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FERMENTING KASIM WITH DIVERSE SUGARS – A NOVEL APPROACH TO AN ANCIENT NATURAL DYE

Aakanksha AGRAWAL[1]*
Sunita AGGARWAL[2]
Charu GUPTA[1]
[1]Department of Fabric and Apparel Science, Institute of Home Economics, University of Delhi, New Delhi, India
[2]Department of Microbiology, Institute of Home Economics, University of Delhi, New Delhi, India

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ABSTRACT: Kasim, an ancient natural black dye, has been an integral part of traditional textile crafts of India like Kalamkari, Bagh, Ajrakh, etc. Despite being an important natural dye since the 16th century, there is a lack of scientific evaluation of Kasim in literature. In the present study, Kasim fermentation was optimized using different sugar sources with iron scrap in the ratio of 1:2. In addition to the traditionally used jaggery, a novel approach of fermenting Kasim with sugarcane juice was studied. The dyeing efficiency of each variation was evaluated by dyeing 100% cotton fabric pre-mordanted using myrobalan nut powder. The pH levels of fermenting liquor were observed at regular intervals and found to vary between 3.5 to 6.5 during fermentation. FT-IR analysis of the dyed samples was conducted for preliminary characterization of the dye. The spectra indicated the presence of functional groups such as, ether, carbonyl, and alcohol. The color strength (K/S) increased as fermentation progressed, with the highest values observed in samples dyed with sugarcane juice liquors fermented for 7 days. The CIE *L*a*b** values were very low, indicating a purer hue of black. The samples developed brown-black to charcoal-black hues. The colorfastness properties did not show any significant variation with the varying sugar sources and were observed to be good to excellent. The novel approach of fermenting Kasim using sugarcane juice produced the best dyeing results in much lesser time.

Keywords: Fermented dye, Kasim, Myrobalan, natural black dye

KASİM'İN ÇEŞİTLİ ŞEKERLERLE FERMENTE EDİLMESİ - ESKİ BİR DOĞAL BOYAYA YENİ BİR YAKLAŞIM

ÖZ: Antik bir siyah doğal boya olan Kasim, Hindistan'ın Kalamkari, Bagh, Ajrakh gibi bölgelerindeki geleneksel tekstil zanaatlarının ayrılmaz bir parçası olmuştur. 16. yüzyıldan beri önemli bir doğal boya olmasına karşın, Kasim hakkında literatürde bilimsel bir değerlendirme eksikliği bulunmaktadır. Bu çalışmada, Kasim, demir hurdası ile 1:2 oranında farklı şeker kaynakları kullanılarak fermente edilmiştir. Geleneksel olarak kullanılan ve şeker kamışından elde edilmiş koyu kahverengi rafine edilmemiş bir şeker olan jaggery'nin yanı sıra, Kasim'in şeker kamışı suyu kullanılarak fermente edilmesi gibi yenilikçi bir yaklaşım da incelenmiştir. Her varyasyonun boyama verimliliği, mirobalan fındığı tozu kullanılarak önceden mordanlanmış %100 pamuk kumaşların boyanmasıyla değerlendirilmiştir. Boyanın karakterize edilmesi için fermentasyon sıvısının pH'ı belirlenmiş ve boyanmış örneklerin FT-IR analizi gerçekleştirilmiştir. Fermantasyon sırasında 3,5 ila 6,5 arasında asidik bir pH gözlemlenmiştir. FT-IR analizi, eter, karboksilik ve alkol gibi fonksiyonel grupların varlığını göstermiştir. Renk verimi (K/S), fermantasyon ilerledikçe artmış ve en yüksek değerler, 7 gün boyunca fermente edilen şeker kamışı suyu sıvılarıyla boyanan örneklerde gözlemlenmiştir. CIE *L*a*b** değerleri çok düşük olup, daha saf bir siyah tonu göstermektedir. Örnekler kahverengi-siyah ile kömür-siyah tonları geliştirmiştir. En derin siyah ton, 7 gün boyunca fermente edilen şeker kamışı suyu ile elde edilmiştir. Renk haslığı değerleri farklı şeker kaynaklarıyla önemli bir değişiklik göstermemiş ve iyi ile mükemmel arasında olduğu gözlemlenmiştir.

Anahtar Kelimeler: Fermente boya; Kasim; Mirobalan; doğal siyah boya

***Sorumlu Yazarlar/Corresponding Authors:** *aakanksha.agrawal@ihe.du.ac.in*
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1. INTRODUCTION

In the late 20th century, due to industrialization and increased demand for mill dyed textile products, the textile industry shifted towards synthetic dyes. This led to the art and science of natural dyeing getting limited to some traditional crafts only. Owing to the harmful effects of synthetic dyes on the environment and human life, a global sensitization towards the revival of natural dyes has been observed [1, 2]. However, the natural dyes obtained from plant and animal materials have a general limitation in the form of their laborious extraction and application processes, poor color fastness, and limited supply [3, 4]. This emphasizes the need for research into alternative sources of natural dyes as well as in the improvement of the existing natural dyes and dyeing techniques [5].

Among the different natural dyeing techniques, producing black color on textiles has always proven to be challenging for traditional dyers. The multiple dyeing technique is often employed by traditional dyers, wherein the fabric is treated repeatedly with indigo to obtain a deep blue-black hue. Some other dyers have also used a combination of indigo, madder, and weld to produce a dark black-like hue [6, 7]. In some parts of South-Eastern Asia such as Indonesia, Thailand, Japan, and India, mud dyeing technique is also employed to obtain grey to charcoal color on fabric [8, 9]. All these techniques, however, are difficult, time consuming, labor intensive, and unable to produce a true black hue on textiles.

Many traditional crafts of India, like *Kalamkari, Bagh, Ajrakh, Bagru, Mata-ni-pachedi*, etc., have employed the technique of fermenting a mixture of jaggery and iron for 15 to 45 days to yield a black dye for printing and painting textiles. This ancient natural dye, called Kasim, produces a grey-black to charcoal-black color when applied to fabric pre-treated with a tannin-based mordant, usually myrobalan nut powder. [10-14].

Despite being essential to numerous traditional textile crafts in India, the review of literature showed that Kasim has not been evaluated scientifically. The Government of India has documented the intricacies of the production methods of different traditional crafts of India, based on the information provided by the prominent artisans of those crafts. These documentations record the widespread use of Kasim, which is the fermented black dye, for making black outlines of motifs in designs by means of hand painting and printing. The recipe of Kasim has been described using regional names for ingredients and measurements. However, several variations can be seen, and the production process is often attributed to the expertise of the master artisans [6, 15, 16].

The essential raw materials required for Kasim fermentation across various crafts include jaggery (as a sugar source) and iron scrap. The type of jaggery used is largely influenced by regional availability. In Northern and Western India, jaggery is predominantly derived from sugarcane juice, whereas date palm jaggery is more common in Southern India. As a result, crafts like *Kalamkari* typically use date palm jaggery for Kasim fermentation, while sugarcane (or cane) jaggery is employed in the preparation of Kasim in *Bagh*, *Ajrakh*, and *Bagru* [6]. Iron scrap can be obtained as an industrial waste at a very low cost. Also, jaggery costs are significantly low in the Indian subcontinent. Therefore, Kasim production proves to be much cheaper than conventional natural dyes that are extracted from plant parts or animal sources.

In addition to this, conventional natural dyes often require extensive equipment set up for extraction, purification and application. The production and application of Kasim does not require any technical set-up. The dyeing of pre-mordanted fabric with Kasim is a heatless process. It requires no input of heat energy, resulting in lowered cost of application. It is therefore widely used for hand painting and hand block printing on textiles.

The use of iron during fermentation of Kasim indicates that it is essentially an iron based natural dye. Iron, however, is a less harmful metal, as compared to heavy metals like tin, lead, chromium, etc.[17]. According to the environmental regulations for most countries iron does not have any regulatory limits associated with it for textile application [18].

Kasim offers another significant advantage in its simplicity and eco-friendliness during the dyeing process. Conventional exhaustive dyeing methods—for natural or synthetic dyes—often require the addition of dyeing auxiliaries such as salts (sodium chloride), alkalis (sodium bicarbonate), and acids (acetic acid) to facilitate the dyeing process. The presence of such chemicals in dye baths poses challenges in effluent treatment, and if inadequately treated, can have many detrimental effects on aquatic ecosystems and soil health [14, 19]. In contrast, Kasim eliminates the need for these chemical additives. Dyeing with Kasim is free from auxiliary chemicals, and it does not leave behind any spent dye liquor as effluent. This makes it a more sustainable choice, with minimal environmental impact both in the short and long term. Thus, while remaining an eco-friendly dye, it overcomes the inherent cumbersome and expensive nature of conventional natural dyes.

Jaggery is a non-centrifugal sugar which is obtained by boiling and concentrating the juice of sugarcane, or sap of crops like date palm, palmyra palm, etc. in open vats. It is a mixture of sugar and molasses and is used as a natural traditional sweetening agent. It is known by different names in different regions and languages like jaggery (English), guda (Hindi), kokuto (Japanese), panela (Mexico and South America), desi (Pakistan), hakuru (Sri Lanka), rapadura (Brazil), naam taan oi (Thailand) etc. Jaggery is usually brown in color and is available in the form of solid blocks of different shapes and sizes. Since jaggery undergoes comparatively lesser refining processes using various chemicals during its production, it is considered a healthier option to table sugar. [20, 21].

The quality of jaggery is assessed by its color. Therefore, sometimes, the manufacturers practice chemical washing of cane jaggery by adding chemicals like sodium bicarbonate, calcium hydroxide, lady-finger juice, and artificial colors in increased quantities [20, 22, 23]. When these chemicals are added in higher quantities, it gives jaggery a bright yellow-orange color, which may impact its use as an edible product. This jaggery, termed as chemically washed cane jaggery in this study, differs from organic cane jaggery, to which little or no chemicals have been added during the production process.

The present study investigated the optimization of Kasim by fermenting it with four different sugar sources and evaluating their dyeing performance. Traditionally, cane jaggery and date palm jaggery have been used in the preparation of Kasim for textile applications. It was noted that cane jaggery is often subjected to adulteration through chemical washing, as previously discussed. Since both chemically washed and organic varieties of cane jaggery are commonly found in Northern India—and there is no clear consensus on which type is used by artisans—both forms were included in the study. The effect of chemically washed cane jaggery on the color development of Kasim was also assessed. In addition to jaggery, a novel approach was undertaken by fermenting Kasim with sugarcane juice, an area that has not been explored yet. As the existing literature showed a lack of scientific evaluation of this fermented black dye, this study also identified the functional groups present in Kasim through FT-IR spectra analysis.

2. MATERIALS AND METHODS

2.1. Materials

The natural black dye Kasim was prepared by fermenting different sources of sugar, viz., organic cane jaggery, chemically washed cane jaggery, date palm jaggery, and sugarcane juice. The date palm jaggery was sourced from GiTagged Gajapati Pvt. Ltd. The cane jaggery and juice were sourced from the Indian National Airways (INA) Market, New Delhi. The iron scrap used for fermentation was obtained from a scrap shop in Safdarjung Enclave, New Delhi. 100% cotton cambric fabric with a thread count of 210 x 215 was sourced from INA Market, New Delhi. The myrobalan nut powder was sourced from Isha Agro Developers Pvt. Ltd. The cambric fabric was scoured using detergent solution obtained from Tide Plus washing powder, Procter & Gamble Home Products Pvt. Ltd.

2.2. Methods

2.2.1. Fermentation of Kasim

The different types of jaggery were individually mixed with iron scrap in a ratio of 1:2 (sugar:iron) in 250 ml of water. For sugarcane juice, a 5:1 ratio (juice in milliliters to iron scrap in grams) was employed without adding water. This higher ratio accounted for the fact that during the process of boiling sugarcane juice to produce jaggery, only about one-tenth of the initial quantity remains as jaggery [24]. Thus, the 5:1 ratio was chosen to approximate the 1:2 ratio applied when using jaggery as the sugar source. The mixtures were kept in glass beakers that were covered with a black sheet to provide a dark, undisturbed environment for natural fermentation to occur for a period of 30 days.

2.2.2. Pre-mordanting of fabric

The 100% cotton fabric was scoured in 5g/l detergent solution at 80ºC for 30 minutes. It was then pre-mordanted using myrobalan nut powder (*Terminalia chebula*). The scoured fabric was treated with 20% owf myrobalan nut powder in 1:30 MLR at 70ºC for 45 minutes. The fabric was stirred to ensure uniform application of myrobalan. After 45 minutes, the fabric was dried, and the excess powder deposition on the fabric surface was brushed off using hands.

2.2.3. Dyeing with Kasim

Dyeing with Kasim does not require any energy consumption or heating. The pre-mordanted fabric was simply dipped in the dye liquor for a few seconds and spread on a blotting paper to dry. The color developed on the fabric within 1-2 minutes.

2.2.4. Preliminary characterization of natural dye Kasim

The pH of the fermenting Kasim liquor was monitored to understand the fermentation process. A laboratory pH meter was used for this. Also, the Fourier Transform Infrared Spectroscopy (FT-IR) analysis of fabric dyed using Kasim was conducted at the Northern India Textile Research Association (NITRA), Ghaziabad, to identify the important functional groups present in Kasim.

2.2.5. Measurement of color strength

The dyeing efficiency of Kasim was evaluated based on the color strength of dyed samples. It was analyzed using two parameters- the K/S value and the CIE $L^*a^*b^*$ values. The Color-eye Macbeth 3100 Spectrophotometer was used for measurement of the color strength values. The measurement was done at three different areas on the sample to obtain the average readings.

2.2.6. Assessment of color fastness

The dyed samples were further assessed for their color fastness properties to washing (ISO105C06:2010A1S), rubbing (ISO105-X12:2016), light (ISO:105-B02:2014 Exposure Cycle A1), and perspiration (acidic and alkaline) (ISO105E04:2013). The tests for color fastness to washing, perspiration, and light were conducted at the Northern India Textile Research Association (NITRA), Ghaziabad, while the test for color fastness to rubbing was conducted at the Institute of Home Economics, University of Delhi using the laboratory crock meter.

The changes in color and staining of the adjacent fabric were assessed using the ISO105, BS1006 AO3-1978 SDC standard grey scale and blue wool scale.

3. RESULTS AND DISCUSSION

3.1. pH variation during fermentation

The pH level plays a pivotal role in governing the outcomes of fermentation processes, influencing the spectrum of products and by-products generated through enzymatic pathways and microbial activities [25]. It significantly affects the growth of microorganisms, including yeast and bacteria, which are instrumental to the fermentation process. The kind of microbial community, as well as the primary biometabolites produced, depend greatly on the pH level [25, 26]. Under acidic pH conditions, chemical reactions tend to exhibit reduced kinetics, while microbial activity of the acidophilic bacteria increases. This dynamic relationship between pH and fermentation parameters highlights the importance of maintaining an optimal pH environment to regulate and optimize the desired outcomes of the fermentation process [27].

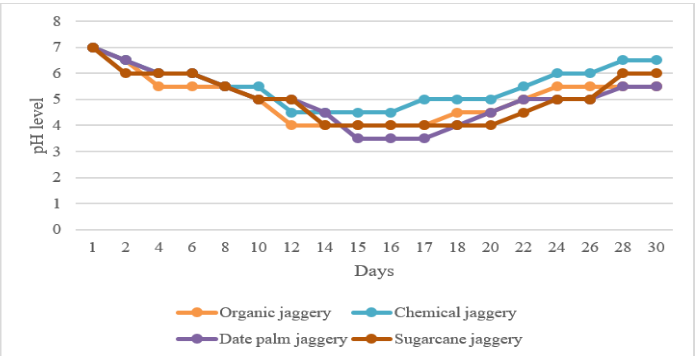


Figure 1. Variation in pH during fermentation of Kasim

The pH of Kasim became strongly acidic, between 3.5 to 4.5, by day 14 of fermentation. Thereafter, it again increased to a slightly acidic pH of 5.5 to 6.5 by 30th day. The variation in pH of the Kasim solution during fermentation has been depicted in Figure 1. The acidic pH in Kasim indicates an increase in microbial activity between the 8th and 22nd days of fermentation.

It was observed that the pH of date palm jaggery dye liquors reduced more than the other variations (up to 3.5). Similarly, the pH of dye liquors fermented with chemically washed cane jaggery reached the lowest of 4.5, which was higher as compared to other variations.

During the fermentation of Kasim, the presence of an acidic pH indicates the proliferation of acidophilic bacteria in the liquor, a bacterial class thriving in highly acidic environments [28]. Additionally, some researchers have observed that the microbial oxidation of inorganic metallic compounds, such as iron and sulphur, yields an acidic solution rich in metal ions. Therefore, it has been observed that bacteria possessing the ability to metabolize metals are also able to withstand acidic surroundings [29], [30]. Specifically, species like *Thiobacillus ferredoxins* and *Ferrobacillus ferredoxins* have been identified as iron-oxidizing bacteria thriving under low pH conditions [31], [32]. Thus, the observed reduced pH level during the fermentation process of Kasim can potentially be a direct indicator of these microbial activities.

3.2. FT-IR analysis

Fourier transform infrared (FT-IR) spectroscopy is a subset of vibrational spectroscopy. It is an important qualitative analytical method that can reveal the specific bonding arrangements in the substrate. Moreover, the amplitudes of peaks observed in the spectra are indicative of the quantity of the material or specific chemical bond arrangements present, enabling quantitative assessments. Therefore, FT-IR spectroscopy is a valuable tool for characterizing a wide range of materials by investigating their molecular composition [33-36].

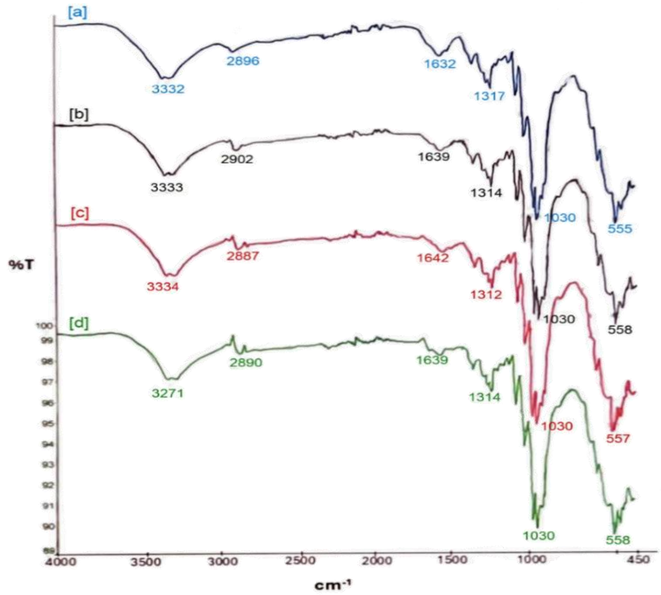


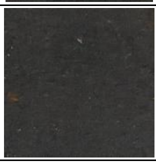
Figure 2. FT-IR spectra of fabric dyed with Kasim fermented with [a] organic cane jaggery, [b] chemically washed cane jaggery, [c] date palm jaggery, and [d] sugarcane juice, with iron scrap

FT-IR analysis was done to identify the functional groups present in Kasim dye (Figure 2). Strong peaks were observed at the frequencies approximating 3332 cm^{-1}, 1632 cm^{-1}, 1317 cm^{-1}, 1030 cm^{-1}, and 555 cm^{-1}. The peak at 2896 cm^{-1} was medium, while those at 1423 cm^{-1}, 1110 cm^{-1}, 1058 cm^{-1}, and 661 cm^{-1} were weak. The peak forming around the frequency of 3332 cm^{-1} was due to the characteristic vibration of the hydroxyl group, which confirmed the presence of alcohol group (-OH) in the dye. The strong peak around 1632 cm^{-1} was indicative of the carbonyl group (-C=O), while that around 1317 cm^{-1} indicated the stretching of the -C=O group. The medium and strong peaks from 1100 cm^{-1} to 1000 cm^{-1} indicated the presence of ether, ester, or alcohol groups (-C-O). These groups may indicate the presence of polysaccharides in the dye, such as sugars and pectin. The peaks between 555 cm^{-1} and 700 cm^{-1} indicated the presence of aromatic rings in the dye structure [37-40].

The functional groups present in a natural dye enable it to form complexes with the active sites of the fibers. Functional groups can affect the color and stability of the natural dyes. The conjugations between different functional groups facilitate the bond formation of dye molecules with the mordant or fiber molecules. They also impart functional properties like antimicrobial property and UV protection. The presence of polar groups, such as alcohol group, carbonyl group and aldehyde group, indicates that the dye is readily soluble in polar solvents (like water) [41, 42].

The analysis of the FT-IR spectra of Kasim fermented using different types of sugar sources revealed negligible variations, as depicted in Figure 2, suggesting that altering the sugar source for Kasim fermentation does not significantly affect the predominant functional groups within the resulting product. This observation indicates consistency in the composition of Kasim across different fermentation conditions.

Table 1. Cotton cambric fabric dyed with Kasim prepared using different sugars fermented for different time intervals

Days	Organic cane jaggery	Chemically washed cane jaggery	Date palm jaggery	Sugarcane juice
1				
4				
7				
11				
14				
18				
21				
26				
30				

3.3. Measurement of color strength

The dyeability of Kasim fermented with varying sugar sources was evaluated by producing a shade card on 100% cotton cambric fabric pre-mordanted using myrobalan nut powder.

The samples developed a visibly darker hue as fermentation progressed. It was also observed that Kasim made by fermenting date palm jaggery produced a deep brown-black hue on the fabric. On the basis of visual evaluation, it can be concluded that the deepest hue was obtained on the 7th day for sugarcane juice liquors, while it was observed on the 11th day for organic cane jaggery liquors, 14th day for date palm jaggery liquors and 21st day for chemically washed cane jaggery liquors. The color intensity of the samples dyed using sugarcane juice liquor seemed to remain similar from the 7th day onwards. The shades obtained on different days of fermentation of Kasim have been shown in Table 1.

The visual analysis of color strength was confirmed by the trend in K/S values as well, as depicted in Table 2. The K/S values (at λ_{max}=530nm) indicated a general increase as fermentation progressed. The highest color strength in terms of the highest K/S value, i.e. 19.05, was seen in samples dyed using sugarcane juice fermented liquors in 7 days of fermentation. On the other hand, Kasim prepared from chemically washed cane jaggery produced the lowest K/S (16.25) in 21 days.

On the basis of both visual examination and color strength (K/S) values, it can be concluded that the most intense black hue was obtained when dyeing with sugarcane juice dye liquor. This dye liquor also matured at a faster rate than the other variants. The lower fermentation duration in the case of sugarcane juice can be attributed to the easy availability of sugars due to its liquid state. The sugars and other minerals would thus be readily utilized by microorganisms to enhance the rate of fermentation.

The color coordinates CIE *L*a*b** values of the samples showed a general decrease as the fermentation progressed. The *a** and *b** values ranged between -3.59 to 2.37. The low values of *a** and *b** indicated a progressive reduction of colored components and a purer hue of black in the dyed samples. The decreasing *L** values indicated that the hue was getting darker. The CIE *L*a*b** values for the cambric samples dyed on different days of fermentation of various sugar sources have been shown in Table 3.

3.4. Assessment of color fastness properties

Color fastness properties are crucial as they govern the type of usage of the dyed textile material. The color fastness properties of the cambric samples dyed using Kasim fermented with different sugar sources were found to be comparable, as shown in Table 4 below.

Table 2. Variation of color strength (K/S values) of fabrics dyed with Kasim fermented using different sugars with increasing duration of fermentation

Days	Organic cane jaggery	Chemically washed cane jaggery	Date palm jaggery	Sugarcane juice
1	6.02	5.2	5.95	8.12
4	10.21	11.65	9.62	15.24
7	14.32	12.1	9.45	**19.05**
11	**17.5**	12.51	11.33	18.55
14	16.33	13.37	**17.6**	18.28
18	15.92	13.79	17.55	17.87
21	14	**16.25**	11.9	18.08
26	13.63	15.19	11.16	18.91
30	13.1	15.26	10.53	18.32

Table 3. Variation of CIE *L*a*b** values of fabrics dyed with Kasim fermented using different sugars with increasing duration of fermentation

Days	Organic cane jaggery			Chemically washed cane jaggery			Date palm jaggery			Sugarcane juice		
	*L**	*a**	*b**	*L**	*a**	*b**	*L**	*a**	*b**	*L**	*a**	*b**
1	35.68	4.09	2.14	38.81	5.12	-4.06	41.59	10.37	7.20	31.87	2.19	-2.92
4	25.66	1.40	0.01	21.12	2.09	-2.13	26.84	1.33	0.80	21.87	-0.17	1.18
7	19.38	1.44	-1.78	22.61	-0.25	-3.10	23.55	0.48	-1.87	17.09	0.34	0.01
11	**17.81**	0.49	2.20	21.90	2.13	-3.05	23.18	2.37	0.81	17.32	1.58	0.83
14	19.28	0.96	-2.35	22.24	0.31	-3.59	19.97	1.42	-1.48	18.47	2.20	-1.81
18	19.89	1.32	-1.58	19.45	-1.69	-2.89	**17.63**	0.62	1.15	16.06	1.04	1.47
21	21.37	1.29	-0.23	**18.51**	1.35	-4.72	24.90	-0.83	-0.70	**15.12**	0.53	-1.84
26	22.19	2.01	1.13	18.97	1.93	-2.53	25.32	1.28	-1.78	16.08	1.19	-0.82
30	22.80	1.17	-1.46	19.24	-0.36	-2.01	25.91	-1.77	-3.24	15.91	0.98	-0.49

Table 4. Color fastness properties of fabric dyed with Kasim

Samples dyed with Kasim fermented with:	Fastness to washing		Fastness to rubbing (dry)		Fastness to rubbing (wet)		Fastness to perspiration (acidic and alkaline)		Fastness to light (on blue wool scale)
	Staining	Fading	Staining	Fading	Staining	Fading	Staining	Fading	
Organic cane jaggery	4-5	3-4	4	4-5	4	4-5	4-5	3-4	2-3
Chemically washed cane jaggery	4-5	3-4	4-5	4-5	4	4-5	4-5	3-4	2
Date palm jaggery	4-5	3-4	4-5	4-5	4-5	4-5	4-5	3-4	2
Sugarcane juice	4-5	3-4	4-5	4-5	4-5	4-5	4-5	3-4	2

The grey scale is used to evaluate how resistant a dye or pigment is to be fading or staining under the impact of different agencies like washing, rubbing and perspiration. It uses a rating of 1–5, with 1 being poor and 5 being excellent color fastness. Similarly, the blue wool scale is used to evaluate the color fastness to light. The scale ranges from 1 to 8, with 1 being the least resistant and 8 being the most resistant [43].

Natural dyes are often non-substantive in nature and do not possess direct affinity for the textile material. This leads to poor color fastness properties [44-46]. The color fastness of Kasim dyed samples to wash was observed to be good to excellent. The dyed fabric did not stain the adjacent undyed fabric, but it faded slightly on washing, as evident by the good to very good rating of fading on the grey scale. Similar results were obtained while testing for color fastness to perspiration (acidic and alkaline). The color fastness to wet and dry rubbing were also found to be very good to excellent. However, the color fastness to light of the dyed samples was poor. From the above Table 4, it can be concluded that varying the sugar source for fermentation of Kasim has little or no impact on the color fastness properties of dyed fabric.

4. CONCLUSION

The ancient natural fermented black dye, Kasim, has been integral to Indian traditional crafts like *Kalamkari*, *Bagh*, and *Ajrakh*. But it lacks standardized scientific assessment despite its usage since the 16th century. This research aimed to revive and evaluate Kasim's dyeing efficiency by fermenting it with various sugar sources (organic cane jaggery, chemically washed cane jaggery, date palm jaggery, and sugarcane juice) in a ratio of 1:2 (5:1 for sugarcane juice) with iron scrap. The pH monitoring during fermentation indicated microbial activity, with levels rising from 3.5–4.5 at 15th day, to 5.5–6.5 by the 30th day. The acidic pH also indicated that acidophilic microorganisms could play an important role. The FT-IR analysis indicated the presence of various functional groups, viz., alcohol, carbonyl, ether, and ester, in the dyed fabrics. However, it showed no significant variation due to fermentation using different sugar sources.

The effect of fermenting Kasim using different sugar sources on dyeing efficiency was assessed by color strength and color fastness analysis. The samples dyed using sugarcane juice dye liquor exhibited the highest K/S values (19.05) and the deepest black hues. Moreover, the dye liquor matured in 7 days, greatly reducing the fermentation duration and the associated costs. The color fastness to washing, rubbing, perspiration, and light varied little with sugar sources, where fastness to washing, rubbing and perspiration ranged from good to excellent, while fastness to light rated poor. Further attempts to improve the light fastness of samples dyed with Kasim can be made by treating them with ultraviolet absorbing biomaterials like certain tannin compounds [47-49].

The present study highlights the cost-effectiveness and simplicity of the extraction and application processes of Kasim, requiring minimal energy and no complex machinery. Optimal outcomes were achieved through the utilization of sugarcane juice, the use of which had not been documented so far. This brings a novel approach of preparing this traditional black dye of India, Kasim, at a faster pace. The findings put further emphasis on the viability of Kasim as a comparatively more environmentally friendly and cost-effective natural dye for textile purposes. The findings pave the way for future research into the characterization and promote the widespread application of this heritage dye.

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