it becomes very difficult to spin the yarns especially the 70:30 and 50:50 blend ratios. To spin these yarns, higher twist level had to be employed during the spinning of 50:50 and 70:30 flax/cotton blended yarns (Lawal, 2008). It should be noted that upon reaching the optimum twist level a particular blend of fibres can be spun, any further increase in twist will lead to a decrease in the tenacity of the produced yarn and the subsequent fabrics to be produced. This is clearly shown from the data shown in Table 1 for the 50:50 and 70:30 blended flax/cotton yarns (Lawal, 2008) .

Table 2.1: Effect of Twist on Tenacity and Extension of Flax/Cotton Blended Open-End Yarns (Lawal, 2008).

Blend ratio (flax/cotton)	Linear density (tex)	Twist (turs/m)	Tenacity (cN/tex)	CVm (%) of tenacity	Extension (%)	CVm (%) of extension
70:30	39	1345	5.89	13.31	4.15	11.33
50:50	39	1055	9.86	10.61	6.55	8.69
30:70	39	765	10.18	9.13	6.75	6.46
10:90	39	765	12.65	5.83	8.50	4.03

Increase in yarn twist will cause the fibre angle of inclination to increase with respect to the yarn axis. This leads to decrease in the component fibre strength in the direction of yarn axis. Consequently, fabrics produced from such yarns when subjected to tensile strength test may have weaker tensile behaviour. Theoretically, fibre strength makes its maximum contribution to the yarn strength when the fibres lie parallel to the yarn axis. From the results of the yarn properties as presented by Lawal in his research work (Lawal, 2008), it would be observed that the tenacity of the yarns decreases with an increase in the flax content in the blend. The high number of floating fibres i.e. short fibres especially from the flax fibre may be one of the reasons. This is because the presence of too many floating fibres will cause irregularity in the yarn which may affect the yarn strength (Lawal, 2008).

In terms of breaking extension of the yarns, it would be realized that as the twist level increases, the breaking extension also increases. The result also shows that as the flax content in the blend composition increases, the breaking extension tends to decrease. Therefore the flax fibres in the yarn cross section would have to bear greater part of the load applied. From the above explanation, it would be predicted that fabrics made from a higher blend composition of flax would have the tendency of having lower extension at break. The total number of yarn imperfections increases with an increase in the flax percentage or composition in the blend. This could be as a result of high number of floating fibres. It would also be noticed from Lawal research work that as both the twist and flax content increases, the hairiness value gradually increases as shown in Table 2.2 (Lawal, 2008) These may influence the abrasion resistance of the resultant fabrics when subjected to rubbing action.

Table 2.2 Effect of Twist on Evenness and Imperfection of Flax/Cotton Blend used on the Construction of the Fabric Sample (Lawal, 2008)

Blend ratio	Linear density	Twist (turns/m)	Imperfection /Km			Total imperfection/ Km	Hairiness
			Thin places (-50%) per Km	Thick places (+50%) per Km	Neps (+200%) per Km		
70:30	39	1345	2096	1030	3239	6365	5.80
50:50	39	1055	224	385	1832	2441	5.45
30:70	39	765	4	157	288	451	5.03
10:90	39	765	0	10	35	44	2.81

2.2 Mechanical Behaviour.

Textile materials differ considerably from conventional engineering materials in many ways. They are inhomogeneous, discontinuous, non-linear and highly anisotropic in nature. They are easily deformed, suffering large strains and displacement even at low stress, under ordinary conditions or in normal use (Jinlian, 2004).

The geometric structure of a fabric is extremely complicated especially when the cross-sectional and surface images of the fabric is viewed (Jinlian, 2004). On the general note however, every piece of woven fabric is an integration of warp and weft yarns through intersection. The extent of this interlacing is largely dependent on the friction between fibres and yarns entanglement. The distance between two parallel adjacent yarns determines the porosity of a fabric structure and it is such discrete porous structure that distinguishes fabric from a continuous engineering structure and /or materials (Jinlian, 2004)

Grosberg and his co-workers at the Leeds University in the 1960s pioneered the theoretical analysis of fabric mechanical properties such as tensile, bending, buckling, shear and compression etc.(Grosberg, 1966; Grosberg and Park, 1966; Grosberg and Swani, 1966). Their contributions led to a relatively clear picture of the physical and mechanical description of woven fabrics and their deformation properties.

Another research by Lindberg et al., (1960) in the late 1950s and early 1960s extensively studied the mechanical behaviour of fabrics and related the basic mechanical properties of fabric to the tailorability and appearance of manufactured clothing. Their investigations became the focus of serious work by other researchers. Experimental techniques for the measurement of these mechanical properties have been evolved over a number of years by many researchers. A variety of equipment and test methods are now available. These also form the basis for the development of

fabric objective measurement techniques especially in the structure and mechanics of woven fabrics (Jinlian, 2004).

As the consumers have become increasingly sophisticated in their demand for quality textile products that would meet their variety of needs and requirements it thus calls for automatic and objective evaluation of fabric appearance with respect to such characteristics like abrasion, tearing strength, tensile, elongation, hairiness etc. An understanding of the formation mechanisms of fabric is useful for fabric design and process control. This includes investigation of the relationship between fibre properties, yarn structure and properties, fabric construction and fabric physical properties. All these issues add up to a need for greater knowledge and more thorough understanding on the fabric structure and mechanical response (Jinlian, 2004).

2.2.1 Fabric Sett

In woven fabric the warp yarns are commonly referred to as ends and the number of warp threads per centimeter width of a given cloth or fabric are referred to as the ends per centimeter. The threads of the weft are called picks and the number of weft threads per centimeter width of a given fabric is known as the picks per centimeter. Consequently a fabric may therefore be described in terms of ends and picks since the fabric is an integration of warp and weft through intersection (Jinlian, 2004).

Fabric sett is one of the fabric structural parameters that may influence mechanical and end-use properties of a given fabric. It is obvious that with higher number of ends and picks per centimeter in a given fabric, there would be increase in the number of interlacements per unit area in that given fabric.

The influence of fabric structures on its air permeability and abrasion resistance was investigated by some workers (Milasius et al., 2003). They established that when a

fabric structure stiffened its air permeability decreases while on the other hand there would be increase in the abrasion resistance of the fabric. This is so for the air permeability because the greater the value of the thread density, the more resistance to air due to fewer openings in the fabric. As for the abrasion, this is due to the fact that more number of yarns get abraded during the act of abrasion (Milasius et al., 2003) .

There are five different methods of determining the fabric sett of a given fabric i.e. (epcm x ppcm) and these includes; one-inch counting glass, traversing thread counter, fabric dissection, parallel line gratings and the taper line grating (B.S.2862, 1957) . It should be mentioned here that the regions near the selvedges should be avoided when counting the threads; this is because the spacing of the threads is often a little different than in the body of the cloth.

Five readings of every sample are taken to represent the threads per unit length of one material. From the average number of threads per cm, the thread spacing can then be calculated using the formula below:

$$Pi = \frac{1}{nj} \qquad ij = 1, 2, 3, \ldots\ldots.$$

Where

$$P = thread\ spacing$$

$$n = threads\ per\ unit\ length$$

2.2.2 Crimp

Generally when warp and weft yarns interlace in fabric, they follow a wavy or corrugated path. Therefore an attempt to measure the crimp percentage has to do with the determination of the waviness in yarns in a given fabric.

However, in his paper on cloth geometry Peirce (1937) described Crimp geometrically as the percentage excess of length of the yarn axis over the cloth length. On the other hand, crimp % as described in B.S Handbook, is defined as the mean difference between the straightened thread length and the distance between the ends of the thread while in the cloth, expressed as a percentage (B.S 2864, 1974).

Crimp amplitude, a term used in the fabric mechanics or geometry, refers to the extent to which threads are deflected from the central plane of the cloth. In this context, it is assumed that the yarns are circular in cross-section and remain so when in the cloth.

Presently there are two methods for the measurement of the crimp in a woven fabric namely, the image analysis and the tension method. From the definition of crimp, two values or parameters must be known for the measurement of crimp percentage. These include, cloth length from which the yarn is removed and the straightened length of the thread. In order to straighten the thread, tension must be applied just sufficient to remove all the kinks without stretching the yarn (Booth, 1968). Several crimp testers are available and they include the ones designed and developed by British Research Associations, the W.I.R.A and Shirley crimp testers.

The crimp of a given fabric is an important parameter which affects most of its physical properties. Crimp is dependent on many factors such as the bulkiness of the yarn, yarn bending stiffness, yarn packing density as well as the fabric design and construction (Punj et al., 2004). It is obvious that with an increase in yarn diameter, yarn has to take the longer path in the fabric and this will increase the crimp amplitude. From the result of yarn imperfections shown in Table 2.2 it is obvious that the yarns, even though are of the same linear density (tex), yarn imperfection increases with increase in the flax content in the blend. Fabrics produced from such blend would therefore be marked with imperfections.

2.2.3 Fabric Thickness

Fabric thickness is an important parameter in studying the fabric characteristics such as thermal insulation, resilience, dimensional stability, fabric stiffness and abrasion resistance (Booth, 1968).

The amount of twist in a yarn influences the crimp, which in turn is related to many fabric properties such as the thickness, cover factor, handle and flexibility (Booth, 1968). Yarn diameter also has a lot of influence on the thickness of a given fabric.

As mentioned earlier, textile materials are readily compressed and therefore the instrument for the measurement of fabric thickness differs from the ones used in the measurement of engineering materials.

Fabric thickness involves the precise measurement of the distance between two plane parallel plates when they are separated by the cloth. It is convenient to regard one of the plates as the presser foot and the other as the anvil (Booth, 1968).

The study of the fabric thickness is important because results obtained from the thickness test may be used in various ways. These include the checking of materials against specification in production, the study of other fabric properties such as the thermal insulation, resilience, dimensional stability, fabric stiffness, abrasion, etc. The results from the thickness would also assist in the study of fabric geometry (Booth, 1968).

There are various instruments designed and produced for the measurement of fabric thickness including the Heal's thickness gauge, Reynolds and Branson cloth thickness tester, Essdiel thickness gauge etc.

2.2.4 Drape

Drape is a property of textile materials which allows a fabric to orient itself into graceful folds or pleats when acted upon by force of gravity (Chu, et al., 1950). On the other hand, drape is a description of the deformation of the fabric produced by gravity when only part of it is directly supported (Cusick, 1965).

In a broader sense, drape of a fabric refers to the manner in which the fabric hangs, shapes and flows on the model form, such as on the body and furniture, by gravity when only part of it is directly supported (Jinlian, 2004). In some literature however, wrinkling, buckling, handle and bending may mean drape.

According to IS-8357/1977, drape is defined as the extent to which a fabric will deform when it is allowed to hung under its own weight.

Drape is an important subjective performance characteristics that are evaluated at least in part by personal reaction (Bhalerao, 2007). As mentioned in the literature , drape differs from rigidity because the weight of material influences a deformation at some angle to the line of action. The specimen usually deforms with a multi-directional curvature and the result is dependent upon the shear stiffness of the fabric in addition to bending stiffness. It should be recalled that drapability is inversely proportional to drape coefficient (Punj, et al, 2004).

Research into the theoretical and practical aspects of this important topic originated in 1930s (Peirce, 1937). For several decades , his paper has been regarded as a benchmark and a source of investigation for many researchers, particularly since the year 2000. The investigation of fabric drape has attracted the attention of many researchers. This is partly because of the attempt to realize the clothing Computer Aided Design (CAD) system by introducing fabric properties in which the fabric drape is the key element (Jinlian, 2004) .

In the past, the cantilever test was mainly used to determine fabric stiffness and equally used to obtain the result for the drape. This is in recognition that stiffness has a large effect on drapeability. It should be noted that the cantilever test utilizes the response of a fabric under its own weight which is essentially the drape behaviour of a fabric in only two dimensions.

Drape may be classified into two categories, namely, the two-dimensional in which fabric bends under its own weight in one plane and the three-dimensional drape which allows a fabric to be deformed into folds in more than one plane under its own weight. The study of three-dimensional drape was initiated by Chu et al (1950) when they established a measuring method for fabric drape using the F.R.L drapemeter. Chu quantified the drapeability of a fabric into a dimensionless value termed the drape coefficient. The drape coefficient which measures the drape of a fabric has a theoretical maximum of 100 and minimum of zero depending upon the shear stiffness and bending stiffness of the fabric.

The apparatus (F.R.L Drapemeter) was further studied by Kaswell (1953) and later revised by Chu et al, (1960,1962). Cusick (1968) further re-investigated the experimental method by using a parallel light source which reflects the drape shadow of a circular specimen from a hanging disc onto a paper ring. In recent years, the emphasis has been on improving the efficiency and accuracy of Cusick's drapemeter by using digital readout of the drape shadow from photovoltaic cells (Collier, et al, 1991), as well as computerized image analysis (Vangheluwe and Kiekens, 1993). Further attention of researchers has been attracted since the year 2000 with attempt to investigate fabric drape using the Clothing Computer Aided Design (CAD) system (Jinlian, 2004).

Drape coefficient which is a measure of drape, is a number with a theoretical maximum of hundred and a minimum of zero depending upon the shear stiffness and bending stiffness of the fabric.

In the Cusick's modified formula, the drape coefficient is defined as the ratio of the paper weight from the drape shadow W_2 to the paper weight of the full specimen W_1 (Jinlian, 2004). This can be represented in the formula below:

$$DC\% = \frac{W2}{W1} \times 100\%$$

Where

$$DC = drape\ coefficient$$

$$W1 = Paper\ weight\ from\ thebdrape\ shadow$$

$$W2 = Paper\ weight\ of\ full\ specimen$$

The quantitative value of DC% can represent the drapeability of fabrics in three dimensions. It should be noted that DC% is high on stiff fabrics but is low on limp fabrics.

2.2.5 Crease Recovery

Many materials resist creasing and deformation and are therefore rigid. However, what is required is a textile product which can be deformed but rapidly recovers from deformation. In this context, some resilience which includes some resistance to creasing with a powerful and rapid recovery therefore, is needed (Kaswell, 1953).

The molecular structure of fibre has a considerable effect on the creasing properties of a given fabric. It should be noted that the flax fibre molecular structure is more ordered than that of cotton and posses greater susceptibility to creasing (Peters, 1963).

Research has shown that fabrics produced from 100% flax are noted for low crease resistance (Irish, 2005).

It should be noted that cellulosic materials are notoriously susceptible to creasing. Creasing is usually more evident in fabric produced from fibres that are hydrophilic in nature such as cotton. The creasing of cotton may be due to its amorphous structure which allows relative movement of its molecules (Alonge, 2004).

The creasing of textile material is a complex effect involving some parameters such as tensile, flexing, compressive, as well as torsional stresses. The tensile extension plays a relatively small part in elastic recovery of material, while the bending elasticity seems to be of great importance in the phenomenon of creasing.

Literature has shown that amongst the common textile materials the order of diminishing crease resistance is wool, silk, acetate rayon, viscose rayon, cuprammonium rayon, cotton and flax (Booth, 1968). The fabrics of linen are notoriously bad in respect of creasing and this may be attributed to the high degree of the orientation of the cellulose in the fibre. Other factors in relation to crease recovery of fabric include the plastic behavior of the fibre, and the geometry of yarn in the fabric.

The crease recovery angle tester is one of the instruments used to determine the recovery from creasing of a horizontally folded specimen by measuring the angle of recovery.

2.2.6 Abrasion Resistance

Abrasion is an aspect of wear which has to do with the rubbing away of the component fibres and yarns in a given fabric with the result of reducing the serviceability of the article (Booth, 1968). Abrasion resistance therefore is the ability

of an article or fabric to withstand rubbing (frictional force) applied to its surface**.** Fabrics with high abrasion resistance retain their physical integrity while fabrics with low abrasion resistance become thin and/ or develop holes.

The parameter is of great concern especially in assessing fabric performance when in use. Abrasion resistance of any given fabric is highly dependent upon the yarn breaking strength from which it is composed. It has been claimed that yarn strength is often lower when flax is blended with cotton (Foulk and Danny, 2001). Thus higher content of flax fibres would lead to lower yarn strength. This may be attributed to the brittle and straight nature of flax fibres which lack crimp and convolutions to produce the necessary cohesiveness between two cellulosic fibres (Schulze, 1998) . It has been shown that the cohesiveness of flax fibre is generally inferior to cotton and thus making flax fibres more difficult to handle during processing (Pringle, 1949).

Another structural parameter that may influence the abrasion resistance properties of a given fabric is the fabric structure (sett). It has been established that as the fabric structure stiffened, there would be an increase in the abrasion resistance (Milašius, et al ,2003) . This is evident because more number of yarns in cross -sectional area get abraded during the abrasion action. With an increase in the picks per centimeter , there would be an increase in the number of interlacing per unit area of the fabric. This trend ultimately increase the frictional resistance between the two sets of threads and increase the abrasion resistance. Another parameter that may influence abrasion resistance is the fabric thickness.

There are basically three broad divisions of abrasion (Booth, 1968) namely;

i. Plane or flat abrasion

ii. Edge abrasion

iii. Flex abrasion

Flat Abrasion:-This has to do with the rubbing away of component fibres when a flat area of the material is abraded.

Edge Abrasion:- This is the rubbing away of fibres from the fabric as a result of folding action as it occurs in the collars and folds.

Flex Abrasion:- In this kind of abrasion rubbing is accompanied by both flexing and bending.

It is however, imperative to note that in actual service a complex mixture of some or all types may be encountered by the materials.

Fabric made from fibres that possess both high breaking strength and abrasion resistance can be worn often and for a long period of time before signs of physical wear appear. The resistance of fabrics to abrasion according to Backers (1951) should be restricted to the ability of a fabric to withstand direct rubbing under condition of intended use. He further discussed a general fabric abrasion mechanism. The methods includes; frictional wear, surface cutting and fibre plucking or slippage (Backer, 1951) It should be noted that fibres that are not firmly held in the yarn are readily subjected to plucking action of the abradant while those held firmly will suffer frictional wear (Kaswell, 1946).

2.2.7 Fabric Tearing Strength

The tearing strength is one of the most important characteristics governing fabric performance in use. Fabric which tears easily is usually regarded as an inferior product except where an easy tear is essential e.g. bandages and adhesive tapes (Booth, 1968) Studies on the resistance of a fabric to tearing has been conducted by various researchers and the following conclusions were made:

(i) During tear, threads break singly or in very small groups which mean the single thread strength of the component yarns is of great importance in the determination of the fabric tearing strength.

(ii) Under the force of tearing agency, where the fabric characteristics allow the threads group closer, instead of the successive breakage of individual threads, the action becomes more of a strength test on plied yarns. The grouping of the threads may be easier if the yarns are smooth and can slip over each other.

(iii) The effect of weave is another important parameter in determining the tear strength of a given fabric. Thus, a twill or a 2/2 matt structure allows the thread to group better than a plain weave. Twills and matt weave exhibit better resistance to tearing than plain weave.

(iv) High-set fabrics preclude thread movement and the assistance by thread grouping is greatly reduced.

(v) Special fabric finishes such as drip-dry and crease resist treatment may reduce the tearing strength (Booth, 1968)

It has been pointed out that many tears in practice occur suddenly and that a tearing test should be made at high speed rather than at the normal slow traverse speed of tensile tests (Booth, 1968). Some of the instruments used in the measurement of tear strength of fabric include the Instron machine, Elmendorf tearing tester and the Shirley double pendulum ballistic tester.

2.2.8 Tensile Properties of Fabrics

It is desirable that fabrics strength be adequate to withstand any stress to which the article would be subjected to during use. It is important to note that most domestic and

apparel fabrics are subjected to not only tensile but also bending and tensional stresses.

The deformation of garment with the application of small loads may take place progressively under cyclic loading conditions. However, the end point of acceptability may be reached on aesthetic grounds before physical break down of the fabric occurs (Weston, 1974).

Fabric produced from strong fibres will tend to have adequate strength for the selected end use and care. On the other hand, other factors may tend to influence the strength properties and the resultant fabric may be subjected to quick wear due to low resistance to tear and pulling stress.

When extending textile fabrics to breakage, it is possible to determine the half cyclic breaking characteristics. This includes the breaking loads, breaking elongation, work of rupture, the stiffness and extension. The breaking load (N) is the maximum stress which fabric withstands up to breakage. The breaking elongation is the increment of length of the extended test strip or fabric to the moment of breakage (Koblyakov, 1989).

When load is applied to a particular fabric, the crimp in the direction of loading is gradually reduced while the crimp in the transverse threads increases. This is referred to as crimp interchange (Booth, 1986).

The visible effect of the crimp interchange is “the wasting” of the specimen. This causes contraction in width greatly in the middle and decrease towards the Jaws. In the region of the jaws, the stresses in the specimen are high and can be the cause of jaw breaks (Booth, 1968).

The concept of fabric strength is thus a complex one as series of variables would come to play a part in its determination. These includes fibre characteristics, yarn

structure (count irregularity, twist factor etc), fabric structure (setting, crimp weave) and also fabric finish.

Yarn strength is a parameter which influences many mechanical and end-use properties of a given fabric. Nikolic et al, (2000) in his research expressed fabric strength by the thread strength , fabric setting and thread strength coefficient. It was established that with an increase in thread strength , the fabric strength also increases. The changes in the strength of a blended yarn and by extension that of the fabric may be attributed to the breaking extension of the constituent fibres (Hearle,1969). It would be recall that the breaking extension of cotton is 11.9% while that of flax is 10.5% this shows that flax fibre has a lower breaking extension value than that of cotton fibre. The behavior of a blended yarn when subjected to a load is such that the fibres of both blend component will be extended as the applied force increases until the fibres with the lower extension breaks and therefore transfers the entire load to the other fibres (Lawal, 2008). The presence of sufficient fibres with higher extension in the yarn cross section will cause the blended yarn to continue to deform without registering failure. However, the effect of fibre slippage is also of great concern in the analysis of fabric tensile properties.

CHAPTER THREE

3.0 Materials and Methods

3.1 Materials

The materials comprises of samples of blended yarns in the ratios of 70:30 flax/cotton (Sample A), 50:50 flax/cotton (Sample B), 30:70 flax/cotton (Sample C), 10:90 flax/cotton (Sample D), and 100% cotton yarns (Sample E) which serves as the control sample. These materials were used as weft yarns in the fabric construction. The materials were obtained from the Council for Industrial and Scientific Research (CSIR), Port Elizabeth, South Africa.

The other sized cotton yarns (20cc) were obtained from Zaria Industry Limited, Nigeria, which serves as the warp yarns on the weaver's beam.

3.2 Equipment

In this research work, the following equipments were used;

Winding machine

Tappet loom

Shirley crimp tester

Digital weighing balance

Counting glass

Essdiel thickness gauge

Cusick drape tester

Martindale abrasion tester

Shirley crease recovery tester

Testometric testing machine

Elmendorf tearing tester

3.3 Fabric Production

3.3.1 Pirn Winding Operations

The weft yarns used in the fabric construction were obtained in cone package and because the weaving machine is a shuttle loom it becomes obvious that pirn winding operation has to be done in order to transfer the yarn from the cone unto the pirn. The machine used is the pirn winder produced by Ishkawa Seisakusho Ltd obtained at the Zaria Industries Ltd.

The yarns from the cones were creeled unto the pirn winder frame. The diameter of the pirn used was determined depending on the type and size of the shuttle used. The yarn traverse length was set at less than 45^0 and the yarn from the cone was then passed through the tension device and set at the required tension . Because of the low strength of the yarns, which makes it impossible to wind at various tensioning levels, the tension device was then set at zero. The yarn from the tension device was then passed through the protector device, guide and then unto the pirn. Four pirns from each of the yarn samples were produced at a machine speed of 450 rpm.

3.3.2 Weaving Operations

The machine used in the construction of the fabric was a Northrop shuttle loom. With the power switch of the machine switched on, demarcation threads were inserted manually i.e. using coloured sewing thread to the cloth felt on the loom. It should be noted that the warp beam consist of sized cotton yarns of 20cc

The first set of pirns from a particular blend of yarn was then introduced into the shuttle for the commencement of the weaving operation. The weave pattern used was the plain weave. From each of the five samples of yarns blends (A) 70:30, (B)50:50, (C)30:70, (D)10:90 and (E) 0:100 flax/cotton, four pirns were used from each. Upon exhausting the four pirns of a particular blend yarn, another demarcation threads were

inserted into the shed to create a barrier between the different blend fabrics produced. Two yards of fabrics were produced from each of the class of yarn blends

3.3.3 Fabric Conditioning

All the fabric samples produced were conditioned under standard atmosphere for testing for at least 48 hours to attain a relative humidity of 65± 2% and a temperature of 20± 2^{o}C.

3.4 Fabric Testing

3.4.1 Yarn Crimp Measurement

This test method covers the determination of the relationship between the length of a piece of fabric and length of yarn in the fabric and was carried out in both warp and weft directions for each of the fabric samples. The Shirley crimp tester was used in the measurement using the British Standards method (BS 2863,1972).

The conditioned fabric was laid flat and kept free from tension and creases, after which a square strip (20 cm by 20 cm) was cut out of the sample fabrics. A dissecting needle was used gently to remove from the flap the outermost yarn while ensuring that the loss of twist is avoided. The last part of the end was then inserted into one grip of the apparatus. The grip was then closed to permit the withdrawal of yarn under slight tension until its end coincides with the datum line in the mirror on the apparatus. The straightened length of the thread was then measured. This was repeated for twenty threads in both warp and weft directions for all the sample fabrics. The mean, the coefficient of variation and the percentage yarn crimp were obtained. The formula used in calculating the % crimp is shown below;

$$\%\ Crimp = \frac{straightened\ yarn\ length - length\ in\ \ fabric}{length\ of\ yarn\ in\ fabric} \times 100$$

Where $Length\ of\ yarn\ in\ fabric = 20\ cm$

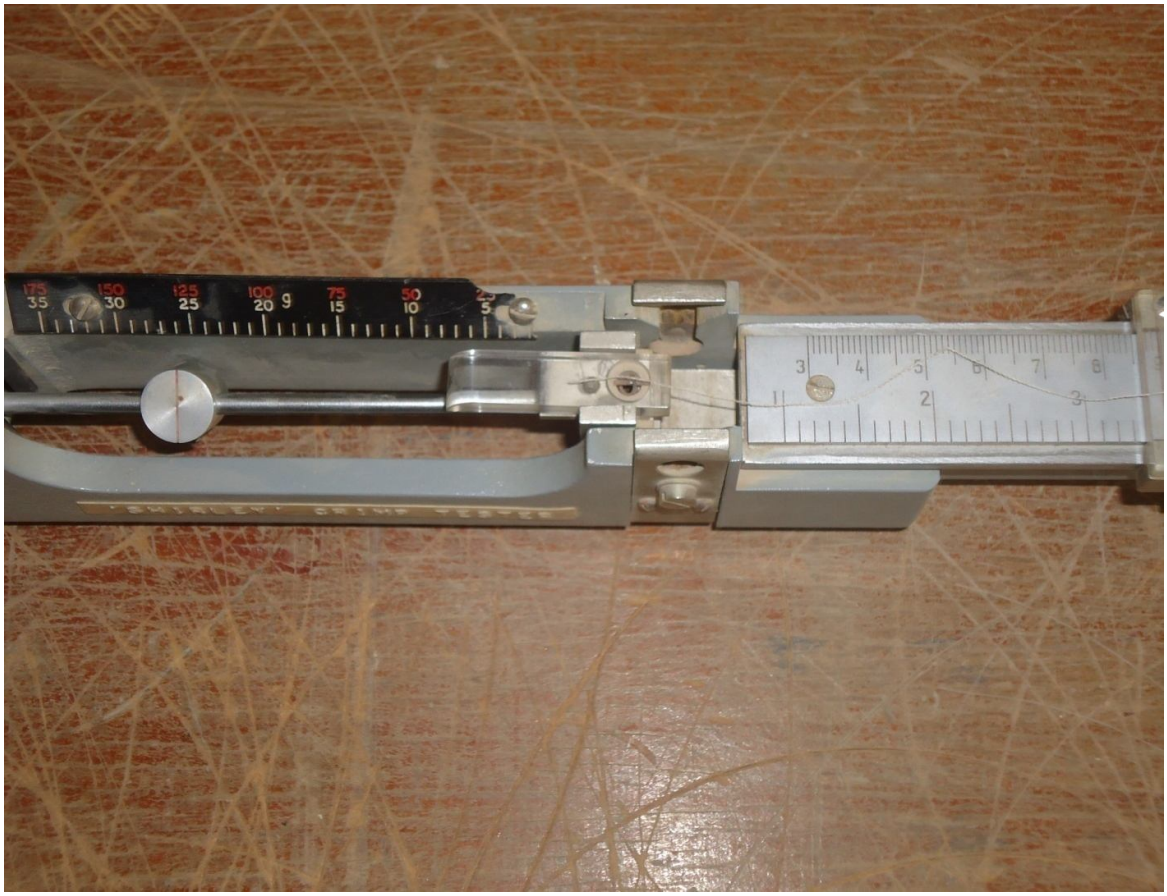


Plate 3.1: Shirley Crimp Tester

3.4.2 Determination of Fabric Sett

This test was carried out in accordance with the method described in BS Handbook, 1972; using the counting glass system.

The fabric sample was laid flat on a horizontal surface and the counting glass placed on it so that one of the edges of its aperture becomes parallel to the warp threads. The number of warp yarns (ends) per centimetre (epcm) was then counted and recorded. With the other edge of the aperture parallel to the weft direction, the number of weft (ppcm) were counted and recorded. This was repeated on five different portions of the fabric sample for all the sample fabrics. The mean for ends and picks per centimetre were then calculated.



Plate 3.2: Counting Glass

3.4.3 Determination of Fabric Thickness

This test was carried out in accordance with the procedure in BS Handbook 2544, 1967 using the "Essediel thickness guage. The test specimen's area for all the sampled fabrics was randomly selected.

The surface of the anvil was cleaned and the instrument was adjusted until the guage reads zero, the plates were then separated and uncreased, part of the specimen was placed in contact with the anvil without tension. The reading of the guage was observed and fabric thickness recorded. The pressure used was 1.96 $x10^{-3}$ N/mm^2. This was repeated ten times for all the sample fabrics. The mean and coefficient of the variation were then calculated.



Plate 3.3 Essediel Thickness Guage

3.4.4 Determination of Fabric Drape

The test was carried out in accordance with BS 5058, BS Handbook 1973 using the Cusick drape tester. From each of the sample fabrics, two specimens were cut with the aid of a template of 30 cm diameter. The specimen was placed on the lower horizontal disc of the apparatus to allow pin to pass through the centre of the specimen. The top disc was then positioned on the specimen with the pin fitted into the hole in the top disc. The lid of the apparatus was then lowered. An annular ring of paper of the same outside diameter (30 cm) as the test specimen was placed on the lid. The light of the instrument was then switched on and the periphery of the shadow on the paper ring was traced out. The paper was then removed, folded and its weight was obtained to the nearest 0.01 g. Then the papering which was drawn around the periphery of the shadow was cut and the area of the paper ring was then determined to the nearest 0.01 g. The results are expressed as a percentage Drape coefficient.

$$DC = \frac{M2}{M1} \times 100$$

Where

M_1 = Weight of the annular paper

M_2 = Weight of the outline of the shadow caste unto the annular paper by the fabric.



Plate 3.4: Cusick Drape Tester

3.4.5 Determination of Fabric Crease Recovery

The Shirley crease recovery tester was used by applying both NIS 28,1983 and ISO 2313/BS EN 22313 standards. Rectangular shape 2 cm by 4 cm specimen was cut from both the warp and weft directions not less than 5 cm from the selvedge and conditioned to equilibrium in a standard atmosphere. The specimen was then folded end to end to form a square before insertion between the upper and lower surfaces of the loading device. A load of 1 kg was then applied to the folded specimen for 5 minutes after which the load was removed.

The specimen was then transferred to the measuring instrument by gently holding in the flat jaws of the forcep's one arm of the specimen. The other arm of the specimen was introduced between the two parts of the grips. Care was taken not to disturb the existing crease formulation.

The specimen was then released from the forceps and the grip closed. The grip was rotated so that the free arm of the specimen hang vertically. The free arm was allowed to hang vertically for 5 minutes by necessary rotation of the grip. At the end of 5 minutes, the crease recovery angle was read off and recorded. This was repeated for all the sampled fabrics.



Plate 3.5: Shirley Crease Recovery Tester

3.4.6 Determination of Fabric Abrasion Resistance

The test was carried out in accordance with BS 5690, 1988 using the Martindale wear and abrasion tester model 103. The top plate and sample holders were removed, the quick release nuts were then rotated to approximately 180^0 in an anti-clockwise direction and lifting them vertically. The retaining rings were then removed. A non woven felt of approximately 140 mm diameter was placed on top of each abrading table. Abrasive cloth of approximately 140 mm diameter was then cut and placed on each of the felts. The abrading table weight was put on top of the abrasive cloth, taking care to smooth out any wrinkles. The retaining ring was then dropped over the weight and secured in position with four nuts. Throughout this entire operation, it was ensured that both felt and abrasive material were free of creases and folds and held tightly in position over the top of the tables.

The hand-operated lever press was used to produce 38 mm diameter specimen of the cloth to be tested, equally, 38 mm diameter piece of polyurethane foam was cut. The sample holder was then unscrewed and the insert removed. The specimen was laid (face down), polyurethane foam and the head inserted and tightened firmly. The machine was set at appropriate rubs for each sample and the abrasion of each specimen was performed under a pressure of 12 kpa.



Plate 3.6: Martindale Wear and Abrasion Tester (model 103)

3.4.7 Fabric Tearing Strength

The test was carried out using the Elmendorf tearing tester SDL 008 model. 5 cm by 8 cm of the fabric sample was cut out with the sample cutter supplied with the tester. The cutting was for both warp and weft directions for all the sample fabrics to be tested.

With the pendulum in its initial operating position, the test sample was clamped centrally in the jaws with the specimen side facing the initial incision knife. The test sample was then slitted with the pivoted knife blade. The knife was allowed to return to its rest position. The pendulum upon initial incision would tear the remaining portion of the sample. The pendulum release lever was then depressed smartly, keeping the lever depressed, the pendulum was caught gently as it swung back to its initial position. The reading was then noted and recorded. The pendulum and pointer were then returned to the initial position and the torn sample was removed. Five test specimens from the sample fabrics were used. From the means, tear strengths were then calculated. `



Plate 3.7: Elmendorf Tearing Tester (SDL 008 model)

3.4.8 Fabric Tensile Strength

This test was carried out using the Testometric testing machine. The speed of the instrument used was 60.0 mm/min with a load cell of 500 kgf. 200 mm by 100 mm of the sample fabric in both warp and weft directions were cut. Using the standard test mode which allows standard test to be performed, the tester when initially powered up after delivery will normally be set- up for standard tests and in tension mode.

Tare button was pressed which zero the load figure. With the positioned crosshead knock- off blocks and desired crosshead speed, the sample was loaded in the grips and up button of the machine was pressed to start the test. At the end of the test, the peak load and extension figures were displayed automatically and the readings were noted and recorded. The down button was then pressed which returns the crosshead to the lower crosshead knock- off block. The peak load and extension figures were then cancelled by pressing the Endtest button. The tester then becomes ready for another sample to be loaded. Five different tests for each of the sampled fabrics were carried out.



Plate 3.8: Testometric Material Testing Machine

CHAPTER FOUR

4.0 Results and Discussion

4.1 Fabric Production

4.1.1 Pirn Winding Operations

The pirn winding operations carried out in this research were basically to transfer the sample yarns from different sample packages (cones) unto the pirns which were designed to fit into the shuttle. As mentioned in the methodology the machine used was the pirn winder produced by Ishkawa Seisakusho Ltd obtained at Zaria Industries Ltd. From the pirn winding operations it was evident that the blended yarns were very weak due to frequent yarn breakages observed. Infact because of the low strength of the yarns it was almost impossible to wind at different tension levels. The winding only became successful when the tension device was set at zero and yarn traverse angle set at less than 45^0 . Four pirns from each of the sample yarns were produced at machine speed of 450 rpm.

4.1.2 Weaving Operations

The sample fabrics were produced through the interlacing or intersection of two distinct series of threads commonly refered to as warp and weft threads. It was obvious from the fabrics produced that the weft threads were actually the blended flax/cotton yarns. The warp warp threads on the other side were sized cotton yarns. From the fabric structure analysis it shows that the materials produced were constructed using the plain weave pattern. The pattern (plain weave) is the simplest form of interlacing in which warp and weft threads are arranged more or less at right angle to each other and interlace in alternate manner. One repeat unit of the fabric design is shown below;

	X
X	

The marked square indicates warp floating over the weft, while the blank space indicates weft floating over the warp.

4.1.3 Fabric Conditioning

All the fabric samples produced from the weaving shed were conditioned under standard atmosphere for testing for at least 48 hours and attained a relative humidity of 65± 2% and a temperature of 20± 2^{o}C.

4.2 Fabric Testing

4.2.1 Fabric Yarn Crimp

The crimp of a given fabric is an important parameter which affects most of its physical properties. Crimp in itself is dependent on many factors such as the bulkiness of the yarn , yarn bending stiffness, yarn packing density as well as the fabric design and construction.

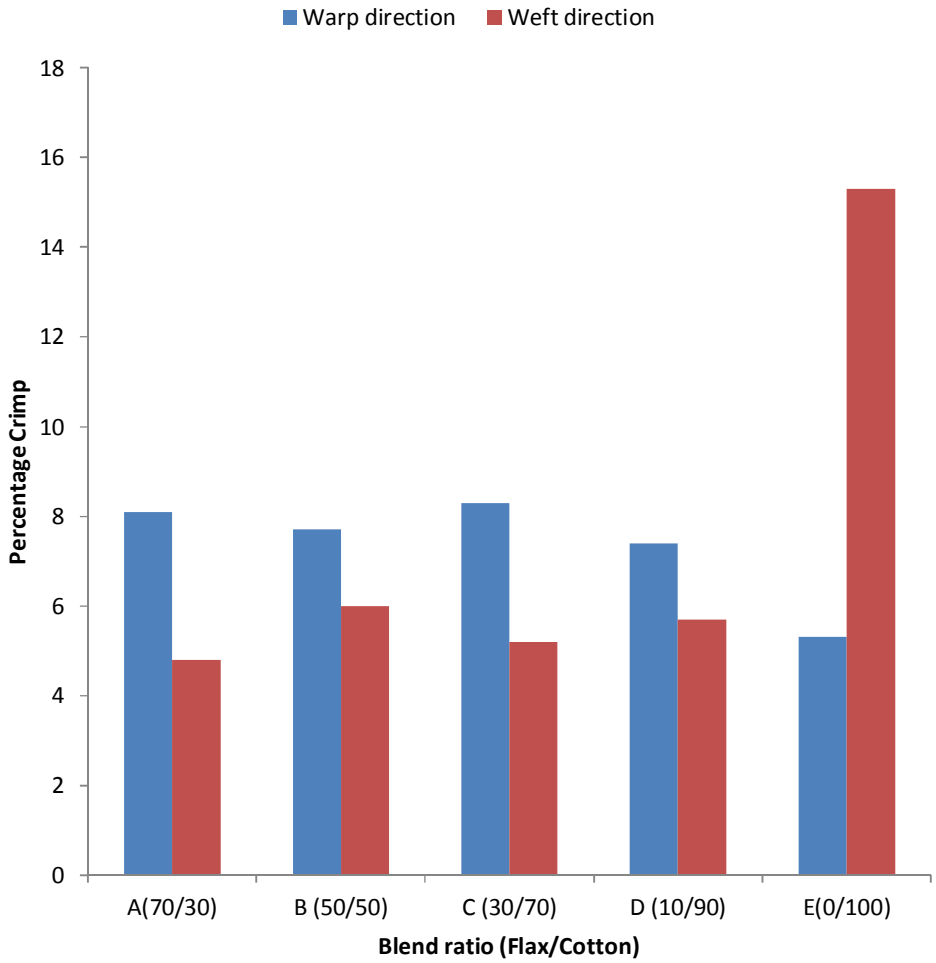


Fig.4.1: Percentage Crimp versus Blend ratios for warp and weft directions

From the result , as shown in Figure 4.1 ,it was discovered that percentage crimp reduces as the flax content in the blend is increased i.e. weft directions (where the blended yarns were used as picks in the fabric construction). It was clear from the result that in almost all the samples except for sample E, percentage crimp in the weft direction is lower than the corresponding warp direction. This may partly be attributed to the yarn linear density of the weft yarns spun at 39 tex. Infact a higher linear density produces high bending rigidity and low crimp (Alonge 2004). Yarn crimp on the weft direction shows that sample A (70:30 flax/cotton) has the least percentage crimp (4.8%), followed by sample C with percentage crimp of 5.2% . On the other hand sample E recorded the highest percentage yarn crimp when the fabric sample was tested in the weft direction (15.3%). Interms of higher percentage crimp in the same weft direction sample B is second, with precentage crimp of 6.0% . sample E recorded least crimp percent in the warp direction while sample C recorded the highest crimp percent in the same warp direction.

Generally, the low crimp in one direction is balanced by a higher crimp on the other direction. Crimp in either direction is shown to be dependent on fabric structure even though it is largely affected by yarn count and thread density (Greenwood, 1975). Other factors influencing the crimp percentage of yarn in a given fabric includes

i. High tension in which the warp yarns are subjected to during weaving

ii. The twist (usually increase the bending properties)

iii. High frictional resistance

iv. Flexibility of yarn or stiffness

v. The level of yarn irregularities which is very high among the blend ratios of 70:30 and 50:50 flax/cotton. It should be recalled here that flax is generally inferior to cotton in terms of uniformity and thus flax yarns or blend of flax of

high ratio than cotton is characterized by pronounced irregularities. This may be one of the reasons why sample B even though has greater percentage of flax recorded crimp percentage greater than samples C and D.

vi. The beat-up and take-up motions of the weaving machine due to ageing may have cause variation on the fabric construction which also has effect on the crimp.

4.2.2 Fabric Sett

Fabric sett is one of the fabric structural parameters that may influence mechanical and end-use properties of a given fabric. It is obvious that with higher number of ends and picks per centimeter in a given fabric, there would be increase in the number of interlacements per unit area.

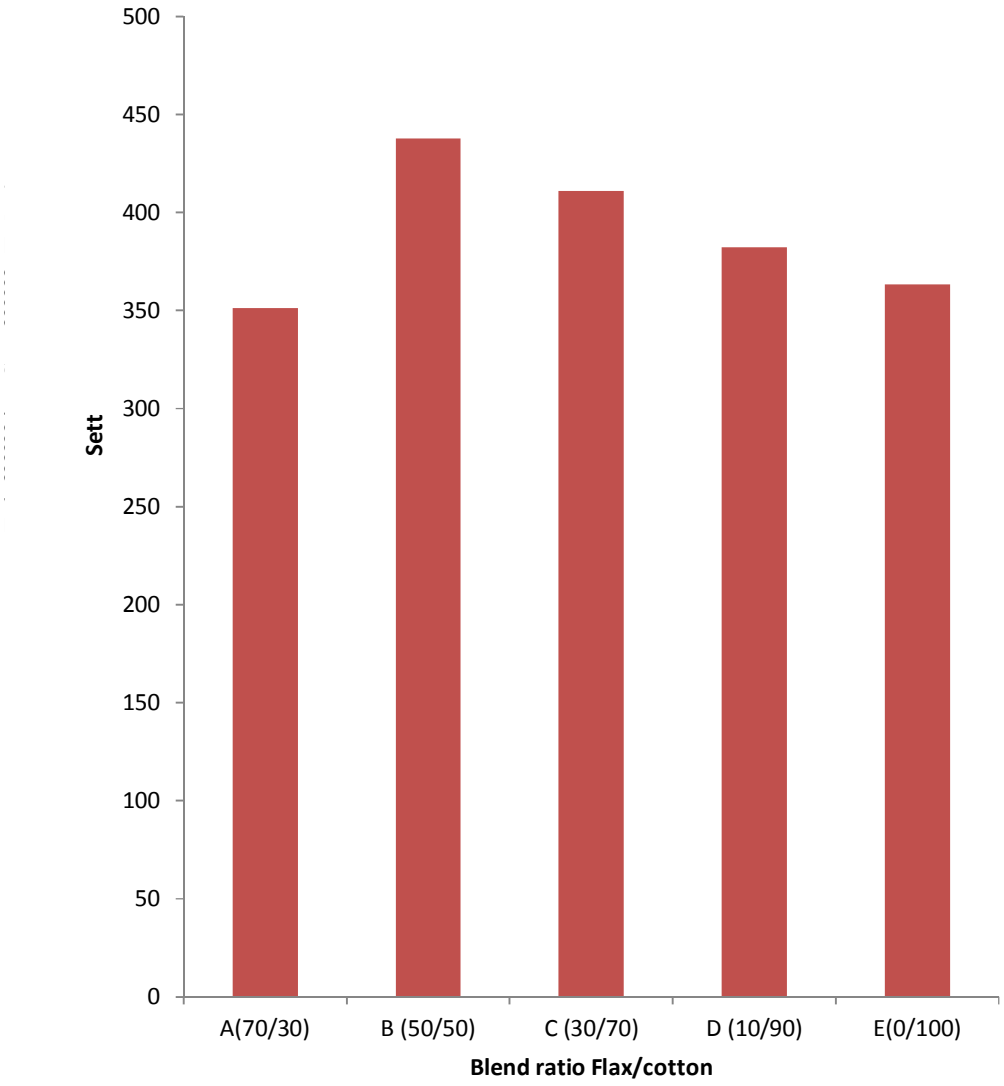


Fig. 4.2: Fabric Sett versus Blend ratio

From the result obtained in this work on the fabric sett, as shown in Figure 4.2,it would be observed that sample A(blend of 70:30 flax/cotton) fabrics has the least number of ends and picks per centimeter(351.2).This is closely followed by sample E (controlled sample 100% cotton yarn) fabric with 363.4 ends x picks per centimeter. On the other hand, sample B recorded the highest fabric sett with 437.4 ends and picks per centimeter. Sample C however recorded 410.8 ends and picks per centimeter and is second in terms of the fabric density (sett).

It is evident from the results that as the flax content in the blend is increased, the ends and picks per centimeter increases for sample B, C and D. As mentioned earlier sample A with the highest percentage of flax recorded the least fabric density. One of the major reasons is the effect of twist on the yarn during the spinning process. It should be noted that the blend yarns used in the construction of sample A fabric was spun at twist level of 1,431 turns/m, sample B was spun at 1,055 turns/m, while samples C and D where spun at 765 turns/m (Lawal, 2008)

The variations in the fabric sett despite the fact that the yarns are of the same linear density (tex) may be attributed to the following factors;

i. The level of yarn irregularity (total yarn imperfection per km) as shown in Table 2.1 in the literature.

ii. The frictional resistance of the component fibres and yarns may also affect the fabric density. In fact it is obvious that higher frictional resistance causes higher weaving resistance and consequently result in lower pick density on the fabric.

iii. The ageing of the machine may have affected the beat-up and the take-up motions of the weaving machine and could cause variation on the fabric setting as evident in the result obtained.

iv. The flexibility of the yarn also affects the weaving resistance which ultimately affects the pick density in the produced fabric. Research has shown that the greater the percentage of flax in the blended yarn, the stiffer the yarn. (Hunter and Gee, 1982).

Other areas where fabric sett could influence the fabric behavior includes the abrasion resistance, tensile strength, tearing strength as well as the draping properties of the fabric.

The fabric sett was found to be in the following order as presented in Table 4.2

B > C > D > E > A

4.2.3 Fabric Thickness

Fabric thickness is another important parameter in studying the fabric characteristics such as thermal insulation, resilience, dimensional stability, fabric stiffness, and abrasion resistance (Morton and Wray, 1964).

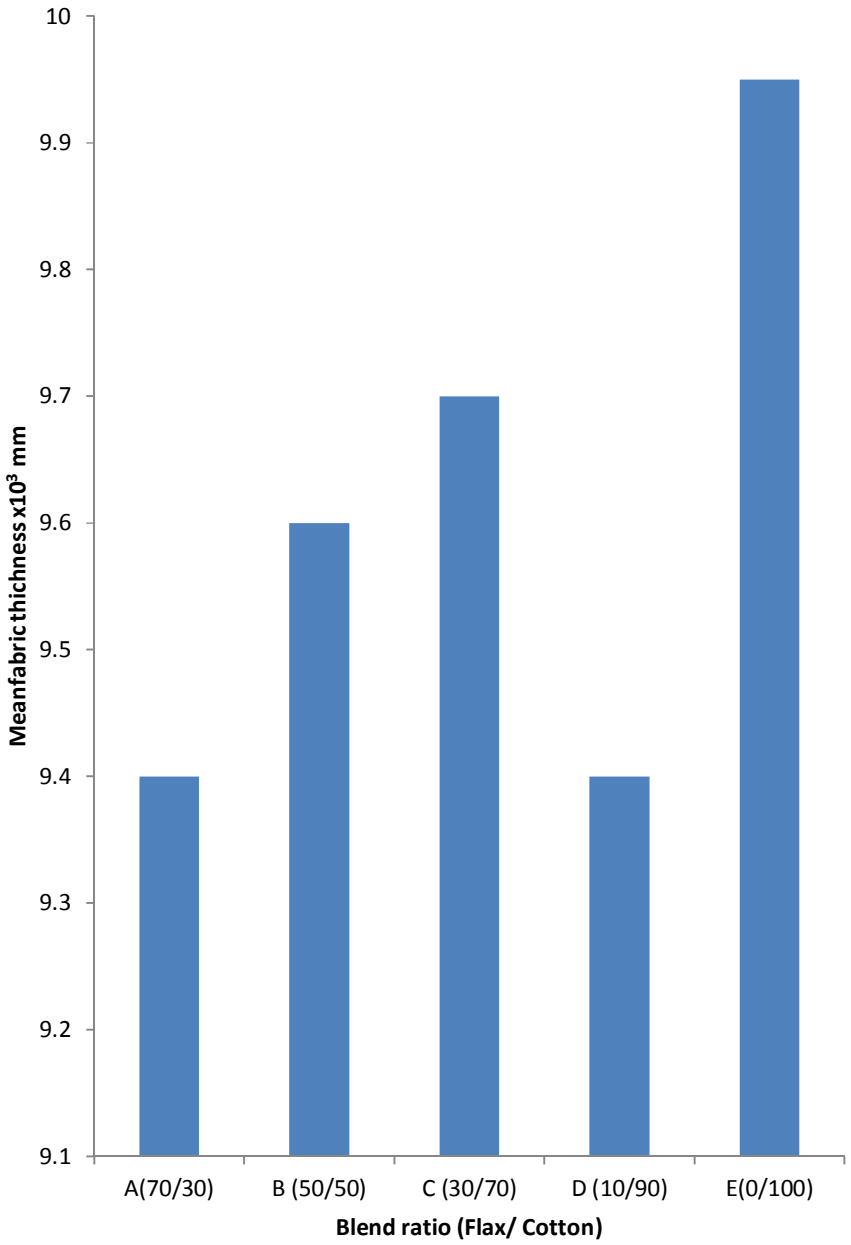


Fig.4.3: Fabric Thickness versus Blend ratios

Results obtained from the thickness test carried out on the sample fabrics is shown in Figure 4.3 above. It would be realized that sample A (70:30 flax/cotton) blend has the least thickness value while sample E (100% cotton yarn) has the highest thickness. This shows that as the percentage of flax fibre in the blend is increased, the fabric thickness reduces. However ,it would also be observed that the thickness of sample A and D are the same even though the percentage flax is higher in sample A. The irregularities in the yarn construction may be a significant factor to the trend.

Fabric thickness has an influence on the abrasion resistance of fabric (Morton and Wray, 1964). From the result of the abrasion resistance as shown in table 4.6 , it would be observed that as the thickness reduces, the weight loss and corresponding percentage weight loss increases during the abrasion action.

4.2.4 Fabric Drape

The drape is an important subjective performance characteristics that are evaluated at least in part by personal reaction (Bhalerao, 2007). As mentioned in the literature , drape differs from rigidity because the weight of material influences a deformation at some angle to the line of action. The specimen usually deforms with a multi-directional curvature and the result is dependent upon the shear stiffness of the fabric in addition to bending stiffness. It should be recall that drapability is inversely proportional to drape coefficient (Punj et al, 2004).

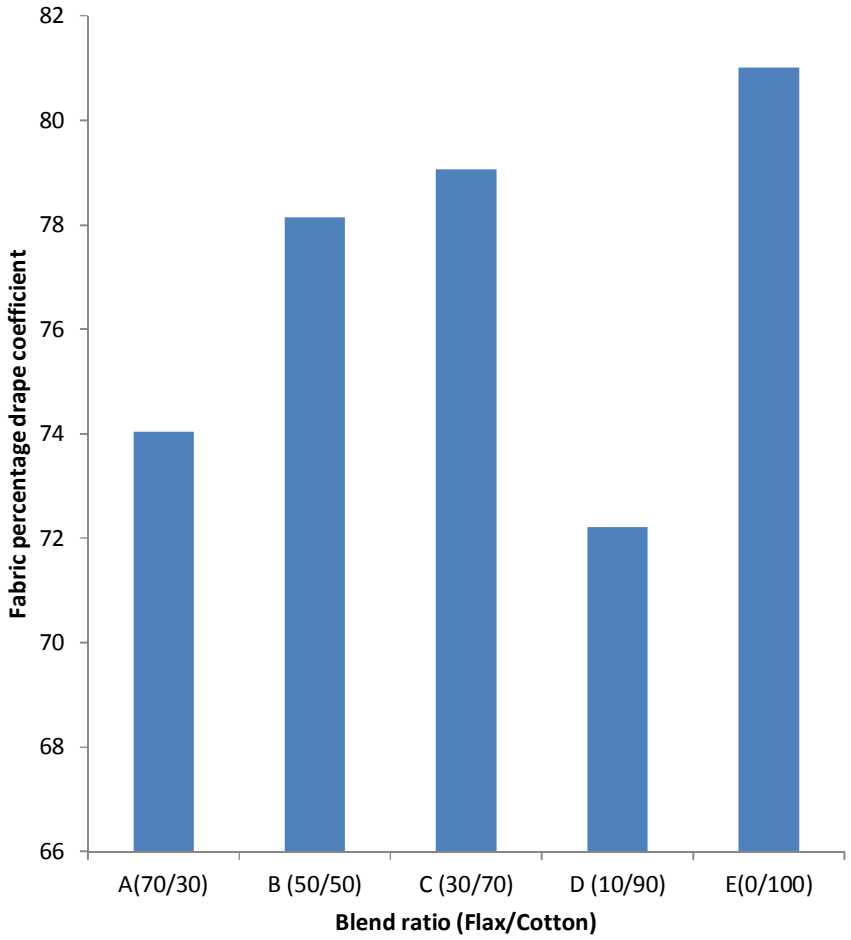


Fig. 4.4: Fabric Percentage drape coefficient versus blend ratio

Drape is largely affected by the thickness of the fabric, usually the thicker the fabric, the lower the drapability (Alonge, 2004). From the result of the fabric drape obtained, it is evident that sample E with the highest fabric thickness of as shown in Table 4.3 recorded the highest drape coefficient of 81.01% and hence has the lowest drapability. This is closely followed by sample C with a drape coefficient of 79.07% , sample B which has 78.14%, sample A with drape coefficient of 74.04% and sample D with the lowest value of 72.21%. From the above results it is very clear that fabric thickness has significant influence on the draping quality of a given fabric.

It would be realized from the result that the drape coefficient shows higher values as the flax content in the blend is increased for samples A, B, and C. The increase in drape coefficient with increase in the flax content is a direct reflection of reduced bending stiffness for fabrics, which have high flax content. It is evident that as picks per centimeter increase , drape coefficient will increase. The probable reason being that higher picks give lesser space for yarn movement in fabric giving tighter and stiffer fabrics.

4.2.5 Fabric Crease Recovery

The molecular structure of fibre has a considerable effect on the creasing properties of a given fabric. From the literature flax fibre molecular structure is more ordered than that of cotton and posses greater susceptibility to creasing (Peters, 1963). Research has shown that fabrics produced from 100 % flax are noted for low crease resistance (Irish,, 2005).

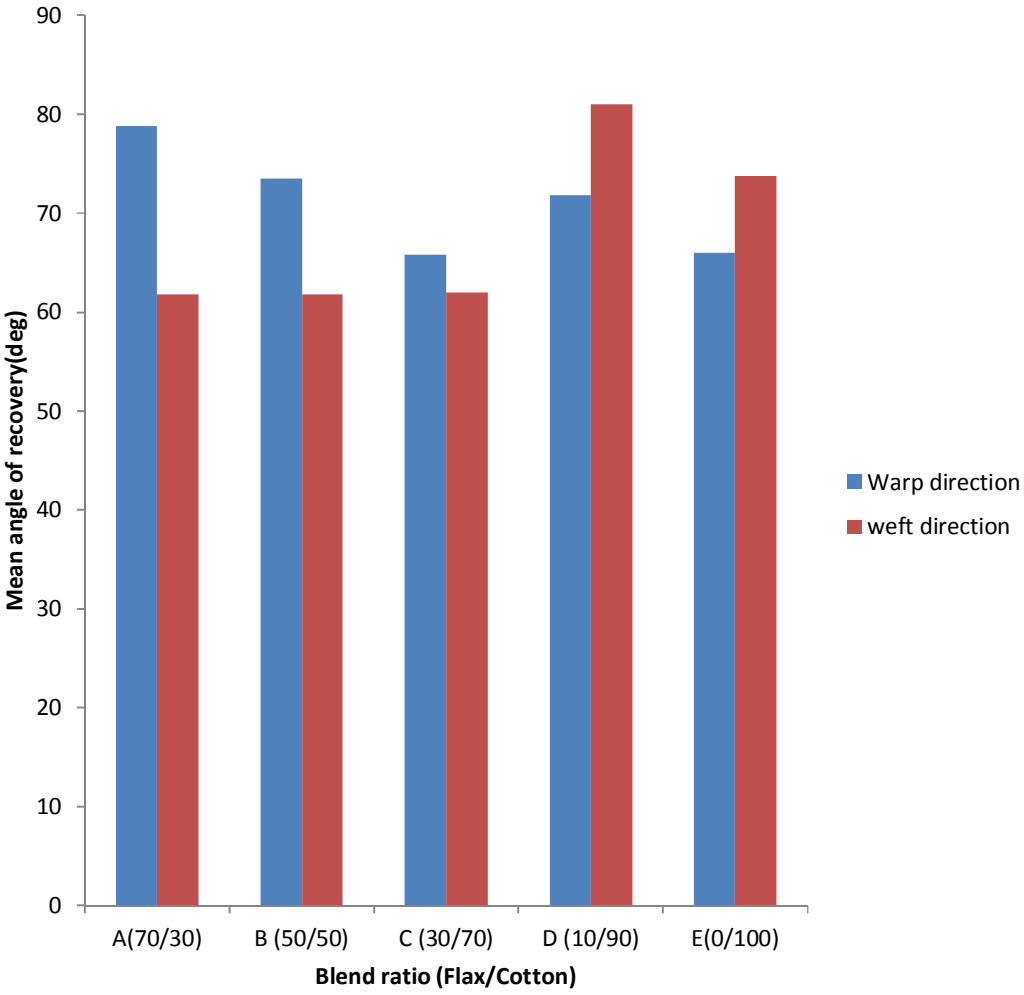


Fig.4.5: Fabric Angle of Recovery versus Blend ratio

From the result obtained in the weft direction in this research work as shown in Figure 4.5 , it is evident that sample E with the lowest flax content in the blend has the highest crease recovery angle in the weft direction. Samples A (70:30 flax/cotton) and B (50:50 flax/cotton) with higher percentages of flax recorded the least crease recovery angle when tested in the same weft direction. This means that as the flax content is increased, the crease recovery angle is reduced. One of the major reasons is the molecular structure of flax which is more ordered than that of cotton and posseses greater susceptibility to creasing (Peters, 1963). The result of the crease recovery angle in this reaserch is equally in agreement with findings that says fabrics produced from 100% flax are noted for low crease resistance (Irish, 2005). The result also implies that sample E fabric with the highest crease recovery angle does not require much ironing even if the fabric is to be used as apparel. The inherent low extensibility and resiliency of the flax may be attributed to the lower crease recovery ability on the fabric. In fact there is good correlation between fabric crease recovery angle and fibre elastic properties such as the instantaneous recovery and resilience (Punj, et al., 2004). It should be noted that flax does not possess good resilience property. Therefore as the flax content increases in the fabric ,the crease recovery reduces. It should also be noted that when a fibre with low degree of crystalinity or fibre in which the force of attraction between adjacent molecular chains are weak, when bent (creased), there is a relative movement between the molecular chains and the fibre becomes almost set in the bent state. However, if the fibre structure is very crystalline and the intermolecular forces are strong, there would be no relative movement and as such the fibre will return almost to its initial unbent state on removal of the applied force (Alonge, 2004). It is important to note that when fabric is folded sharply for crease formation, high stress and strain are developed at crease line. The extension of the fibre caused by

stress result in movement of the molecules within the fibre. For the attainment of maximum crease recovery, the construction of the fabric should be such that fibre strains are at minimum (Punj et al,. 2004).

It would also be observed from the result that samples A,B and C in the warp direction have recorded higher recovery angles than the corresponding weft directions. The order of increasing crease recovery in the weft direction is shown below.

Sample A < B < C < E < D

4.2.6 Abrasion Resistance

It has been established that when fabric structure stiffened, there would be increase in the abrasion resistance of the fabric because more number of yarns get abraded during the act of abrasion (MilaŠius, et al, 2003). It is therefore very clear that the fabric setting is an important parameter that influences the abrasion resistance of a fabric when subjected to rubbing action.

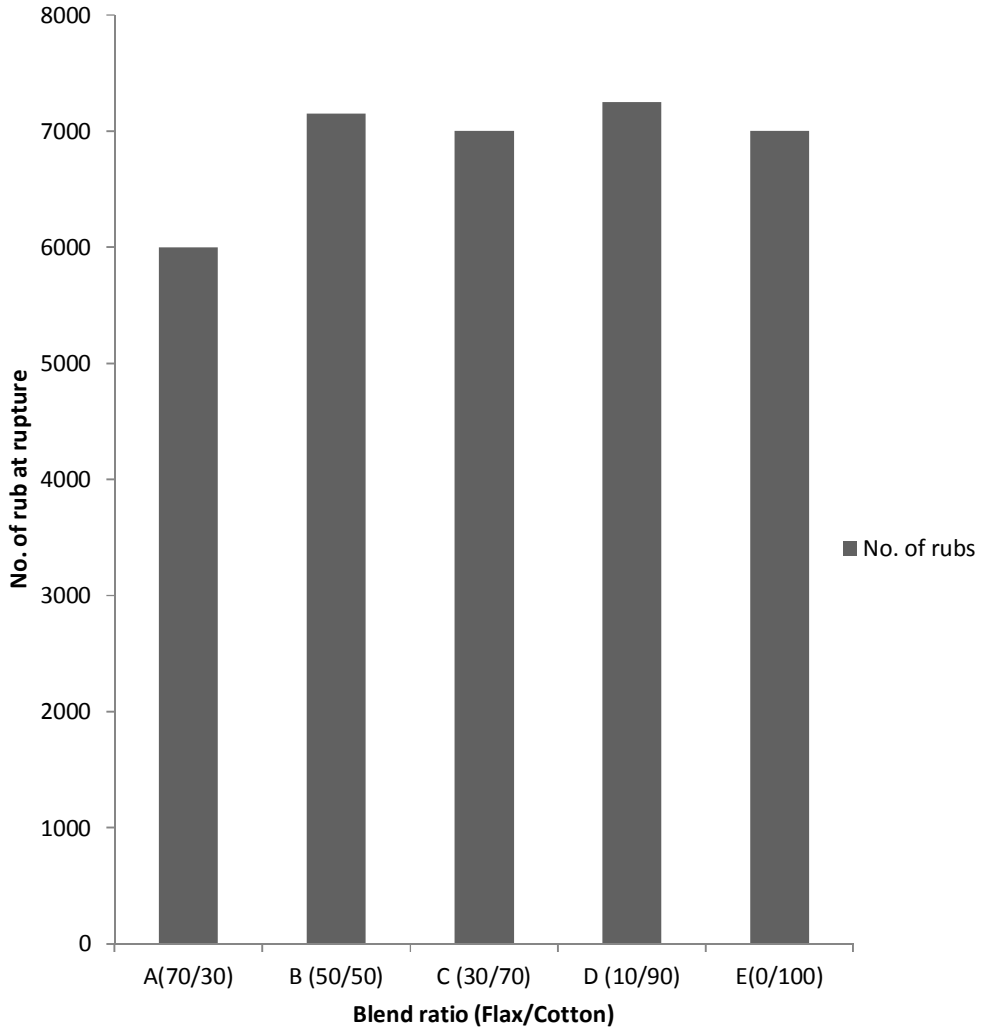


Fig 4.6: Number of Rubs at rupture versus Bend ratio

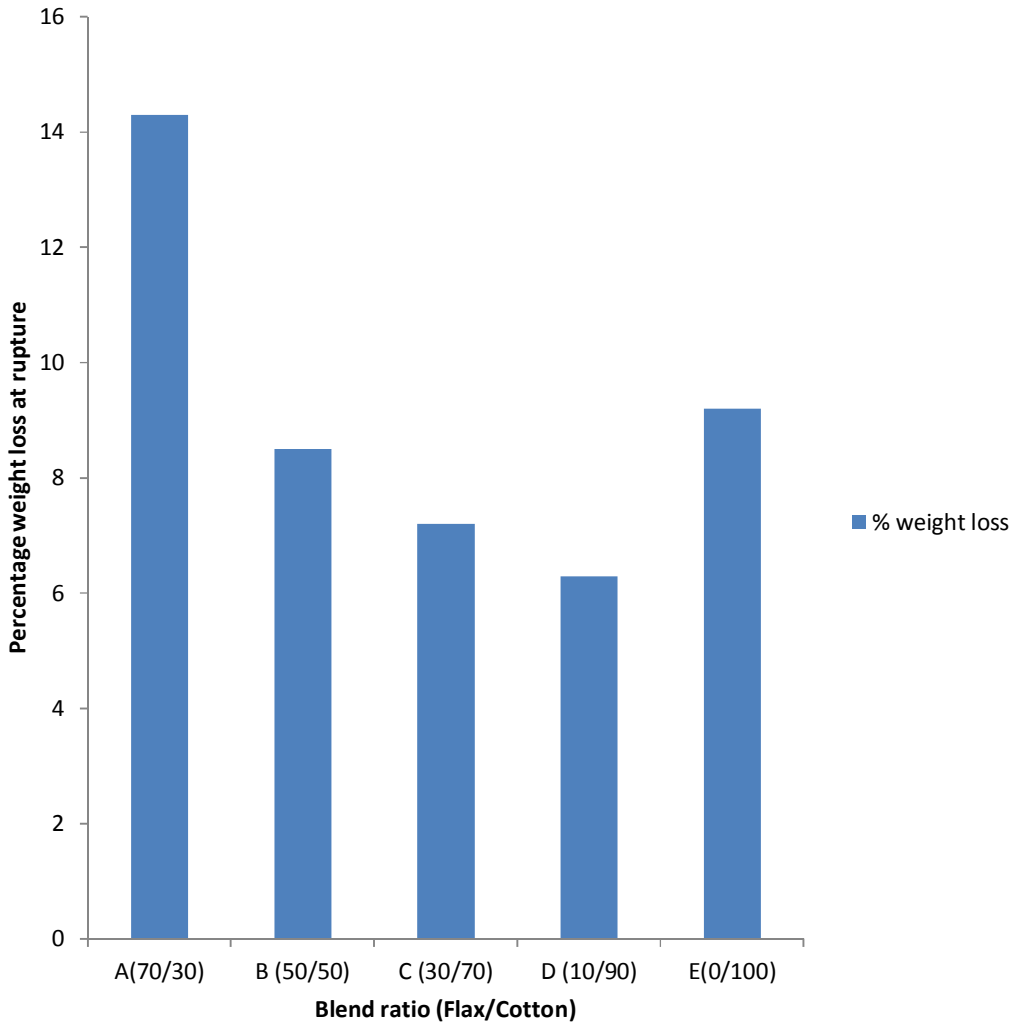


Fig.4.7: Percentage weight loss on abraded fabric versus Blend ratio

However , the result obtained in the abrasion resistance of the fabrics in this research as shown in Figure 4.6. and 4.7 shows that sample A with the least ends x picks per centimeter recorded the highest weight loss of 0.0221 g with percentage weight loss of 14.34 %. This is because there were fewer number of threads to be abraded during rubbing action. Sample E is second to sample A in terms of weight loss with a corresponding weight loss value of 0.0173 g and percentage weight loss 9.21 % respectively. It would be observed from the results shown in Table 4.6 that abrasion resistance decreases with an increase in the percentage of the flax in the blend composition. Sample A (70:30 flax/cotton blend) with the lowest number of rubs at rupture (6,000 rubs) has recorded the highest weight loss of 0.0221 g and percentage weight loss of up to 14.3 %. On the other hand sample D (10:90 flax/cotton blend) which has the lowest content of flax in the blend recorded the highest number of rubs before the article breaks at (7,250 rubs). The corresponding weight loss and % weight loss for sample D are 0.0107 g and 6.1% respectively.

The blend of yarn with higher flax content is reported to have a lower tenacity (Lawal, 2008), The results on the tensile strength especially in the weft direction shows that tensile strength also decreases as the flax content in the blend increased. It is therefore evident that yarn strength has great influence on the abrasion resistance of any given fabric.

Generally from the result it would be concluded that as the percentage of flax in the blend is increased, the lower the abrasion resistance of the fabric when subjected to rubbing action.

4.2.7 Fabric Tearing Strength

The mechanism of fabric tearing is different from tensile strength, and relates to the ability of individual yarn to slide and pack together or 'Jam' into a bundle, thereby increase the tearing force (Dorothy, 1977).

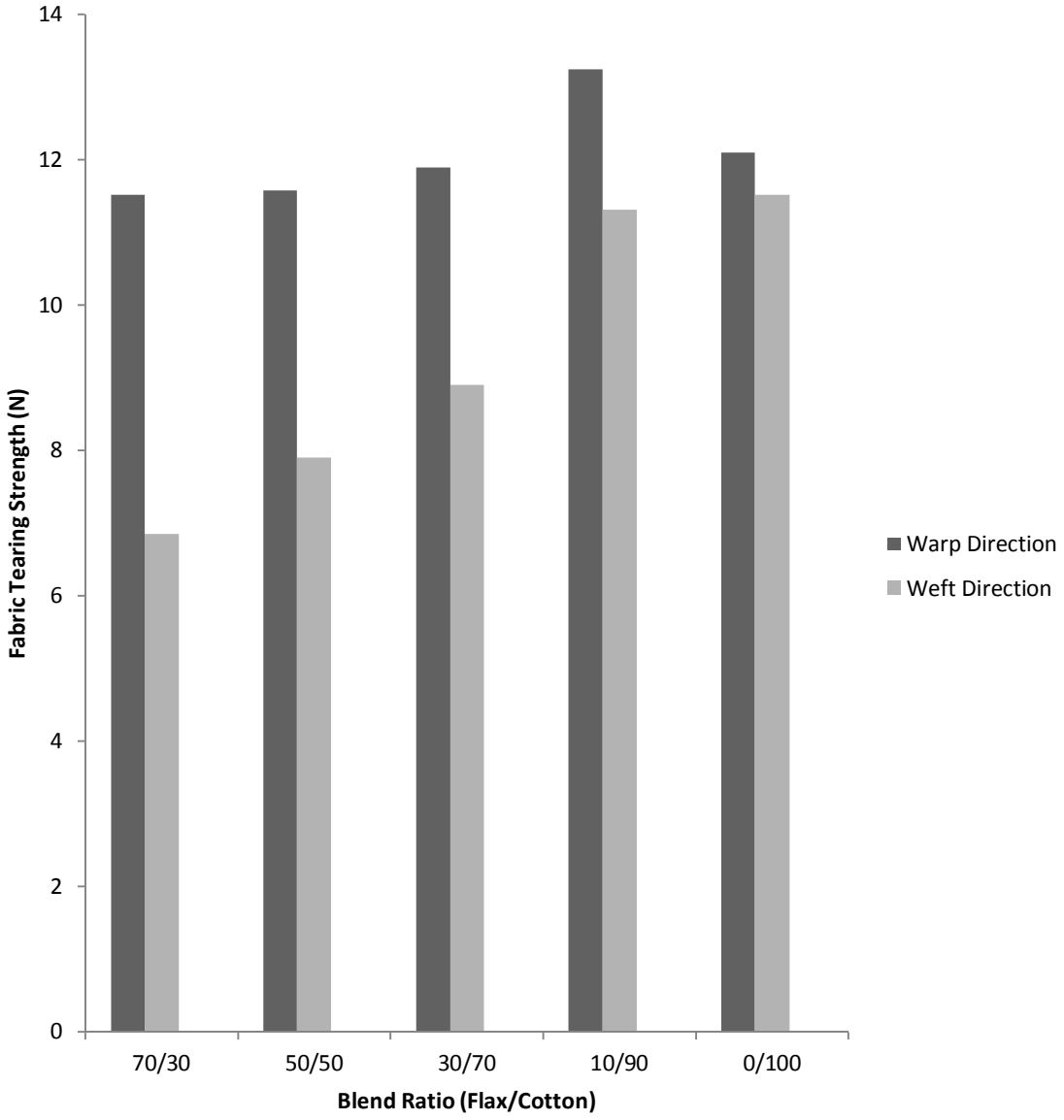


Fig. 4.8: Fabric Tearing Strength Versus Blend ratio

The tearing strength of a fabric is related with tensile strength of the yarn. The higher the strength of the constituent yarn, the higher the tearing strength of the resultant fabric (Punj. S k., et al 2004). It is evident from the result as shown in Table 4.7 that warp and weft way tearing strength decreases with increase in the flax content in the blend fabric due to lower strength of the constituent yarn. This is in agreement with the results on the tenacity of the blended yarn (Lawal, 2008) which gives the tenacity in cN/tex of the blended yarn in the following order;

Sample A (5.89cN/tex) < B (9.86cN/tex) < C (10.18cN/tex) < D (12.62cN/tex)

From the result obtained from the fabric analysis on tensile strength , it would be realized that the same pattern was recorded i.e. tensile strength increases with decrease in the flax content in the blend.

4.2.8 Fabric Tensile Strength

It is desirable that fabric strength be adequate to withstand any stress to which the article would be subjected to during use. It should be noted that domestic and apparel fabrics are subjected to not only tensile but also bending and tensional stresses.

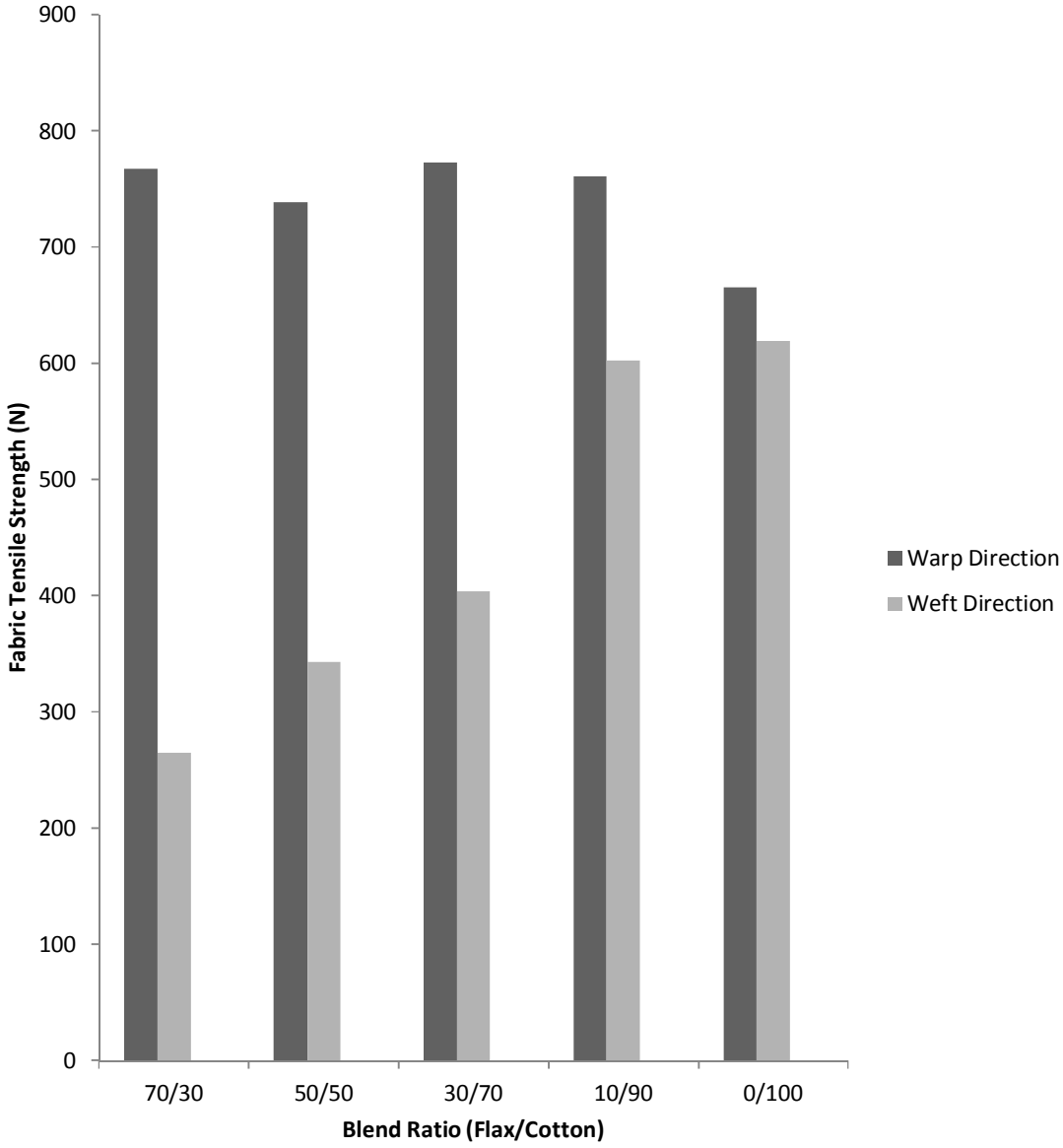


Fig.4.9: Fabric Tensile Strength versus Blend ratio

In line with the fabric tensile strength, it would be realized that increase in the yarn strength produced fabric of higher tensile strength. The result obtained in this research work shows that tensile strength in weft direction generally decreases with increase in the flax content in the blend. While sample A (70:30 flax/cotton) has the least tensile strength of 265.06 N sample D (10:90 flax/cotton) recorded 603.86 N. Sample E which serves as the control sample comprising of 100% cotton recorded 619.38 N. It is therefore evident that with increase in the flax content in the blend ,there would be a corresponding decrease in both the yarn tenacity and the fabric tensile strength. It would be observed that warp tensile strength in all the fabric tested is higher than the weft tensile strength. This is in accordance with single yarn strength result as presented (Lawal, 2008).

From the spinning parameters shown in Table 2.2 on the blended yarns (Lawal, 2008) , it would be noticed that as the percentage of flax in the blend increases, the yarn irregularities also increases. Consequently, fabric produced from such yarns would contain high percentage of fabric irregularities e.g. fabric thickness, fabric density (sett) and fabric crimp. These irregularities would certainly affect the fabric properties during testing or during use. These properties would includes tear strength , tensile strength, extension at break, abrasion resistance etc. the yarn irregularities may have contributed significantly to the fluctuation in fabric sett as shown in Table 4.2 .

It would be recalled that the sample yarns were produced from the rotor spinning technique. In this type of system, there is usually poor fibre extent ,lack of tension control and inferior fibre migration within the yarn body. These leads to a relatively high proportion of hooked and entangled fibres. This does not always provide an interlocking structure that would provide coherence to the yarn in order to withstand

an external load. The tensile behavior of the fabrics produced from such yarns are ultimately affected.

From the tensile strength result as mentioned, there is a progressive increase in the fabric tensile strength with a decrease in the flax content in the blend especially when tested in the weft direction. Higher flax content in the blend would cause the yarn to have more of the flax fibres in the external regions of the yarn. From the results shown in Table 4.8 ,it is clear that in order to produce fabric with stronger tensile behavior, the flax content must be reduced. Alternatively, another technique must be adopted for the cottonization of the flax fibres due to its effect on the fibre during processing. Flax in itself is very strong with a tensile strength of 6.4N/tex compared to 3.0-5.0N/tex for cotton (Trotman, 1984). However, the harsh process the fibres were subjected to during the cottonization has greatly reduced or affected the fabric tensile behavior. It should be remembered that the strength of a yarn is not necessarily related to the strength of the fibres because strong fibres badly arranged can produce a weak yarn (Pringle, 1949).

4.2.9 Fabric Extension and Elongation at Break

The differences in the breaking extension of the constituent fibres is one of the factors that influences the change in strength of a blended yarn (Hearle, et al., 1969)

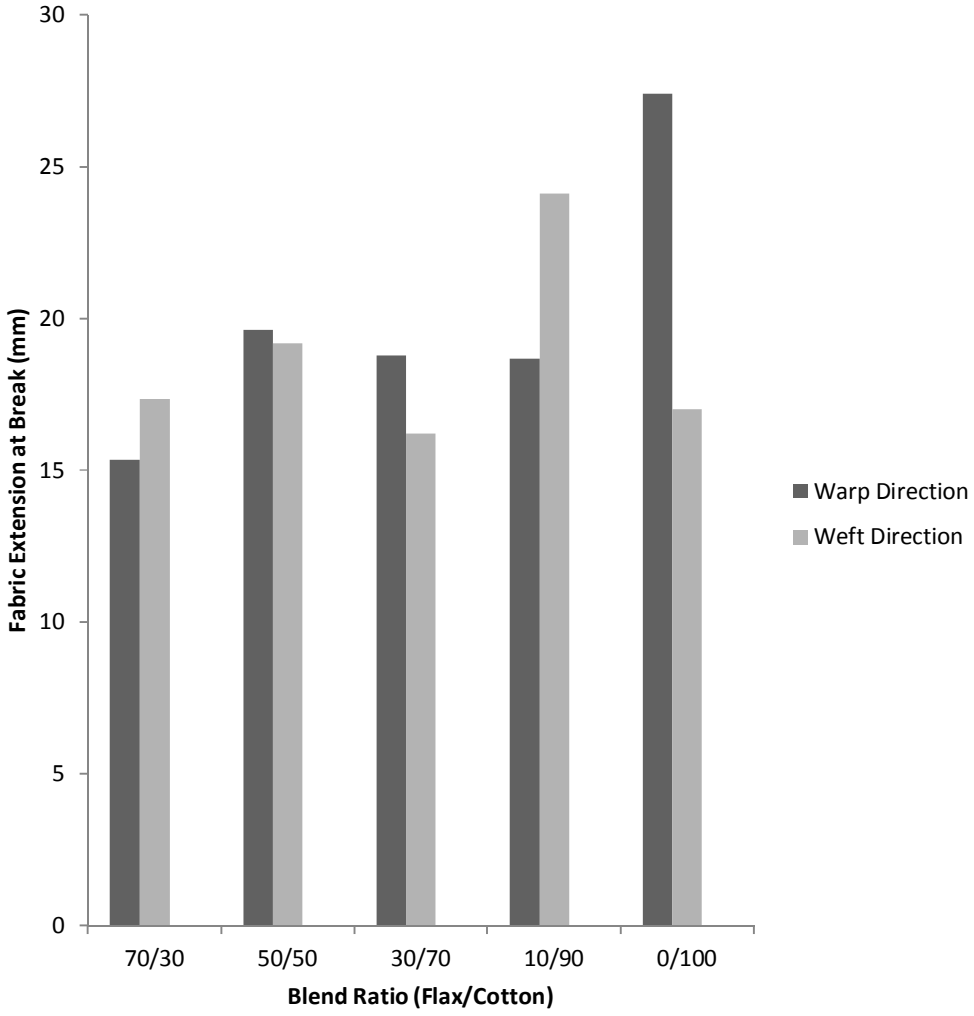


Fig.4.10 : Fabric Extension at Break (mm) Versus Blend ratio

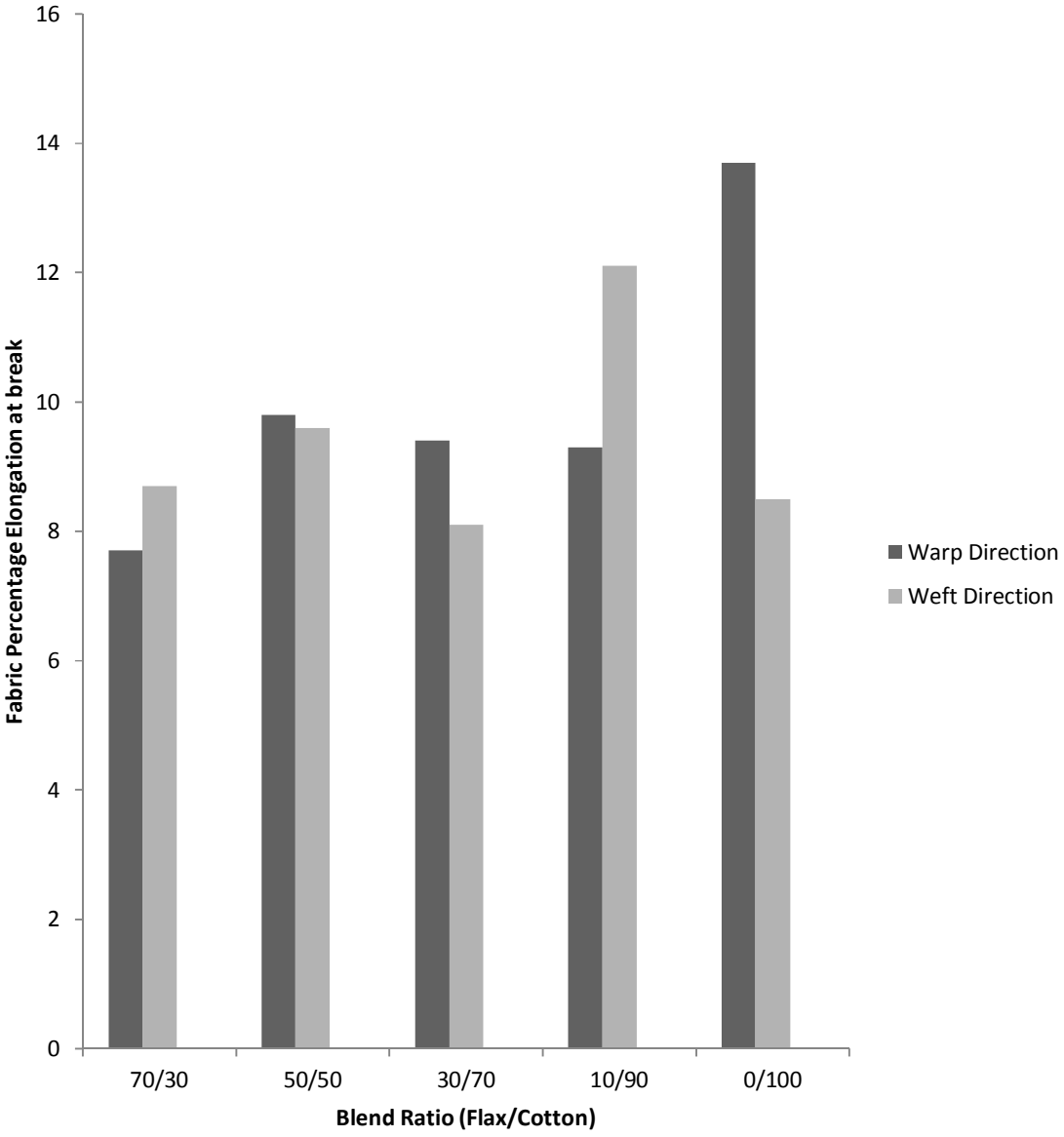


Fig. 4.11: Fabric Elongation Percent Versus Blend ratio

The breaking extension of cotton fibre in the literature is 11.9 % and that of flax is 10.5 % (Hearle, 1969). The elongation at break of cotton ranges from 4 % to 13 % depending on the variety and is regarded as high among the natural cellulosic fibres.

From the test results for the extension shown in Table 4.9 it is evident that with increase in the flax content in the blended fabric , extensibility is reduced. It is well known that fabric extension is the result of crimp removal and yarn extension. From the result it would be observed that the extension at break of the fabric in the weft direction for sample C (30:70 flax/cotton) and sample D (10:90 flax /cotton) shows a great difference. Sample C was observed to have a lowest extension at break. The major reason for the deviation may be the effect of twist during spinning process.

It would be observed that the blend ratios of 30:70 (sample C) and 10:90 (sample D) flax/cotton were produced at the same twist level i.e at 765 turns/min. The blend ratio of 50:50 on the other side was produced at 1,055 turns/min. This significant difference in the number of turns/min shows that sample C (30:70)flax/cotton blend did not attain the optimum twist level required. This in turn will affect the yarn extension at break and other tensile properties of the yarn. It should be noted that when optimum twist is not attained, fibre slippage may occur as a result of the inability of the component fibres in the yarn to be coherently binded by the action of twist (Lawal, 2008). By increasing the twist to the optimum level for the 30:70 flax/cotton blended yarn will increase the extension at break value for both the yarn and fabric.

CHAPTER FIVE

5.0 Conclusion And Recommendations

5.1 Conclusion

From the research work carried out and comparing with the previous spinning parametres , the following conclusions can be drawn out as follows: The tenacity of the yarn with higher flax content in the blend is lower and the resultant fabric from such yarns gave material with lower fabric tensile behaviour.

From the results obtained, it would be concluded that the 70:30 flax/cotton blended fabric recorded the least number of picks and ends per centimetre. Usually with higher number of ends and picks per centimetre in a given fabric, there would be increase in the number of interlacements per unit area as a result of increase in the pressure at the cross over points. It can be concluded therefore that the fabric produced from the 70:30 flax/cotton blend recorded the least fabric density which ultimately reduced the abrasion resistance of the fabric. This was evident from the high percentage weight loss recorded when the fabric was subjected to rubbing action.

From the fabric draping point of view, it would be concluded that fabric with higher flax component in the blend gives lower drape coefficient. On the fabric thickness however, it would be concluded that as the percentage of flax is increased, the fabric thickness tends to reduce. It should be remembered that fabric thickness influences the abrasion resistance of a given fabric. This was evident from the results obtained in the fabric thickness and that of the percentage weight loss after the abrasion action. It would be seen that fabric with the lowest thickness recorded the highest percentage weight loss i.e. 70:30 flax/cotton blend.

The yarn crimp results show that percentage crimp reduces greatly as the flax content in the blend is increased. This is supported by the results obtained which showed lower crimp percentage as the flax content of the blend increased.

The molecular structure of flax is more ordered than that of cotton and possesses greater susceptibility to creasing. The results obtained from the fabric creasing properties, showed that increase in the flax content of the blend, gave a corresponding decrease in the crease recovery of the material. The inherent low extensibility and resiliency of the flax may be attributed to the lower crease recovery ability of the fabric with higher percentage of flax in the blend. Hence to produce fabric with higher crease recovery from such blend, the component of the flax would have to be low.

It would be concluded that sample A (70:30 flax/cotton) blended fabric had the least number of rubs before the article breaks i.e 6,000 rubs. The sample also had the highest weight loss of 0.0221 g and percentage weight loss of 14.3 %. However, sample D (10:90 flax/cotton) with the lowest flax content in the blend recorded the highest number of rubs before the article breaks at (7,250 rubs) and had weight loss and percentage weight loss of 0.0107 g and 6.1 % respectively.

From the tensile strength test results, it would be concluded that there was a progressive increase in the fabric tensile strength with a decrease in the flax content in the blend. Therefore in order to produce flax/cotton blended fabric with strong tensile behaviour, the flax content must be reduced. The extension at break is also reduced with an increase in the flax content in the blend. From the tearing strength results ,it would be concluded that the tear strength generally increased with decrease in the flax content in the blend.

5.2 Recommendations

From the work carried out the following recommendations can be made:

i Further study on the absorption properties of the fabric is recommended.

ii Another approach to the cottonization of the flax should be investigated. This is because flax fibre is very strong but the harsh processing during cottonization has greatly reduced its strength.

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APPENDIX

EXPERIMENTAL DETAILED RESULTS

Table 4.1: Fabric Percentage Crimp

Blend Ratio Flax/Cotton	Percentage Crimp		Percentage variation	Coefficient of
	Warp direction	Weft direction	Warp direction	Weft direction
70/30	8.1	4.8	11.5	7.2
50/50	7.7	6.0	4.9	5.7
30/70	8.3	5.2	7.5	5.8
10/90	7.4	5.7	4,9	4.6
100/0	5.3	15.3	6.2	2.2

Table 4.2: Fabric sett

Blend Ratio (Flax/Cotton)	Sett		
	ep (cm)	pp (cm)	ep x pp (cm^2)
70/30	22.8	15.4	351.2
50/50	23.4	18.4	437.4
30/70	23.6	16.2	410.8
10/90	23.6	16.2	322.4
100/0	23.0	15.8	363.4

Table 4.3: Fabric Thickness

Blend Ratio (Flax/Cotton)	Mean Fabric Thickness x 10^{-3} mm
70/30	9.40
50/50	9.60
30/70	9.70
10/90	9.40
100/0	9.95

Table 4.4: Fabric Drape

Blend Ratio (Flax/Cotton)	Fabric Drape coefficient (%)
70/30	74.04
50/50	78.14
30/70	79.09
10/90	72.21
100/0	81.01

Table 4.5: Fabric Crease Recovery

Blend Ratio (Flax/Cotton)	Mean angle of recovery (deg.)	
	Warp Direction	Weft Direction
70/30	78.8	61.8
50/50	73.5	61.8
30/70	65.8	62.0
10/90	71.8	81.0
100/0	66.0	73.8

Table 4.6: Fabric Abrasion Resistance

Blend Ratio Flax/Cotton	No. of rubs (at rapture)	Weight loss (g) (after rapture)	Percentage weight (loss at rapture)
70/30	6,000	0.0221	14.3
50/50	7,150	0.0139	8.5
30/70	7,000	0.0128	7.2
10/90	7,250	0.0107	6.1
100/0	7,000	0/0173	9.2

Table 4.7: Fabric Tearing Strength

Blend Ratio (Flax/Cotton)	Tearing Strength (N)	
	Warp Direction	Weft Direction
70/30	11.52	6.85
50/50	11.58	7.90
30/70	11.90	8.90
10/90	13.25	11.32
0/100	12.10	11.52

Table 4.8: Fabric Tensile Strength

Blend Ratio Flax/Cotton	Warp Tensile Strength (N)	Weft Tensile Strength (N)
70/30	767.70	265.06
50/50	739.10	342.88
30/70	773.24	403.88
10/90	760.80	603.86
0/100	665.40	619.38

Table 4.9: Fabric Extension at Break

Blend Ratio (Flax/Cotton)	Fabric Extension at Break (mm)	
	Warp Direction	Weft Direction
70/30	15.34	17.35
50/50	19.62	19.19
30/70	18.78	16.22
10/90	18.67	24.12
0/100	27.41	17.00

Table 4.10: Fabric Percentage Elongation at Break

Blend ratio (Flax/cotton)	Fabric percentage elongation	
	Warp direction	Weft direction
70/30	7.7	8.7
50/50	9.8	9.6
30/70	9.4	8.1
10/90	9.3	12.1
0/100	13.7	8.5