Effect of anionic and cationic softener on the property of *Kydia calycina* fibres

TAYYABA FATMA and SHAHNAZ JAHAN

Department of Clothing and Textiles, College of Home Science, G. B. Pant University of Agriculture and Technology, Pantnagar-263 145, (U.S. Nagar, Uttarakhand)

ABSTRACT : Softening is beneficial process to reduce the flexural rigidity of *Kydia calycina* fibres and make it suitable for preparation of yarn. The *Kydia calycina* fibres were extracted from the young shoots of *Kydia calycina* plant through water retting. The extracted fibres were scoured with pectinase enzyme and bleached with TAED activated sodium perborate. In the present study, appropriate softening method was selected among one anionic and two cationic softening methods on the basis of physical properties. Effect of softening variables i.e. concentration of rossari softener, time, temperature and material liquor ratio were studied with the help of *Duncun post hoc* statistical test. The results indicated that the cationic softening method i.e. rossari softener gave better properties as compared to other two methods. At 1 % concentration of rossari softener, 1:30 material liquor ratio , 30^0C temperature and 30 min time of selected method, the tenacity, elongation, fineness and flexural rigidity of *Kydia calycina* fibres were obtained as 4.24±0.08 g/d, 2.95±0.05 %, 23.68±0.43 denier and 1234.19±23.31 mg/mm^2.

Key words: Anionic and cationic softener, *Kydia calycina* fibres, physical properties, softening

In the bast fibre processing industries, bleached fibres become harsh and needs to reduce the rigidity of fibres. Hence, softening is a significant process for reducing the rigidity of *Kydia calycina* fibres. Now-a-days, lot of softeners are available for softening the *Kydia calycina* fibres. Softened fibres are more convenience to produce better quality spun yarn because of flexible nature. Softening treatment with a suitable agent is essential before spinning. The softening treatment for decorticated fibre consisted of soaking of fibre in water and subsequent treatment with a cationic surfactant (Pandey, 1998). Hasani (2010) found that the type of softener plays an important role to create desired changes in mechanical and surface properties. An increase in concentration of the softener, the fabric makes softer, more flexible and smoother. Slade (1998) said that the softeners are applied at levels of about 1% during textiles processing either dyeing step or some later procedure. Cationic softeners are generally considered as +classes of softener because they are substantive to all types of fibres. Shenai and Saraf (1980) described that an effective softener readily dispersed in water and absorbed by the material**,** So that uniform deposition can occur within a relatively short treatment time. It imparted the softness, fluffiness and lubricity to the treated cloth and to reduce static build-up, especially in the case of the hydrophobic fibres.

Present research work was proposed to assess the effect of anionic and cationic softener on the physical properties of *Kydia calycina* fibres. After extracting the fibres from the young shoots of *Kydia calycina* plant, the scouring and bleaching of *Kydia calycina* fibres were done by pectinase enzyme and TAED activated sodium perborate respectively. Both processing methods were eco-friendly and do not affect the environment and human being. According to Mojsov, 2012, enzymes are leading substitute in the textile processing industries due to their non-toxic and environmental friendly nature. Chakraborty and Dyal (1998) reported that the bleaching of cotton using TAED activated sodium perborate instead of conventional bleaching process was a qualitative process. Because TAED activated sodium perborate is an environment friendly, energy saving and low temperature process along with improved whiteness and minimum fibre damage. This process was found to reduce energy cost and effluent load on environment. Afterwards, the softening of *Kydia calycina* fibres were carried out with three different methods i.e. one anionic and two cationic softener. Various physical properties i.e. tenacity, elongation, fineness, fibre length, weight loss and flexural rigidity of softened fibres were tested. On the basis of these properties, one method was selected for softening of *Kydia calycina* fibres and assessed the effect of softening variables on the properties of fibres in regard with better quality.

MATERIALS AND METHODS

Materials

The young shoots of *Kydia calycina* plant were used to extract the fibres which were collected from the Agro-forestry Research Center, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand.

Pectinase enzyme, sodium perborate, TAED, stearic acid, potassium stearate, industrial cationic softener and rossari industrial softener were used in the present study.

Extraction, scouring and bleaching of fibres

Kydia calycina fibres were extracted from young shoots of plant through water retting. The extracted *Kydia calycina* fibres were scoured with pectinase enzyme because of better properties (Fatma, Tayyaba and Jahan, Shahnaz, 2016[1]). Then, TAED activated Sodium perborate was used to bleach the scoured fibres for increasing the whiteness of fibres (Fatma, Tayyaba and Jahan, Shahnaz, 2016[2]).

Softening of fibres

Three different methods were used to reduce the flexural rigidity of fibres which are given below:

Method-I: The anionic softening solution was prepared with combination of 1% concentration of stearic acid and 3 % concentration of potassium stearate. The temperature of bath was maintained at 95^0 C for 60 min. The material liquor was kept 1:30. The one gram bleached fibres were softened with prepared softening solution. After softening, the fibre samples were washed under running water (Marsh, 1979).

Method-II: The solutions of 1 % concentration of industrial cationic softener for both fibres were prepared. One gram of bleached fibres samples were softened with prepared solutions at room temperature for 1 hour. The material to liquor ratio was taken as 1:30. Then, the fibre samples were washed with running water.

Method-III: The rossari industrial cationic softener was used for softening of bleached fibres**.** The one gram bleached fibres were taken in the beaker and softened with 1 % concentration of softener solution at room temperature for 1 hour. The material to liquor ratio was taken as 1:30. The treated softened fibres were washed with running water.

Out of these methods, the best softening method was selected on the basis of their tenacity, elongation, fineness, fibre length, weight loss and flexural rigidity.

Physical testing of fibres

The tenacity, elongation, fineness, fibre length and weight loss were determined. The tenacity, elongation and fineness of the *Kydia calycina* fibres were tested using Fafegraph-M. Length of the *Kydia calycina* fibres was analyzed by the single fibre measurement method given by Booth (1968). The weight loss was determined using method given by Garg *et al.* (2013).Flexural rigidity of *Kydia calycina* fibres were tested according to the procedure given by Vigneswaran and Jayapriya, 2010.

Statistical analysis

One way analysis of variance (ANOVA) was used to analyze the significant difference among each variables of softening by using SAS (*Duncun post hoc test*) at 5 % level of significance. The higher the *p*-value means lower the significance. So, we can say that $p \leq 0.05$ means that the difference is significant and the properties of *Kydia calycina* fibres were significantly affected by softening variables.

RESULTS AND DISCUSSION

The bleached *Kydia calycina* fibres were softened with three softening methods. Out of these three methods, the best softening methods were selected on the basis of tenacity, elongation, fineness, fibre length, weight loss and flexural rigidity. The data regarding the testing of softened fibres are shown in Table 1.

It can be observed from Table 1 that the *Kydia calycina* fibres softened with Method-III had maximum tenacity (4.08±0.13 g/d), elongation (2.85±0.03 %) and fibre length (6.76±0.18 cm) along with minimum flexural rigidity (1353.76±4.33 mg/mm^2) and weight loss (0.78±0.06 %) than the fibres softened with Method-I and Method-II. The fineness of this fibre sample was found as 23.68±0.43 denier which was exhibited coarser in nature than other softened fibres. It was also indicated that the *p*-value of analysis of variance gave the significant difference among each property of *Kydia calycina* fibres except tenacity and fibre length at 5% level of significance. Due to better tenacity, elongation, fibre length, weight loss and flexural rigidity, Method-III was

Table 1: Physical properties of Kydia calycina fibres softened with different methods

S. No.	Softening methods	Tenacity, g/d (Mean ± S.E.)	Elongation, % (Mean ± S.E.)	Fineness, denier (Mean ± S.E.)	Fibre length, cm (Mean ± S.E.)	Weight loss, % (Mean ± S.E.)	Flexural rigidity, mg/mm^2 (Mean ± S.E.)
1	Method I	$3.69^a \pm 0.20$ (16.93)	$2.63^b \pm 0.06$ (7.18)	$21.22^c \pm 0.08$ (1.13)	$6.56^a \pm 0.17$ (17.93)	$1.14^a \pm 0.06$ (16.98)	$2574.30^a \pm$ 20.76 (2.55)
2	Method II	$3.72^a \pm 0.09$ (7.59)	$2.77^{ab} \pm 0.08$ (8.73)	22.16b ± 0.32 (4.55)	$6.61^a \pm 0.16$ (17.30)	0.86b ± 0.06 (22.06)	$1873.42^b \pm 3.11$ (0.53)
3	Method III*	$4.08^a \pm 0.13$ (10.17)	$2.85^a \pm 0.03$ (3.77)	$23.68^a \pm 0.43$ (5.72)	$6.76^a \pm 0.18$ (19.15)	$0.78^b \pm 0.06$ (24.35)	$1353.76^c \pm 4.33$ (1.01)
Sig (*p*-value)		0.1325	0.0483	0.0001	0.6874	0.0007	0.0001

- *Value in parentheses indicate CV (%)*
- *If the p-value less than 0.05 then significant difference present among mean of all groups within the property*
- *Data followed by same letter within column are not statistically different according to Duncun post hoc test(p>0.05) at 5 % level of significance*
- *Star (*) denotes selected method for softening of Kydia calycina fibres*

selected for softening of *Kydia calycina* fibres. In Method-III, the rossari industrial cationic softener was used which is fatty acid amide based softener. The amide based softener is the combination of fatty acids and amines. The selection of Method-III may be due to covering of fibres an oily film along with slightly changing in molecular structure. During softening of fibres, when the fibres are entered into the solution of cationic softener. The negative charge of fibres attracts the positive ions of cationic softener and obtains soft and pliable fibres. Shenai and Saraf (1980) stated that the higher degree of softening is the advantage of cationic softener along with fast washing affinity and high tenacity and also produce good effects on cellulosic materials. Hasani (2010) described that the cationic softener leads to increase tenacity and softness and also to reduce the bending rigidity of textile materials. Sanap (2011) stated that cationic softener had definite affinity for fibre substance. The cationic softeners are usually quaternary ammonium salts, amino-esters and amino-amides. Slade (1998) said that the cationic softener bases are generally considered superior to the other classes of softener because they are substantive to all types of fibres.

After the selection of softening method for *Kydia calycina* fibres, the effects of all softening variables on the fibres were studied.

Effect of MLR

The bleached *Kydia calycina* fibres were softened with Method-III at five different material liquor ratios i.e.1:10, 1:20, 1:30, 1:40 and1:50. The tenacity, elongation, fineness and flexural rigidity of both softened fibres were tested and results are shown in Table 2.

It was observed from Table 2, the tenacity and elongation of *Kydia calycina* fibres were increased with increasing material liquor ratio up to 1:30 and then both properties were decreased. At same increasing order of material liquor ratio, the fineness of softened fibres were decreased and then it was increased whereas the flexural rigidity was decreased. It was also indicated that the non-significant differences were found among each property of all softened *Kydia calycina* fibres on the basis of *p*-values of statistical analysis. It means that the physical properties of fibres did not significantly affected by material liquor ratio. Due to maximum tenacity (4.21±0.05 g/d) and elongation (3.16±0.05 %), the material liquor ratio i.e. 1:30 for fibres was kept constant which was used for further experiments. At this material liquor ratio, the fineness and flexural rigidity for fibres were 23.68±0.43 denier and 1329.71±76.24 mg/mm^2 respectively.

Effect of concentration of softener

The bleached *Kydia calycina* fibres were softened with ten different concentrations of softener from 0.1 to 1% with difference of 0.1%. The physical properties including tenacity, elongation, fineness and flexural rigidity were tested and the results of fibres are given in Table 3.

It is evident from Table 3 that the tenacity, elongation and flexural rigidity of *Kydia calycina* fibres were increased with increasing concentration of softener. Hasani (2010) also described that the improvement in the tenacity and reduction in the bending rigidity of textile materials obtained by increasing concentration of cationic softener. Sanyal and Mukhopadhyay (1988) reported that the tenacity of jute increases with increasing

Table 2: Physical properties of Kydia calycina fibres softened with different material liquor ratio

S. No.	Material liquor ratio	Tenacity, g/d (Mean ± S.E.)	Elongation, % (Mean ± S.E.)	Fineness, denier (Mean ± S.E.)	Flexural rigidity, mg/mm^2 (Mean ± S.E.)
1	1:10	4.12^a ± 0.11 (8.32)	3.03^a ± 0.04 (4.38)	22.52^{ba} ± 0.29 (4.05)	1343.52^a±19.97 (4.70)
2	1:20	4.12^a ± 0.06 (4.59)	3.07^a ± 0.05 (5.17)	22.89^{ba} ± 0.66 (9.18)	1333.10^a ± 35.96 (8.53)
3	1:30*	4.21^a ± 0.05 (3.88)	3.16^a ± 0.05 (5.36)	23.68^a ± 0.43 (5.72)	1329.71^a±76.24 (18.13)
4	1:40	4.21^a ± 0.10 (7.75)	3.13a ± 0.04 (4.06)	23.03^{ba} ± 0.26 (3.54)	1328.47^a ± 7.92 (1.88)
5	1:50	4.11^a ± 0.06 (4.38)	3.13^a ± 0.08 (8.23)	22.22^b ± 0.27 (3.87)	1327.50^a ± 18.06 (4.30)
Sig (*p*-value)		0.7832	0.4476	0.1453	0.9985

- *Value in parentheses indicate CV (%)*
- *If the p-value less than 0.05 then significant difference present among mean of all groups within the property*
- *Data followed by same letter within column are not statistically different according to Duncun post hoc test(p>0.05)at 5 % level of significance*
- *Star (*) denotes selected range of levels*

Table 3: Physical properties of *Kydia calycina* fibres softened at different concentrations of softener

S. No.	Concentrations of softener, %	Tenacity, g/d (Mean ± S.E.)	Elongation, % (Mean ± S.E.)	Fineness, denier (Mean ± S.E.)	Flexural rigidity, mg/mm^2 (Mean ± S.E.)
1	0.1	3.60^c ± 0.10 (8.96)	2.42^b ± 0.04 (5.72)	21.68^c± 0.31 (4.52)	1557.33^a ±44.26 (8.99)
2	0.2	3.74^{bc} ± 0.09 (7.87)	2.59^{ba} ± 0.08 (9.65)	21.77^c ± 0.30 (4.38)	1465.91^{ba}±60.82 (13.12)
3	0.3	3.80^{bac} ± 0.07 (5.52)	2.60^{ba} ± 0.05 (6.56)	21.99^c ± 0.25 (3.55)	1441.82^{ba} ± 58.18 (12.76)
4	0.4	3.82^{bac} ± 0.06 (5.09)	2.64^{ba} ± 0.09 (10.80)	22.01^c ± 0.28 (4.09)	1383.41^b ± 41.81 (9.56)
5	0.5	3.86^{bac} ± 0.06 (4.61)	2.66^{ba} ± 0.15 (17.71)	22.05^c ± 0.33 (4.72)	1377.76^b ± 40.47 (9.29)
6	0.6	3.90^{ba}± 0.06 (4.55)	2.68b^a ± 0.10 (11.46)	22.24^c ± 0.23 (3.33)	1376.57^b ± 37.04 (8.51)
7	0.7	3.93^{ba} ± 0.08 (6.54)	2.76^a ± 0.05 (5.62)	22.64^c ± 0.41 (5.75)	1365.46^b ± 22.24 (5.15)
8	0.8	4.02^{ba} ± 0.12 (9.31)	2.80^a ± 0.05 (6.16)	23.02^a ± 0.33 (4.49)	1360.96^b ± 35.84 (8.33)
9	0.9	4.05^a ± 0.13 (10.40)	2.81^a ± 0.13 (14.70)	23.06^a ± 0.31 (4.21)	1357.98^b± 26.47 (6.16)
10	1*	4.08^a ± 0.13 (10.17)	2.85^a ± 0.03 (3.77)	23.68^a ± 0.43 (5.72)	1353.76^b ± 4.33 (1.01)
Sig (*p*-value)		0.0140	0.0284	0.0002	0.0094

- *Value in parentheses indicate CV (%)*
- *If the p-value less than 0.05 then significant difference present among mean of all groups within the property*
- *Data followed by same letter within column are not statistically different according to Duncun post hoc test(p>0.05)at 5 % level of significance*
- *Star (*) denotes selected range of levels*

concentration of cationic softener. Rastogi *et al*. (2015) said that the stiffness of the materials reduces by the increasing concentration cationic softener.The fineness was decreased with same pattern concentration of softener. The statistical results showed that significant effects were found among each property of softened fibres. Due to maximum of tenacity (4.08±0.13 g/d) and elongation (2.85±0.03 %) along with minimum flexural rigidity (1353.76±4.33) of fibres, the concentrations of softener i.e. 1 % was selected. Therefore, it was taken for further experiment.

Effect of softening time

The bleached *Kydia calycina* fibres were softened for five different time durations i.e. 15, 30, 45, 60 and 75 minutes separately. The physical properties including tenacity, elongation, fineness and flexural rigidity were tested. The results are reported in Table 4.

Table 4 showed that the tenacity and elongation of *Kydia calycina* fibres were increased with increasing times from 15 minutes to 30 minutes and then both properties were decreased. At same increasing time, the flexural rigidity of fibres was decreased afterwards increased. The fineness of fibres was decreased and then increased. The *p*-values of all properties showed significant effect on the physical properties of fibres. The fibres softened for 30 minutes exhibited maximum tenacity (4.24±0.10 g/d) and elongation (3.02±0.04 %). At this softening time, the fineness and flexural rigidity were 24.01±0.14 denier and 1533.53±55.92 mg.mm^2. Therefore, it was selected as optimum softening time.

Effect of softening temperature

The bleached *Kydia calycina* fibres were softened for five different temperatures i.e. 30^0, 40^0, 50^0, 60^0 and 70^0 C. The physical properties i.e. tenacity, elongation, fineness and flexural rigidity were tested. The results are reported in Table 5.

It was indicated from Table 5 that the tenacity and elongation of *Kydia calycina* fibres were decreased with increasing temperatures whereas the fineness and flexural rigidity were increased. Results of one way

Table 4: Physical properties of *Kydia calycina* fibres softened at different times

S. No.	Softening time, min	Tenacity, g/d (Mean ± S.E.)	Elongation, % (Mean ± S.E.)	Fineness, denier (Mean ± S.E.)	Flexural rigidity, mg/mm$_2$ (Mean ± S.E.)
1	15	$3.89^b \pm 0.03$ (2.46)	$2.87^a \pm 0.05$ (5.61)	$22.18^b \pm 0.29$ (4.10)	$1564.99^a \pm 56.59$ (11.44)
2	30*	$4.24^a \pm 0.10$ (7.15)	$3.02^a \pm 0.04$ (4.03)	$24.01^a \pm 0.14$ (1.81)	$1533.53^a \pm 55.92$ (11.53)
3	45	$4.12b^a \pm 0.10$ (7.60)	$2.91^a \pm 0.07$ (7.27)	$23.89^a \pm 0.23$ (3.09)	$1448.15^{ba} \pm 64.74$ (14.14)
4	60	$4.08^{ba} \pm 0.13$ (10.17)	$2.85^a \pm 0.03$ (3.77)	$23.68^a \pm 0.43$ (5.72)	$1353.76^b \pm 4.33$ (1.01)
5	75	$3.85^b \pm 0.10$ (8.38)	$2.65^b \pm 0.12$ (13.88)	$21.90^b \pm 0.35$ (5.00)	$1372.25^b \pm 41.84$ (9.64)
Sig (*p*-value)		0.0362	0.0093	0.0001	0.0125

- *Value in parentheses indicate CV (%)*
- *If the p-value less than 0.05 then significant difference present among mean of all groups within the property*
- *Data followed by same letter within column are not statistically different according to Duncun post hoc test(p>0.05) at 5 % level of significance*
- *Star (*) denotes selected range of levels*

Table 5: Physical properties of *Kydia calycina* fibres softened at different temperatures

S. No.	Softening temperatures, ^{0}C	Tenacity, g/d (Mean ± S.E.)	Elongation, % (Mean ± S.E.)	Fineness, denier (Mean ± S.E.)	Flexural rigidity, mg/mm$_2$ (Mean ± S.E.)
1	300*	$4.24^a \pm 0.08$ (5.59)	$2.95^a \pm 0.05$ (5.66)	$23.68^a \pm 0.43$ (5.72)	$1234.19^b \pm 23.31$ (5.97)
2	400	$4.02^{ba} \pm 0.09$ (6.72)	$2.73^a \pm 0.13$ (14.80)	$22.76^{ba} \pm 0.32$ (4.45)	$1291.32^{ba} \pm 47.62$ (11.66)
3	500	$3.63^{bac} \pm 0.34$ (29.66)	$2.69^a \pm 0.09$ (10.69)	$22.71^{ba} \pm 0.43$ (5.95)	$1304.65^{ba} \pm 14.49$ (3.51)
4	600	$3.43^{bc} \pm 0.35$ (31.79)	$2.65^a \pm 0.16$ (18.85)	$22.01^b \pm 0.35$ (5.09)	$1337.41^a \pm 16.86$ (3.99)
5	700	$3.00^c \pm 0.17$ (18.24)	$2.19^b \pm 0.14$ (19.84)	$21.90^b \pm 0.29$ (4.19)	$1353.76^a \pm 4.33$ (1.01)
Sig (*p*-value)		0.0051	0.0012	0.0098	0.0202

- *Value in parentheses indicate CV (%)*
- *If the p-value less than 0.05 then significant difference present among mean of all groups within the property*
- *Data followed by same letter within column are not statistically different according to Duncun post hoc test(p>0.05) at 5 % level of significance*
- *Star (*) denotes selected range of levels*

ANOVA showed significant effect in each property of softened fibres. Due to higher tenacity (4.24±0.08 g/d) and elongation (2.95±0.05 %), the temperature i.e. 30^0 C was selected for softening of *Kydia calycina* fibres. The fineness and flexural rigidity of fibres were obtained as 23.68±0.43 denier and 1234.19±23.31 mg/mm^2 respectively.

CONCLUSION

As compared to other two softening methods i.e. Method-I (anionic based stearic acid and potassium stearate) and Method-II (cationic based industrial softener), Method-III (cationic based rossari industrial softener) exhibited better tenacity, elongation, fibre length, weight loss and flexural rigidity. Therefore, Method-III (cationic based rossari industrial softener) was selected for softening of *Kydia calycina* fibres. It was also observed that the concentration, time and temperature of softening treatment were significantly affected the physical properties i.e. tenacity, elongation, fineness and flexural rigidity of *Kydia calycina* fibres except material to liquor ratio.At 1 % concentration of rossari softener, 30^0 C temperature, 30 min time and 1:30 material liquor ratio, the tenacity, elongation, fineness and flexural rigidity of *Kydia calycina* fibres were obtained as 4.24±0.08 g/d, 2.95±0.05 %, 23.68±0.43 denier and 1234.19±23.31 mg/mm^2.

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