

# Cactus Leather In Cricket Balls: Evaluating Its Behavior as an Alternative to Animal-Based Leather

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**ABSTRACT:** The study's purpose is to evaluate the behavior of cactus leather compared to animal-based leather for use in cricket balls. Since many cricket balls are disposed of after usage, large quantities of animal-based leather are wasted. Animal-based leather is a material that damages the environment, and it subsidizes animal slaughter. If sustainable leathers were to replace animal-based leather, this would not only provide a cruelty-free alternative but would also restrict environmental damage. This paper aims to evaluate whether cactus leather, a plant-based leather, could be a replacement for animal-based leather in its application to cricket balls. Tensile strength, tear strength, elongation, and abrasion resistance were seen as testable characteristics for the study. There is minimal published data that compares these characteristics with the intention of finding a replacement for animal-based leather for cricket balls, so it was important to conduct this research. The study involved tests on cactus and animal-based leathers. Since it was not possible to get a full data set for animal-based leather, previous studies were used in order to compare the properties of cactus leather and animal-based leather. Analysis revealed that cactus leather outperformed animal-based leather in some areas and underperformed animal-based leather in others.

**KEYWORDS:** Materials Science, Sustainable Leather, Cactus Leather, Cricket.

## ■ Introduction

Cricket is a bat-and-ball sport that is one of the most popular sports worldwide. It is estimated that over 200 million people regularly play cricket.<sup>1</sup> Cricket balls are made of leather, a polluting material that subsidizes animal slaughter. To combat this, the study evaluated cactus leather as a sustainable alternative for the production of cricket balls. Throughout the study, Desserto's cactus leather was used as a potential candidate to replace real leather and provide a more environmentally friendly, cruelty-free alternative. A cactus leather cricket ball has never been made since the sustainability of cricket balls is not a problem that has been widely addressed in the cricketing community.

When searching for an alternative to leather, it is necessary to find a material that replicates leather rather than outperforms it.<sup>2</sup> To make a cactus leather cricket ball that behaves similarly to that of an animal-based leather cricket ball, the cactus leather must mimic real leather; the tear strength, abrasion resistance, elongation, and tensile strength should be the same as animal-based leather. As a result of this, this study will compare the four metrics' data of both cactus leather and animal leather in order to accurately examine the alternative.

### *1.1 Environmental Effects of Leather-Based Cricket Balls:*

Despite the misconception that the cricket ball production process is not extremely polluting, the issue is substantial. Approximately 1.805 million balls are considered to be unusable after each year.<sup>3</sup>

Since a cricket ball has a surface area of approximately 0.018 m<sup>2</sup>, and there are 1.805 million balls deemed unusable every year, the two numbers can be multiplied to get approximately 32,500 m<sup>2</sup>, and then divided by a cow's surface area, 5 m<sup>2</sup>, to

find how many cows were slaughtered for the production of these balls. From the calculations, it is estimated that approximately 6,500 cows are slaughtered per year.

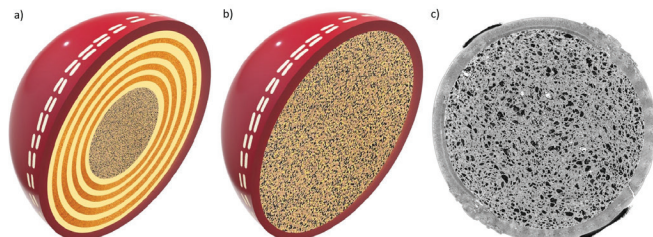
The common belief is that leather is a byproduct of the meat industry, which would go to waste if not used. However, the hide can make up 80% of the animal's total value.<sup>2</sup> This means that meat, rather than animal hide, can be the byproduct. As a result of this, the meat industry needs to utilize animal by-products, such as leather, in order to maintain competitive prices.<sup>4</sup> Given the meat industry's heavy reliance on leather, using an alternative material would substantially avoid subsidizing animal slaughter.

Moreover, there are environmental concerns prevalent in the leather processing phase. For an animal hide to be converted to leather, it must go through the tanning process, which includes many chemical treatments. Firstly, in order to remove the hair from the animal hide, it must go through a process in which the epidermis layer, fats, globular proteins, and other materials are removed from the skin.<sup>5</sup> The dehairing process utilizes sodium sulfide, a chemical that decomposes to produce toxic hydrogen sulfide gas.<sup>5</sup> The issue with the tanning industry is that these chemicals end up going into wastewater.<sup>6</sup> Toxic substances entering water can be detrimental to the environment. An example of this is Kanpur, a designated leather processing hub in India. The Ganga River, which flows through North India and Kanpur, is mainly black and brown in color in the Kanpur area since there are 19 drains carrying sewage directly to the river.<sup>7</sup> The river has developed the status of being a dumping ground for industries.<sup>7</sup> In addition to releasing harmful chemicals into the environment, a carbon footprint assessment revealed that a 1.9 ± 0.1 mm piece of leather emits 79.6 kg CO<sub>2</sub> per m<sup>2</sup> of material.<sup>8</sup> Using the approximation of 33,000 m<sup>2</sup> of leather

required to produce 1.805 million cricket balls, the following calculation can be used for the total emissions:

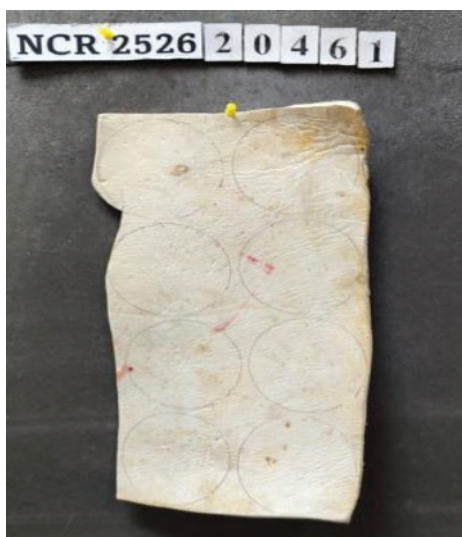
$$79.6 \text{ kg CO}_2/\text{m}^2 \times 33,000 \text{ m}^2 \approx 2,627,000 \text{ kg CO}_2 \approx 2,600 \text{ tons CO}_2 \text{ per year}$$

Considering that animal-based leather is only one component of a cricket ball, 2,600 tons of CO<sub>2</sub> is a substantial amount. In context, a large healthy tree sequesters approximately 48 kg CO<sub>2</sub> per year.<sup>9</sup> This would mean that it would take approximately 53,000 large healthy trees to sequester the emissions from the leather component of cricket balls.



**Figure 1:** The composition and internal structure of cricket balls. The figure was used with permission from Dr. Darshil Shah.<sup>1</sup>

The production of a cricket ball is a manual process that includes stitching using different types of needles, dies, and a hand-driven punch.<sup>10</sup> Stitching one side of the ball takes approximately 30 minutes.<sup>10</sup> A cricket ball has many layers, as shown in Figure 1. In the middle is the cork-rubber core, then comes the cork-and-twine packing, and the outermost layer is stitched leather.<sup>11</sup> The structure of the ball highlights the necessity to find a like-for-like material when substituting leather. Considering the feasibility of manufacturing sustainable cricket balls on a mass scale, it would be most effective to produce a ball with a similar structure, using the same manufacturing technique. From a sustainability standpoint, cork is not the main problem. Cork oak forests contribute to climate change mitigation.<sup>12</sup> For this reason, the main goal is to obtain a sustainable material that can substitute leather for a cricket ball rather than find a replacement for the inner part of the ball, which is derived from cork.



**Figure 2:** Displays the animal-based leather that was tested to obtain our data.

The global leather trade makes a 600 billion US\$ industry.<sup>13</sup> Leather is created from the hides of animals, which are typically derived from cattle, goats, sheep, and pigs.<sup>14</sup> Leather has good hydrothermal stability, a measure of a material's resistance when exposed to liquids, and mechanical properties.<sup>15</sup> The main applicational benefit of animal-based leather is its durability, motivating cricket ball manufacturers to use it, as seen in Figure 2. These traits make leather desirable for a variety of applications, including the fashion industry, furniture, automotive interiors, and luxury items.<sup>16</sup> Despite the many applications leather provides, it undergoes extensive chemical processes during the production phase, which are harmful for humans and the environment. In order to produce leather, manufacturers must use chemicals that are toxic to humans.<sup>17</sup> The leather production and tanning process, which converts animal hide into usable leather, is split into three phases: pre-tanning, tanning, and post-tanning.<sup>18</sup> The pre-tanning phase comprises the selection of hides and the preparation of the skin to receive tanning agents.<sup>18</sup> The tanning phase starts with a saline solution, where the animal hide is prepared to tan.<sup>18</sup> Finally, the leather is post-tanned to impart color, texture, and other physical characteristics.<sup>18</sup>

The entire production cycle is damaging to the environment. Firstly, the production of leather demands large quantities of water for feeding the animals and processing the material during the chemical process.<sup>19</sup> The pollution from tanneries' chemical processes causes hazards as a result of unsafe disposal of untreated effluents on soil and water.<sup>20</sup> For example, from the various chemicals used during the tanning process, only 20% is absorbed by leather.<sup>21</sup> This results in harmful pollutants being released into the environment in large quantities. From the process, chromium, a heavy metal harmful to the environment and human health, is in the wastewater.<sup>22</sup> The Hazaribagh area of Bangladesh, home to the majority of Bangladesh's 200 tanneries, is known to pollute and release liquid waste into the Buriganga River, a nearby river of Hazaribagh.<sup>23</sup> Further, a field study of Kanpur's leather industry, India's leather capital and one of the biggest leather hubs around the world, found that leather was a significant pollutant in the Ganga River, a river that passes through Kanpur.<sup>24</sup> As a result of this, the Ganga River is visibly brown in color.<sup>7</sup>

### 1.2. Sustainable Non-Animal-Based Leather:

Sustainable non-animal-based leather materials come in many forms. Plant-based leather can be made from cactus, sugarcane, pineapple, mushroom, corn, coconut, mango, tomato, oak tree bark, apple, banana leaf, grape, and orange peel waste.<sup>25</sup> As a whole, the textile industry is transitioning towards sustainability.<sup>26</sup> This is a result of animal-based leathers' unsustainability. Further, there has been a shift in consumer attitudes regarding sustainability and ethical consumption, which has had impacts on the demand for goods.<sup>27</sup> As a result, the sustainable leather industry is projected to reach US \$89.6 billion.<sup>28</sup>

The cactus leather used for the experiment was the Desserto Fabric Cabreta Mocha Mousse – SKU 10121, as seen in Figure 3. This material is one of Desserto's thickest, being 1.6

mm  $\pm$  10% thick. It has a Cabreta texture, a Mocha Mousse color, and costs 27 US\$ per linear meter, which is 1 m  $\times$  1.4 m. Across Desserto's 14-acre cactus plantation, the cacti absorb 8,100 tons of CO<sub>2</sub> per year, while emitting only 15.3 tons.<sup>29</sup> To ensure minimal impact on the environment, Desserto harvests a select few mature leaves every 6–8 months, facilitates a solarium drying process without using additional energy, and then uses its patented process to create cactus leather.<sup>29</sup> Unlike other plant-based leathers, Desserto is PVC-free and contains roughly 28% biopolyurethane, which has a lower environmental effect than other synthetic leathers.<sup>30</sup> This ensures that cactus leather is a sustainable material.



**Figure 3:** Shows the cactus leather, which was used to obtain our data.

However, there are questions about Desserto's and other sustainable leather manufacturers' ability to replicate real leather. For example, Desserto's cactus leather was unable to meet the strength requirements needed for shoe manufacturing.<sup>31</sup> Some sustainable leathers are also known to have lower physical resistance when it comes to durability and lifespan of their materials.<sup>32</sup> As a result of its 28% biopolyurethane composition,<sup>34</sup> Desserto leather aims to provide a more eco-friendly alternative to plant-based leathers, which use PVC (polyvinyl chloride). Polyurethane coating systems are known as substitutes for PVC since they do not use plasticizers.<sup>33</sup> Regardless, Desserto's cactus leather is reported to be flexible and soft, and has been used for the production of car seats, shoes, bags, and other items.<sup>34</sup>

### 1.3. Performance Requirements of Cricket Ball Materials:

That being said, a recent survey indicates that cricketers are willing to test a solution and have been open to sustainable alternatives. In a survey that received 42 cricketers' responses, 71% of participants mentioned they would be willing to trial cricket gear made from plant-based leather.<sup>35</sup>

It is important to research the area as this would provide a solution to a substantial problem. Since sustainable, cruelty-free leathers for cricket ball usage are not a widely covered topic, there is minimal research in this up-and-coming field. The biggest gap in this field is that there is limited data about sustainable leathers. The data obtained from previous studies mostly mentioned animal-based leather, or failed to provide datasets on the properties of cactus leather. Further, most

sources mention sustainable cricket gloves and bats when evaluating sustainable equipment, but fail to analyze cricket balls.

The paper will begin with an introduction and literature review, which will focus on evaluating the research that has already been conducted in the field and provide context about the problem. Next, there will be an explanation of the testing procedure and the methodology of how the cactus leather was compared to real leather. Following this, there will be the data retrieved from our testing, and an analysis of the data consisting of the similarities and differences observed. Lastly, our piece concludes with reevaluating our hypothesis and determining whether utilizing cactus leather for cricket balls is a feasible idea.

It is vital to ensure that a sustainable cricket ball matches the performance and characteristics of a real cricket ball. When choosing an alternative material, it is necessary that the alternative replicates leather rather than outperforms it.<sup>2</sup> This is largely attributed to the nature of the game, including the aerodynamics, and the behavior of the ball as a game of cricket progresses.

Swing, the lateral movement of a cricket ball which is bowled at a batsman, is a major part and tactic of the game. Fast bowlers can swing balls by altering the release angle of the ball such that the seam is not directly pointed at the batsman.<sup>36</sup> As a result of this, the seam then trips the laminar boundary layer into turbulence while the non-seam side remains laminar.<sup>36</sup>

A short while after a game starts, cricket balls tend to become rough and lose their shine; bowlers attempt to preserve shine by rubbing the ball on their trousers.<sup>37</sup> They aim to preserve shine for as long as possible, since bowlers can be more successful when balls are smooth and they move laterally through the air as a result of seam positioning upon release. Later on in the game, it drastically changes. For example, a ball that is approximately 40 overs old, or has been played with for 240 deliveries, typically starts to display lateral movement, known as reverse swing.<sup>38</sup> Reverse swing occurs due to the friction between the air and the ball during flight, and causes a ball to move laterally in the air. As a batsman, someone who strikes the ball after delivery, lateral movement can be challenging to react to and lead to negative implications. On the other hand, bowlers often spend lots of time perfecting the skill of trying to make the ball laterally move, and it is considered a major component of cricket. Taking away reverse swing would cause a significant disruption to many bowlers' abilities, and a ball that does not replicate a real cricket ball's characteristics would risk terminating this part of the game.

## ■ Methods

### 2.1. Tear Strength Test:

The tear strength test was conducted in accordance with ISO 3377-2 guidelines.<sup>39</sup> For the tear strength test, a tensile testing machine with clamps to hold the sample firmly was used to execute the test. The tear strength was reported in Newtons and measures how much force the material can withstand before tearing. The study tested both the cactus leather and the animal-based leather.

### 2.2. Tensile Strength & Elongation Test:

The tensile strength and elongation test was conducted in accordance with ISO 3376 guidelines.<sup>40</sup> For this test, a tensile strength testing machine with clamps to hold the sample firmly was used. The tensile strength was measured as the maximum force the material could withstand before breaking and was reported in megapascals. The elongation was measured as the amount the material could stretch before breaking and was reported as a percentage. The study tested both the cactus leather and the animal-based leather.

### 2.3. Abrasion Resistance Test:

The abrasion resistance test was conducted in accordance with ISO 17704 guidelines.<sup>41</sup> The test measured how many cycles of abrasion the leather could withstand, or its resistance to repeated rubbing. The leather sample was placed in a Martindale abrasion machine, and the number of cycles the leather could endure before showing wear was recorded.

## ■ Results and Discussion

The cactus leather was tested a total of five times: it was tested for abrasion resistance three times, for tensile strength & elongation once, and for tear strength once. The real leather was tested only two times: once for tensile strength & elongation, and once for tear strength. Our abrasion resistance data is compared to the abrasion resistance of a separate leather test conducted during a pre-existing study, which examined the differences between leather and leather with flower-like finishing.

**Table 1:** The data that was collected from Testtex India Laboratories is shown.

Experimental Metric	Cactus Leather	Animal-based Leather
Tear Strength (N)	90.2 N	804.8 N
Tensile Strength (Mpa)	14.92 Mpa	16.31 Mpa
Elongation (%)	45.0%	133%
Abrasion Resistance #1 (Observations)	No discoloration/wear after 25,600 cycles	Not conducted
Abrasion Resistance #2 (Observations)	No discoloration/wear after 25,600 cycles	Not conducted
Abrasion Resistance #3 (Observations)	No discoloration/wear after 25,600 cycles	Not conducted

### 3.1. Tear Strength Data:

Table 1 shows that the real leather demonstrated significantly higher tear strength than that of the cactus leather in Table 1. Desserto's cactus leather withstood a force of merely 90.2 Newtons, while the animal-based leather could withstand a force of 804.8 Newtons. It should be kept in mind, however, that the study only conducted one test for the tear strength of cactus leather and animal-based leather due to funding and time limitations.

### 3.2. Tensile Strength & Elongation Data:

As shown in Table 1, Desserto's cactus leather's tensile strength was 14.92 megapascals, and its elongation was 45.0%. The animal-based leather sample had a tensile strength of 16.31 megapascals and an elongation of 133.2%. It should be kept in mind, however, that the study only conducted one test

for the tensile strength and elongation of cactus leather and animal-based leather due to funding and time limitations.

### 3.3. Abrasion Resistance Data:

Desserto's cactus leather shows substantial abrasion resistance. Across the three trials the study conducted, there was no discoloration or wear on any of the samples after 25,600 cycles. Since the study did not include abrasion resistance tests on the leather sample, our data is compared to the abrasion resistance reported in a separate study, which examined the differences between leather and leather with flower-like finishing. Using the DIN EN ISO 17076-2 Martindale abrasion test, the study found that leather began to break at approximately 1,500 cycles.<sup>42</sup> However, the study was not able to conduct tests and make direct comparisons of animal-based leather, which should be kept in mind.

### 3.4. Discussion:

From the data, it can be concluded that cactus leather did not perfectly replicate animal-based leather. Firstly, looking at tear strength, which was measured in Newtons, the animal-based leather measured 804.8 N, while the cactus leather measured only 90.2 N. There was a stark contrast between the tear strength of the two materials. In fact, the cactus leather's tear strength was 11.2% of the animal-based leather's tear strength, suggesting that it did not replicate the strength of animal-based leather. This is largely because leather's durability and quality ensure the longevity of its material.<sup>43</sup>

Moving on to tensile strength, the animal-based leather recorded 16.31 MPa, while the cactus leather measured 14.92 MPa. The difference was only 8.6%, with cactus leather representing 91.4% of the animal-based leather. This is well within the margin of error of 10%, indicating close similarity in tensile strength. As a result, tensile strength could be classified as a characteristic shared by both cactus leather and animal-based leather.

By contrast, elongation differed significantly between the samples. Animal-based leather had an elongation of 133.2%, while cactus leather had 45.0%. This represents a substantial difference in flexibility, largely because leather inherits biomimetic properties from skin, especially flexibility.<sup>44</sup> From the first three characteristics tested, cactus leather fell short in tear strength and elongation, while tensile strength was within the margin of error. This trend aligns with past studies, which highlight leather's natural flexibility, giving it an advantage in tear strength and elongation.

The abrasion resistance was studied, which found that leather began to break at approximately 1,500 cycles.<sup>42</sup> In comparison, our data showed no signs of wear or discoloration on cactus leather after 25,600 cycles. Although it was not possible to make a directly comparable abrasion resistance comparison, the data indicate that cactus leather is substantially more abrasion-resistant than real leather, which is a critical factor given the rough surfaces cricket balls encounter during play.

Since tear strength and elongation were areas where cactus leather fell short, the ball is likely to face technical challenges during production, where it is necessary to have a flexible ma-

terial to easily wrap around the ball. That being said, its tensile strength was similar to that of animal-based leather, and its abrasion resistance was more than that of animal-based leather. The higher abrasion resistance likely means that a cactus leather cricket ball would be able to have a longer life span and avoid wear and tear for a longer period of time.

## ■ Conclusion

After looking at the results and analyzing the data, it is evident that cactus leather would not be a replacement for the leather of a cricket ball. Although cactus leather provides people with a more sustainable and cruelty-free leather alternative, it does not meet the expectations in terms of the characteristics of the material. It was within the margin of error for only one out of the four metrics that were tested; its tear strength and elongation were not enough to match leather, and its abrasion resistance was higher than that of leather. Since the aim was to find a material that does not outperform nor underperform leather, it is clear that cactus leather does not do that. Due to its lower tear strength and elongation, it is likely that the production of cricket balls would be challenging as a result of its rigidity. However, the usage of a hypothetical ball is likely to have a longer lifespan than a conventional cricket ball. Overall, although cactus is a suitable sustainable alternative for leather, it may hinder a ball's performance or tamper with the structure of the game while playing cricket. In order to use cactus leather as a material for a cricket ball, the cactus leather would need to have a higher tear strength and elongation, while reducing the abrasion resistance, in order to achieve a replacement.

That being said, the future of sustainable leathers for cricket balls has potential. The sustainable leather industry has developed rapidly, and there are many types of sustainable leather besides cactus leather. Hence, our research will continue in other forms: by investigating the production process and comparing a cricket ball with a cactus leather-made cricket ball, it will be helpful to identify metrics within the production process that could help better identify a sustainable leather alternative.

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