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Potato Peel as Starch for Textile Sizing Industries

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Abstract

Sizing is a procedure which uses film forming polymer to offer temporary protection to the warp yarns from abrasive and other stresses generated on the weaving machine to bring down the warp breakages. Potato peel contains starch with other ingredients such as oil, protein etc. The idea of extracting sizing paste from low-cost material potato peel for textile industries, helps to get additional textile sizing agents for industries. Most of the textile factories use PVA, modified starch and wax as sizing agent combined with low starch sizing content like maize and other sizing agent. Therefore, most companies need alternative sizing material, which is easily accessible and gives an acceptable quality level of yarn with minimum cost. So, the sizing material extracted from potato peel as a source of starch can be used to solve this compliance. In this paper we are concerned in sizing warp yarn by starch extracted from potato peel to produce effective sizing material. In this study potato peel and modified starches were used to comparative study for their performance on sized 6.5 Ne warp yarn. The performance properties tested after sizing are yarn strength, elongation and hairiness. From the test result we found strength gain is 36.1% and loss of elongation 32.6% respectively.

Keywords: Sizing Agents; Potato Peel; Modified Starches; Yarn Strength; Emulsions

Introduction

Sizing consists of impregnating the yarn with substances that form on the yarn surface a film with the aim of improving yarn smoothness and tenacity during the subsequent weaving stage. The yarn can withstand without problems the tensions and the rubbing caused by weaving. [1]. To achieve the properties on the warp yarns, a protective coating of a polymeric film forming agent (size) is applied to the warp yarns prior to weaving. This process is called sizing. Adanur S [2] Sizing efficiency does not depend only on the adhesion between the applied sizing agent and the yarn, but also on the ability to form a film, on rheological properties of the size, physical-chemical yarn properties, as well as on the technological parameters in the sizing process. Furthermore, it is necessary to completely remove the sizing agent from the fabric after the weaving process in an environmentally friendly manner. The optimization of the proportion and application of sizing agents to the warp threads is of the utmost importance for the entire weaving process to achieve the planned machine utilization and the quality of the finished fabric. Optimization of size pick-up is one of the problems in the sizing process even today. The purpose of sizing is to reduce the number of warp thread breakages to a minimum. Finding the right recipe that will provide the lowest number of breakages on the weaving machine is the main goal of any technologist Kovacevic Schwarz & Brnada [3], Behera & Joshi [4], Kovacevic, Grancaric, & Stipancic [5], Goswami Anandjiwala & Hall [6], Nisbet [7].

Sizing Agents

Based on the chemical composition, the sizing agents used nowadays can be divided into the following groups: starches, carboxy methylcellulose, polyvinyl alcohols, polyacrylates and polyester resins. From the group of starches, potato is one of the most used. Starch properties depend on the relationship between amylose and amylopectin, but also on other constituents found in a starch granule, such as phosphates, lipids, phospholipids, etc. However, amylopectin, as the main starch ingredient, exerts a dominant influence on starch properties. The lateral chain length in amylopectin accounts for clustering, retrogradation and starch properties in the solution. Starch granules disintegrate only at elevated temperatures, i.e., dissolving happens whereby amorphous amylose is released first which forms a three-dimensional network outside starch granules and inhibits further swelling of starch granules. Besides amylose, the present lipids also inhibit swelling. Although amylose makes only a slight contribution to the viscosity of the starch solution after granule disintegration, when cooling the viscosity of the starch solution increases with increasing amylose content, this is explained (Progress, 2017), (Ismail H, 2013), (Jenkins PJ, 1997).

To allow recycling using ultra-filtration, sizing agents must have the following characteristics: water solubility, mechanical and thermal stability, biological resistance, good washing performance, low average viscosity (Sandhu, 2008), (Hebeish, et al., 2008), (Hottle, Bilec, & Landis, 2013). In this study potato peel was used by replacing potato and other starches for warp yarn sizing. The peels removed from the inner part and Potato peel contains various polyphenols and phenolic acids which are responsible for its antioxidant activities, whereas fatty acids and lipids showed antibacterial activities. Potato peel also contains starch (25%), non-starch polysaccharide (30%), protein (18%), acid-soluble and acid-insoluble lignin (20%), lipids (1%) and ash (6%) on dry basis Liang S MA [8] due to this potato peel can be use act as sizing chemicals (Endale et al. 2008; Tsegaw 2010). Potato peel as a byproduct of food processing industry poses to be totally inexpensive, valuable and affordable starting material Abdel Mohdy [9]. Traditionally potato peel waste is used for producing low-value animal feed Kovacevic SD [10]. Fertilizer or being the raw material of biogas, which causes waste of abundant nutritive materials within it having the properties of antioxidant, antibacterial, apoptotic, chemo preventive and anti-inflammatory (Zhu & Cao, 2004)

Project Description and Justification

The whole work of the project is implemented in two stages. The first stage is collection and preparation of the potato peel starch. To prepare potato peel starch, the potato peel is collected, dried and ground. The second stage is sizing warp yarn with prepared starch. Sizing conditions are set to sizing of cotton with to compare the effectiveness of sizing warp yarn with conventional starch. Finally, the sized yarns are characterized by their weight, elongation and tensile strength. The sizing process provides warp yarns with the necessary strength, elasticity, smoothness, and enables them to acquire resistance to abrasion and static charge. Potato peels have high starch content due to this it can be preferable for sizing warp yarn.

Types of Sizing Ingredients

Each ingredient should impart a particular property to the yarn. Accordingly, there are two types of ingredients, namely the primary and secondary ingredients (Table 1). The primary ingredients are those that are essentially required in the size paste whereas the secondary ingredients are those that may or may not be added to the size mixture according to the requirements. The primary ingredient is the main ingredient, and it helps to give additional strength to the yarn and improves its abrasion resistance. The other ingredients known as the secondary ingredients give additional properties to the yarn such as feel, weight, appearance etc. (Sayed, 2019) Several adhesives are available, and these are listed below:

a) Starch and starch products - Ex: Maize starch, Tapioca starch, Potato starch, Sago starch, Wheat starch etc.

b) Thin boiling starch or soluble starch - Ex: British gum, Dextrin

c) Natural adhesives other than starch - Ex: Tamarind Kernel powder, gum Arabic, gum tragacanth, gum Karaya, beam gums.

d) Protein substances - Ex: Glue and gelatin, Casein, Soya bean protein.

e) Pectin materials - Ex: Alginic acid

f) Starch, gum and cellulose derivatives - Ex: Starch ethers and esters, gum guar, Carboxymethyl cellulose.

g) Synthetic adhesives - Polyvinyl alcohol, acrylic polymers, Vinyl polymers, Polyethylene glycol, Polystyrene etc. (Sayed, 2019) PVA is the product obtained from alcoholics using polyvinyl acetate under the effect of the sodium meth oxide process in Methanol. The sizing properties are influenced by the degree of polymerization and degree of alcoholic's polyvinyl alcohol. Polyvinyl alcohol size has shown excellent water- solubility, adhesiveness to the fiber, especially hydrophobic fiber. The mixtures of polyvinyl alcohol and modified starch could also provide good protection to warp yarn (Zhang, 2013).

Table 1: Types of Sizing Ingredients (Sayed, 2019).

Primary	Secondary
Adhesives	Deliquescent/ Humectants
Softeners/Lubricants	Antistatic
Antiseptics	Weighting agents
	Brightening/ bluing agents
	Wetting agents
	Antifoaming agents

The viscosity and hydrolysis of polyvinyl alcohol are controlled in the manufacturing process and are important in determining end-product sizing characteristics. Both fully hydrolyzed and partially hydrolyzed grades are very useful for sizing purposes. In warp sizing the fully hydrolyzed grades give strong, tough films, are less water sensitive, but require hot water close to the boil for complete removal. Coating with polyvinyl alcohol film eliminates the need for curing cycles. Film formation occurs readily by simply evaporation of water from the solution. This is because polyvinyl alcohol has a very low BOD, which greatly causes pollution problem Adanur [2].

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Carboxyl methyl Cellulose (CMC) Carboxymethyl cellulose is generally sold as sodium salt, and to be scientifically precise should be called sodium Carboxymethyl cellulose. Commercial CMC is a solid granular material which may vary from coarse granules to rather fine powder depending on the source, grade and type. CMC tends to absorb and hold moisture. By evaporating the water from CMC solutions, clear sheets or films are formed which are quite strong and flexible. The advantages of CMC's properties are its water binding ability of CMC makes the need for high humidity in the weave room less critical than required for many other sizes. As a rule, warp-size grade CMC should not contain over 5% salt Adanur [2]. Softeners/Lubricants these are next in importance to the adhesives. The adhesives produce a film on the yarn which is rather stiff and thus renders the yarn inflexible. Hence to make the adhesive film flexible or pliable, softener is added. Another problem is that the adhesive film on the yarn is not smooth i.e. has rough or uneven surface. This tends to generate frictional forces between neighboring warp threads in the loom during shed formation and between yarn and certain loom parts such as reed, Heald eyes etc. The softener thus performs the dual function making the yarn flexible and smooth. Softeners/lubricants used are the following-Oils and fats, waxes, mutton tallow, oils and emulsions, stearic acid emulsions, vegetable tallow, soaps, sulphated oils and fats, mineral oils, paraffin wax, plasticizers etc. of the many softeners available, mutton tallow is the best since it acts well as a softener and lubricant (Sayed, 2019). Anti foaming agents During the sizing there is always the possibility of foam generation in the size or sow box. The foam is generated by surface active agents such present in the size paste such as soaps, Turkey red oil etc. Alkali foam is formed due to the churning action of the squeezing rollers. The foam that is carried by the warp sheets causes smudging of the drying cylinders. Some of the well-known anti-foaming agents used are amyl alcohol, turpentine, pine oil etc. (Sayed, 2019).

Potato peel (Solanum tuberosum)

Potato is one of the agricultural crops and more than 320 million tones are being cultivated annually on 20 million hectares of land worldwide Cromme [11] and there is progress in potato cultivation and marketing Hirpa A [12] Potato has a short growth cycle and can be easily integrated into existing agricultural systems and provides high productivity per area as well as it is used for household consumption or sold as a cash crop. As the population grows rapidly, increased productivity of potatoes is used to meet the growing demand Gildemacher [13].

Chemical Composition of potato peel/Solanum tuberosum

Kovacevic Schwarz & Brnada [3] Size recipe a general ratio of recipe contents is given below. Starch: PVA: Acrylic; Softener 50 %: 30%:15%: 5%. Nawab [14] During the sizing process percentages of concentration for the single yarn were: 5%, 10% and 15%, and for the ply yarn: 1%, 3% and 5%, adapted to industrial conditions Stana Kovacevic [15]. The solid contents of each ingredient will be calculated according to the specified ratio (Table 2).

Table 2: Composition of Potato Peel.

Parameters	Dry weight (%)
Moisture %	85.06
Total carbohydrate	68.7
Total soluble sugar	1
Reducing sugar	0.61
Starch	52.14
Nitrogen	1.3
Protein (Ntot 6.25a)	8
Fat	2.6
Ash	6.34

Material and Methods

Sample Collection for the purposes of this research Potato peel was collected and 100% cotton warp yarns with counts of 6.5Ne (6.5 twists/m) were used. (Figure 1) After gathering of potato peel, record the initial weight and grind them in a motor with sufficient water then collect the potato homogenate into a container and add enough water. Then filter the homogenate through a muslin cloth to remove the particles. The filtrate was allowed to settle and 4g of Sodium hydroxide was added to separate the starch and proteins materials as well as to neutralize the prevailing slight acidity. Wash 4 times and decant the supernatant. Excess sodium hydroxide was removed by washing several times with distilled water. The clear supernatant fluid was removed while sediment starch was collected on a tray and air-dried on a table at room temperature.

Methods of composition testing

To check the presence and absence of starch in potato peel powder by following qualitative starch testing methods by using Iodine. If Iodine reacts with starch to form starch/iodine complex which has a blue-black colour. The appearance of blue-black colour confirms the presence of starch in the given sample. If the reaction is not changed or it shows a brown color, it confirms starch is not present in the given sample.

Application method

In this study follows different tests, up to getting the volume of water. After getting the volume of water apply testing lab practically by changing process parameters, recipes and use standard parameters and recipes for the same count of yarn. The trials will be conducted on cotton yarn count of 6.5 Ne with potato peel starch, wetting agent, softener and water. For sizing the yarns, the laboratory sizing machines are used (Figure 2). Following steps are applied for this study:

a) Step 1 Measure the required amount of chemicals in the weight balance and add the starch powder to pre heated water25°C.

b) Step 2 Stir the mixture from 5 – 10 min. Step 2 cook 30 minutes in the cooking beaker and add the wetting agent.

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c) Step 3 After cooking the prepare recipe sizing materials take and put on the sizing machine.

d) Step 4 After putting it into the sizing machine start the sizing process.

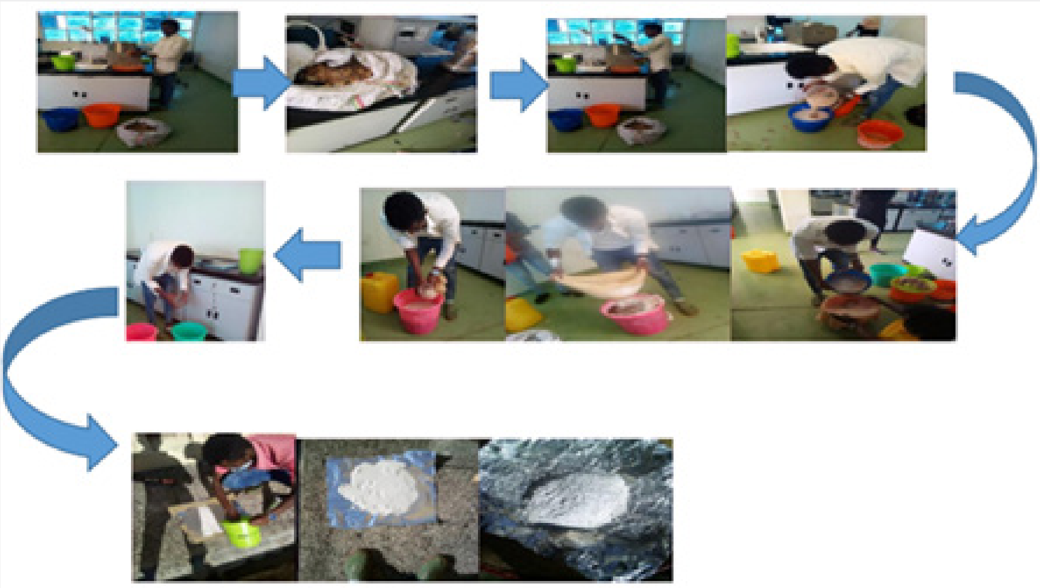

Figure 1: Preparation of Starch from Potato Pell.

Figure 2: Application Procedure of Sizing.

Result and Discussion

Mass Measurement Result (Table 3)

Strength and Elongation Test Unsized yarn strength and elongation test result

(Table 4,5)

Sized Yarn Strength and Elongation Test Result for Test 2 (Table 6,7)

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$$R.K.M = (Unsized \times NM)/1000$$

$$R.K.M\ Unsized = \frac{Average\ unsizing\ breaking\ load * NM}{1000}$$

$$= \frac{755*11}{1000} = 8.3$$

$$R.K.M\ sized = \frac{Average\ sizing\ breaking\ load * NM}{1000}$$

$$945.8*11/1000 = 10.4$$

$$Strength\ regain = (R.K.M\ sized - R.K.M\ Unsized)\times 100/(R.K.M\ Unsized)$$

$$= ((10.4-8.3)\times 100)/8.3 = 25.3\%$$

$$Average\ Elongation\ unsized = 4.19$$

$$Average\ Elongation\ sized = 3.36$$

$$Loss\ elongation = \frac{unsized - sized}{unsized}*100$$

$$=4.19-3.36*100/3.36 = 24.7\%$$

$$R.K.M = \left(Unsized \times NM\right)/1000$$

$$RKM\ unsized = \frac{Average\ unsizing\ breaking\ load * NM}{1000}$$

$$= \frac{755*11}{1000} = 8.3$$

$$RKM\ sized = \frac{Average\ sizing\ breaking\ load * NM}{1000}$$

$$1,001.6*11/1000 = 11.01$$

$$Strength\ regain = (R.K.M\ sized - R.K.M\ Unsized)\times 100/(R.K.M\ Unsized)$$

$$= (11.01-8.3\times 100)/8.3 = 32.65\%$$

$$Average\ Elongation\ unsized = 4.19$$

$$Average\ Elongation\ sized = 3.28$$

$$Loss\ elongation = \frac{unsized - sized}{unsized}*100$$

$$=4.19-3.28*100/3.28 = 27.7\%$$

$$Calculation\ on\ data\ from\ table\ R.K.M = \left(Unsized\ x\ NM\right)/1000$$

$$RKM\ unsized = Average\ unsizing\ breaking\ load * NM\ /1000$$

$$= 8.3$$

$$RKM\ sized = Average\ sizing\ breaking\ load * NM\ /1000 = 10.6$$

$$Strength\ regain = \left(R.K.M\ Sized - R.K.M\ Unsized\right) x100/\left(R.K.M\ Unsized\right) = \left(10.6-8.3\ x\ 100\right)/8.3 = 27.7$$

$$\%\ Average\ Elongation\ unsized = 4.19\ Average\ Elongation\ sized = 3.28$$

$$Loss\ elongation = unsized - sized\ unsized * 100 = 4.19-3.28 * 100/3.28 = 27.7\%$$

Sized Yarn Strength and Elongation Test Result for Modified Starch

Calculation on data from table (Table 8)

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$$R.K.M = (Unsized \times NM)/1000$$

$$RKM\ unsized = \frac{Average\ unsizing\ breaking\ load * NM}{1000}$$

$$= \frac{755*11}{1000} = 8.3$$

$$RKM\ sized = \frac{Average\ sizing\ breaking\ load * NM}{1000}$$

$$1,001.6*11/1000 = 11.01$$

$$Strength\ regain = (R.K.M\ sized - R.K.M\ Unsized)\times 100/(R.K.M\ Unsized)$$

$$= (11.01 - 8.3\times 100)/8.3 = 32.65\%$$

$$Average\ Elongation\ unsized = 4.19$$

$$Average\ Elongation\ sized = 3.28$$

$$Loss\ elongation = \frac{unsized - sized}{unsized} * 100$$

$$= 4.19 - 3.28*100/3.28 = 27.7\%$$

Table 3: Mass Measurement Result.

Number of Test	Unsized Yarn	Sized Yarn
Test 1	2.6	3.9
Test 2	2.06	4.78
Test 3	4.16	7.1
Test 4	4.5	5.4
KAT	5.11	6.87

Table 4: Unsized Yarn Strength and Elongation Test Result.

S. No	Strength before size	Elongation before sized
1	745	5.1
2	689	4.14
3	794	4.08
4	816	4.28
5	731	3.38
Total	3,775	20.98
Average	775	4.19

Table 5: Sized Yarn Strength and Elongation Test Result for Test 1.

Date		19/4/2013, 1.00 pm
MLR		01:13.5
Cooking temperature		90° C
Cooking time		30 min
Water volume		750 ml
Chemical name		Potato peel Starch, wetting agent, Softener
count		6.5
Number of ends		1
Weight of chemical in(g)		40,0.5,0.04
S. No	**Strength**	**Elongation**
1	1079	3.9
2	930	2.6
3	936	3.3

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4	1047	3
5	1009	4
Total	5,001	16.8
Average	1,000	3.36

Table 6: Sized Yarn Strength and Elongation Test Result for Test 2.

Date		19/4/2013, 1.00 pm
MLR		01:13.5
Cooking temperature		90° C
Cooking time		30 min
Water volume		750 ml
Chemical name		Potato peel Starch, wetting agent, Softener
count		6.5
Number of ends		1
Weight of chemical in(g)		35,04,0.03
S. No	**Strength**	**Elongation**
1	948	3.48
2	1079	3.98
3	998	2.72
4	982	2.55
5	904	3.24
Total	4,911	15.97
Average	982.2	3.19

Table 7: Sized Yarn Strength and Elongation Test for Test 3.

Date		19/4/2013, 1.00 pm
MLR		01:13.5
Cooking temperature		90° C
Cooking time		30 min
Water volume		750 ml
Chemical name		Potato peel Starch, wetting agent, Softener
count		6.5
Number of ends		1
Weight of chemical in(g)		30,0.3,0.02
S. No	**Strength**	**Elongation**
1	932	3.42
2	946	3.14
3	988	3.55
4	1011	3.32
5	964	2.98
Total	4,841	16.41
Average	968.2	3.28

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Table 8: Sized Yarn Strength and Elongation Test Result for Modified Starch.

Date		19/4/2013, 1.00 pm
MLR		01:13.5
Cooking temperature		90° C
Cooking time		30 min
Water volume		750 ml
Chemical name		Potato peel Starch, wetting agent, Softener
count		6.5
Number of ends		1
Weight of chemical in(g)		20,0.1
S. No	**Strength**	**Elongation**
1	904	3.06
2	1031	4.66
3	972	2.5
4	978	3.32
5	1123	2.86
Total	5,008	16.4
Average	1,001.60	3.28

Conclusion and Recommendations

Comparison of Different Tests of Potato Peel Starch Sized Yarn (Figure 3).

Elongation Text Result Comparison (Figure 4).

Comparison of Potato Peel Starch and Modified Starch (Figure 5).

Sized Yarn Elongation Test Result Comparison (Figure 6).

Hairiness (Figure 7).

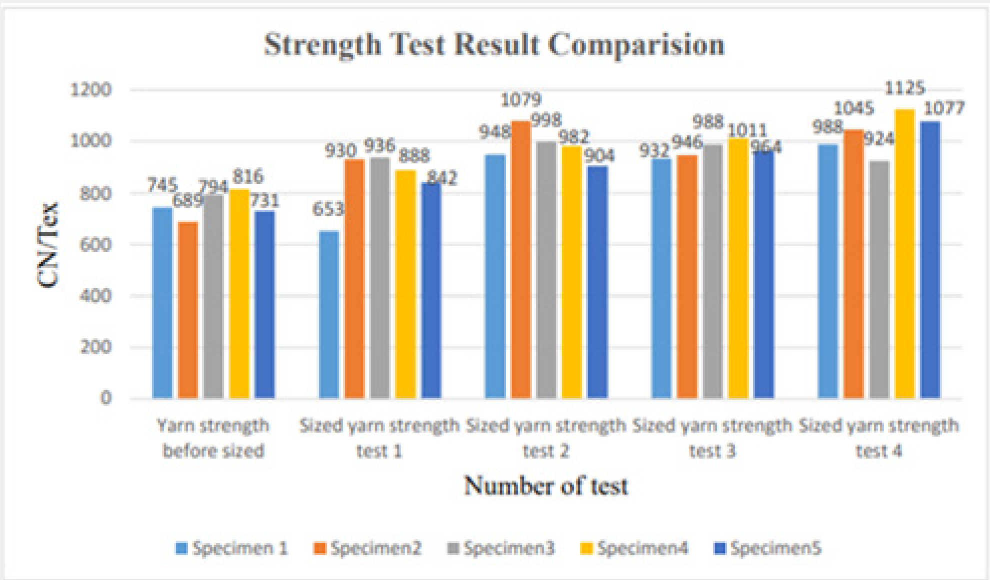

Figure 3: Strength Text Result Comparison.

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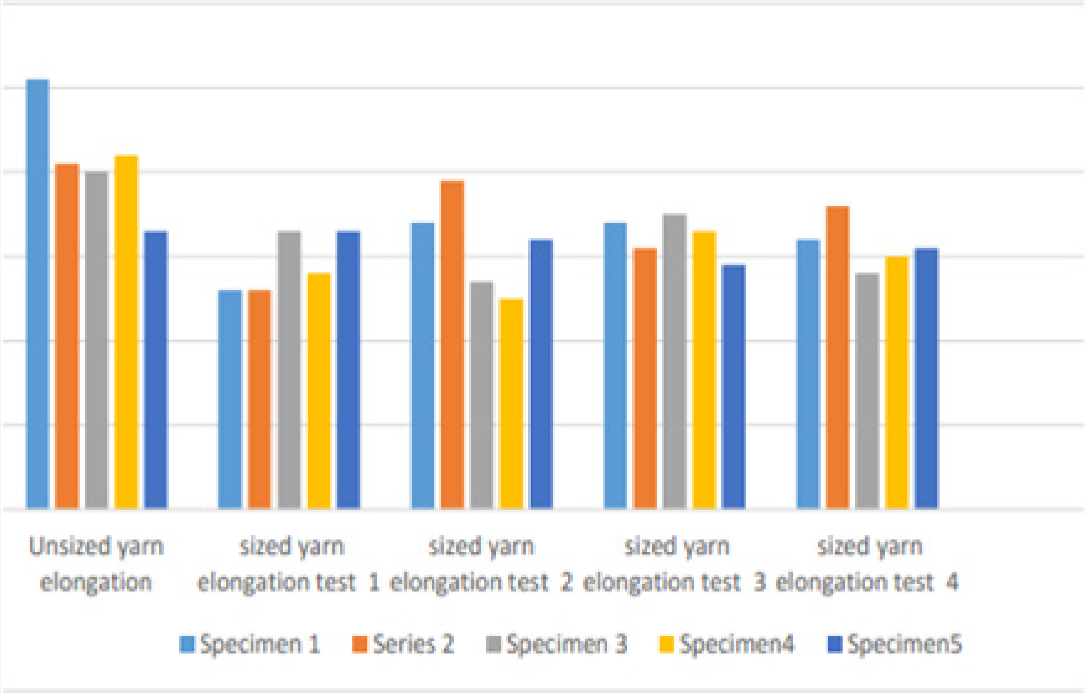

Figure 4: Elongation Text Result Comparison.

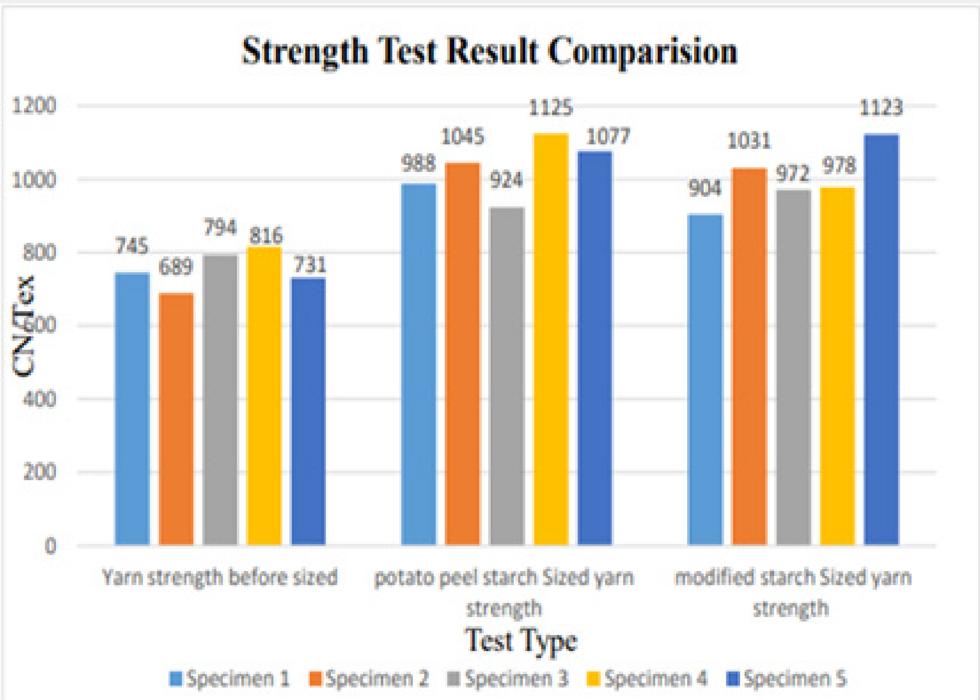

Figure 5: Strength Text Result Comparison of Potato Peel Starch and Modified Starch.

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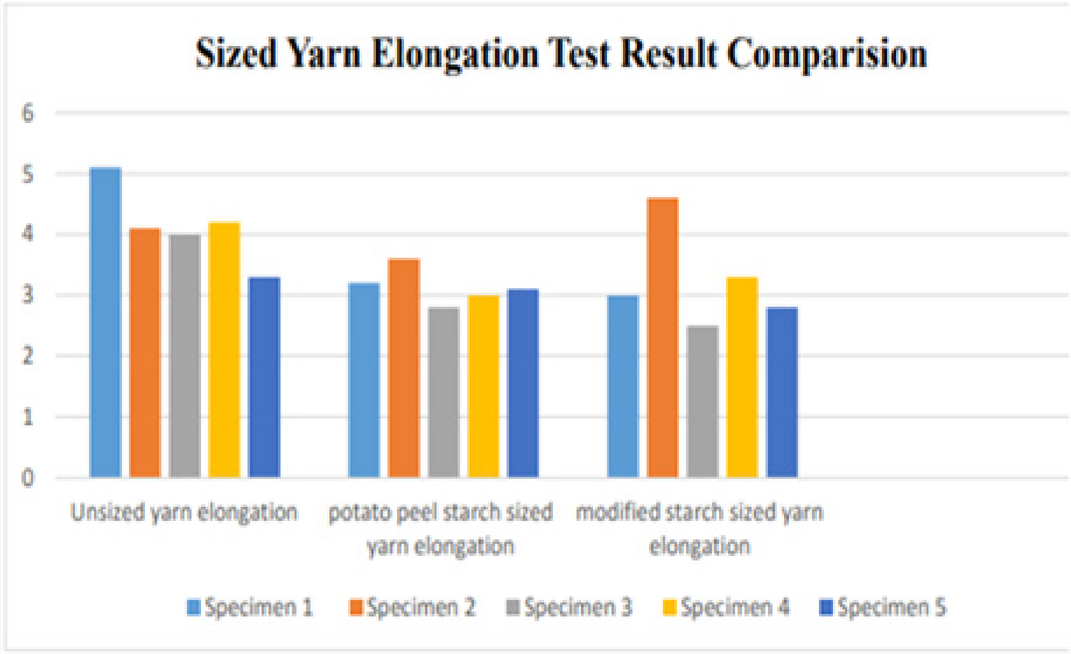

Figure 6: Sized Yarn Elongation Test Result Comparison.

Figure 7: Hairiness.

Discussion

Potato peel starch coated with reference to Table 3, 4, 5 and 6 test results and their calculation shows that preparing sizing agent from potato peel is effective and it is at standard level of (25-40%) strength regains, the strength regain of Test1 was 27.7%, Test 2 was 30.1%, Test 3 was 32%, and Test 4 was 36.1%. From

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those, Test 4 are shows better strength and elongations than other tests, so for potato peel starch sizing the best ratio is 25g of potato peel starch to 750ml of water is preferable for laboratory sizing machine than 30,35, and 40 gram of potato peel starch within 750 ml of water respectively.

From Table 2,6 and 7 shows the average breaking strength values are 755, and 1001, for unsized yarn, potato peel starch and modified starch respectively. As shown in the table above the warp yarn treated with potato peel starch which shows better in breaking strength than modified starch which ultimately gives enhanced weaving performance from the result, we can see that the strength gain is found to be 36.1%. which is acceptable as per standard (25-40) % to the test result according to BITRA (Bombay Textile Research Association) which ensures that potato peel starch can give sufficient strength to the sized yarn and can be utilized for warp sizing. the loss in elongation is found to be about 32.6% which is higher as compared to KAT modified starch at same parameter and recipes which is 32.65 % of strength regain and elongation loss 27.7% and potato peel starch may show improvement in the strength gain. According to the test results, it can be stated that potato peel starch can be used as a sizing material. It satisfies the properties of standard sizing material. It shows good strength and elongation properties which is mandatory for weaving as well as potato peel starch is completely sustainable and environmentally friendly as a sizing agent, he warps yarn excellently after sizing [16-22].

Conclusion

Sizing agent is extracted from potato peel and used for warp sizing. The sized yarn is tested for its performance evaluation and different parameters like tensile strength and elongation end breakage rate. From our test result we have seen that the tensile strength of warp yarn sized using potato peel is very good showing strength regain percentage of 36.1 which is within standard, the loss in elongation was found to be 32.8 which is shows good strength of yarn. From this research experimental result, we have seen potato peel starch sized yarn is showing good performance properties. So, from the research work we can conclude that potato peel starch can be used in textile industry for warp yarn sizing as optional or substitute for other starches and can demonstrate the potential of potato peel as a useful source of starch.

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