

Design and development of anti-heel crack band using banana peel extract

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Abstract

Cracked heel is the most common problem faced by average adult. Cracked heels are formed by dry skin and are compounded by the hard skin. Loss of moisture leads to the buildup of dead cells. When the skin is too dry, it loses its elasticity and leads to crack. When this condition worsens it causes calluses which is tough and thickened skin around the heel. It may be accompanied by bleeding. Crack may allow the entry of bacteria like streptococcus and staphylococcus which leads to infection. Various products are commercially available for cracked heel like silicon socks, heel pads but they are not cost effective. Banana Peel is a part of banana fruit that has the great amount of antibacterial activity against the microorganisms i.e. gram positive and gram negative bacteria. In this research, the extract of banana peel was added with carboxyl methyl cellulose and the banana peel extract was loaded in the gel. The research also developed an ankle band with the developed gel. The gel inside the band is kept in a manner that it will be in contact with heel crack. A survey was performed among the volunteers who used the developed anti heel crack band and results are noted positive. The results were reported in terms of moisturizing effect, softness, healing and comfort. All the participants reported a positive response on all these parameters and accepted the product as a useful aid for heel crack healing.

Keywords—Musa, Eco-friendly Fashion, Domestic laundering.

I. INTRODUCTION

Cracked heels, also referred to as heel fissures, are a common foot condition among humans. They result from dry skin and are accompanied by thickened skin, and sometimes yellow or brown calluses around the heel edge. Cracks in the heels are generally caused by insufficient moisture. These cracks can become sore and may even

bleed. The two biggest risk factors for cracked heels are diabetes and obesity. Diabetics are likely to experience cracked heels because damage to nerves in the feet from uncontrolled blood sugars can cause dry skin. Obesity increases your chances of having cracked heels because there is even more weight on the heel pad, which causes it to expand out further. Dry skin is unable to handle the added pressure and cracks [1]. Direct medications include applying commercially available heel crack gels, creams etc. Other medications include the removal of dead skin, using stronger softening or removal agents, applying medical glue to seal cracks using an antibiotic if there is an infection, strapping the heel with dressings or bandages. Furthermore, people use home remedies using natural materials. One such material is banana peel. The common name for herbaceous plants of the genus *Musa* is banana. They offer great medicinal benefits. Banana helps in the retention of body's calcium, nitrogen, phosphorus. Banana is rich in potassium content. The other components of the banana tree is also used for its medicinal values. The plantain flowers are used to treat ulcers, and diabetics. Sap is used in the treatment of diseases like leprosy, hysteria etc. The roots of the plantain trees are useful for testing disorders in digestion [2]. Also banana peel is said to have antifungal, antimicrobial properties that could be used to inhibit the growth of microorganisms [3]. Banana peel has antioxidant properties which is used for anti-ageing products [4]. Additionally banana peel has UV protection property [5] and can be used as an efficient bio adsorbent [6]. Banana peel pulp is said to have rich potassium content and lipids that are highly used to moisturize the skin.

The banana peel extraction method using the aqueous solvent was patented by Edward [7]. In this process the extract was made in the form of gel or cream and used to test its healing ability. The extract from the banana peel

showed healing from itching, pain, swelling, bruising, wrinkles and sun burns [7]. Other researchers developed banana peel extract from different solvents namely methanol, acetone, ethanol, water and diluted HCl. Out of which the researcher reported that the extracts of acetone and water provided a highest antioxidant activities [8]. When the antibacterial activities were evaluated the banana peel extract showed a higher activity against the gram positive strains and very lower activity against the negative strain. The performance of the extract against *C.Albicans* also found less [9]. The phytochemical analysis of dried banana peel powder had the presence of chemicals like alkaloids, glycosides, saponins, tannins, and flavonoids in the ethanol extract of banana peel. Also the photochemical like glycosides and alkaloids are found in the aqueous extract [10]. On a wound healing study, the banana peel extract gel formulation applied on the rat wound for a period of 7 days and the tissue were analysed for healing ability. The results showed a good wound healing ability for the developed gel with 4% concentration of *Musa sapientum* extract. The researchers also reported the presence of flavanoids, and leucocyanidin as main source of healing ability [11].

Banana Peels are high in tannin and flavonoids which inhibit microbes. Banana Peel provides good source of moisturisation due to the presence of potassium and pectin. Banana peel has high level of magnesium, vitamin C and vitamin B6. Vitamin B6 in banana peel helps to prevent infection by reducing swelling, increasing the production of white blood cells and strengthening the nervous system. It allows self – healing of skin, since it has high level of antioxidant properties which can provide protection from radicals. Hence, this research aims to design and develop the anti heel crack band with gel made from banana peel extract as an active material to cure the heel crack. The principle used here to release the active material is compression leaking.

II. MATERIALS AND METHODS

Banana peel paste preparation:

Banana (*Musa accuminata*) fruits were purchased from the local vendor at fruit stage in Tirupur, Tamilnadu. Banana peel is the rich source of potassium which can be used for moisturizing. They are stored in the room temperature. Banana peels are peeled from the fruit and washed in cold water. Then the peel is ground into a fine paste using the blender. This banana peel paste is used for healing cracks, acene and has more skincare values. Blended banana peel paste is stored in the refrigerator until it is used.

Banana Peel extract preparation:

1 litre of 100 percent ethanol is brought from the chemical vendor and then diluted into 70 percent ethanol. Ten(10) grams of the ground banana peel paste is mixed with 100ml of 70 percent Ethanol. The mixture is stirred vigorously and allowed to stand for 48 hours. Then the mixture is taken and filtered through filter paper to get the banana peel extract as shown in Fig 1.

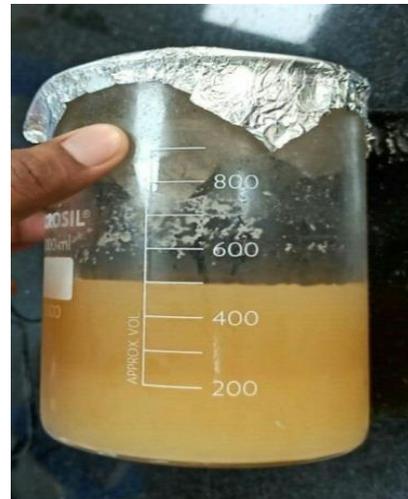


Fig 1. Banana peel extract past developed

Hydrogel preparation:

Hydrogels are gels that can withstand high temperatures and pressure. This is possible with the help of strong emulsifiers such as CMC (Carboxy methyl cellulose). CMC is brought from an online chemical store. Carboxy methyl cellulose is used as a thickening agent in oil drilling industry and emulsifier in food industry. Agar agar is also bought from local shop which is also used for emulsification in food industry. 25ml banana peel extract and 25ml water was added a beaker. Then 0.5 grams of carboxy methyl cellulose was added to it and stirred continuously to avoid lumps. After mixing Carboxy methyl cellulose 0.5 grams of agar-agar was added to the beaker. Then the whole mixture is covered with a silver foil and placed in a water bath at 80 degree Celsius. The mixture is heated for 15 mins and then taken out. Then the gel is a placed in mould and then freezed at 4 degree Celsius for 6 hours. After 6hours the gel (Agar-MC hydrogel) can be taken out of the mould as shown in Fig 2.



Fig 2. Banana peel extract Agar-MC gel developed

Testing temperature stability of hydrogel:

The temperature stability of the Agar-MC hydrogel is tested. Agar-MC hydrogel sample is prepared and poured into the mould and then frozen at a temperature of 4 degree Celsius. Then the hydrogel is taken out of the mould is weighed. The initial weight of the hydrogel is noted. The water bath is pre-heated to the temperature of 70 degree Celsius. The gel is placed into a beaker and the beaker is placed into the water bath for 1 hour. The hydrogel is then taken out of the water bath and weighed. The weight loss of the hydrogel is measured and the temperature stability of the Agar-MC hydrogel is discussed.

Product development Consumer acceptance Survey:

The prepared hydrogel material is kept in a thin fabric, and an ankle band was developed similar to socks to use regularly. The effectiveness of the product was subjectively assessed with the help of volunteers. Anti-heel crack band is given to 5 persons with the cracked heel or hard dry skin on their feet and let them use it for the five consecutive days. Then the survey is taken to know the difficulties they faced before and the improvement that they faced while using this product and to get feedback. The following questions were asked with the participant and rated in a five point scale as provided in Table 2. The following questions were asked with the participants to evaluate their personal opinion about the product.

1. Do you use our product for 5 consecutive days?
2. Have you had calluses or hard dry skin ?
3. Does our product provide moisture to your skin?
4. Do you experienced any change (softness) over this period ?
5. Do you feel this more effective and comfortable than other crack healing product ?
6. Using this product made your daily life difficult?
7. Do you see any healing over this period of time?

8. What are the difficulties faced in this product and suggest the improvement?

TABLE I. 5 POINT LIKERT SCALE RATING FOR PARTICIPANTS

SATISFACTION LEVELS	DEFINITION
1	Excellent
2	Very good
3	Good
4	Bad
5	Poor

III. RESULTS AND DISCUSSIONS

Anti-heel crack band design and development:

The banana peel gel is packed into a package which constantly delivers the banana peel extract in a controlled manner. The product consists of three layers as shown in Figure 3 and the product model is provided in Figure 4.

Layer 1: Cotton Nonwoven - This is the topmost layer that is going to be in contact with the skin. Cotton Nonwovens are durable fabrics for single use. Nonwoven fabrics provide specific functions such as absorbency, softness, strength, cushioning. As this layer is going to be in contact with the skin, it is desirable to have softness and cushioning. This helps in healing the heel crack. Also the whole weight of the body presses the band. Hence it should have enough strength to withstand the load and pressure. It should help in transferring the moisture from the gel to skin. The similar applications of the cotton nonwoven are found in agricultural coverings, disposable diapers, personal wipes etc.

Layer 2: Banana peel gel - This is the middle layer of the band. Hydrogel releases the moisture when it is compressed. The banana peel extract consists of high content of potassium which moisturizes the skin. The hydrogel does not change its state from solid to liquid on varied temperature. Hence it provides optimum moisture to the skin.

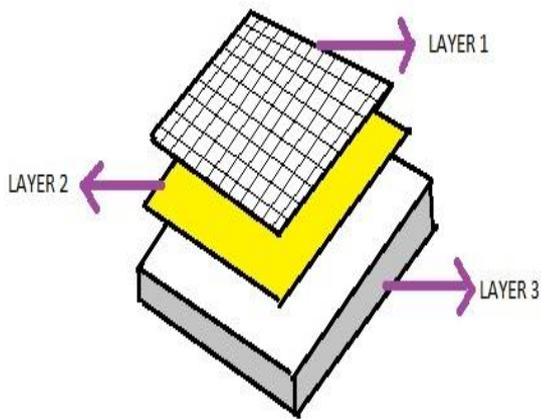


Fig 3. Anti heel crack band construction outline

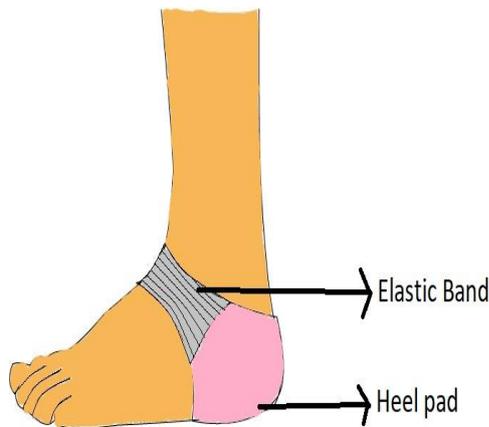


Fig 4. Anti heel crack band product design

Layer 3: Polypropylene - This is the bottom most layer attached to the band. As this layer is attached to the band, it should not let moisture to seep through. Hence this layer must be water repellent. Polypropylene is one of the most commonly used thermoplastics in the world. Polypropylene uses range from plastic packaging, plastic parts for machinery and equipment and even fibres and textiles. As this is a synthetic fibre it has very less moisture absorbency and act good water repellent. Laminated Polypropylene is used for the complete waterproof applications. Similar applications are found in diapers, sanitary napkins and carry bags.

Construction: Rib fabric is stitched like a band based on the average heel circumference. Then the hydrogel layer is placed on the inner side of the rib fabric in the heel part and then stiches along the edges. Final products are shown in below Figure 5.



Fig 5. Anti heel crack band product developed

Compression leaking is the principle used in for releasing the banana peel extract from the package. Compression leaking is defined as the realease of the liquids stored in a medium on the application of the pressure or compression. The key point is that the liquid squeezes and comes out. Compression leaking is the major disadvantage in sanitary napkins. But here we are using the compression leaking as a principle to release the moisture. When the band is worn, the whole weight of the body is put on the band and the banana peel extract hydrogel gets distorted and releases the excessive banana peel extract. The cotton nonwoven layer on the top absorbs the excessive moisture and passes the moisture to the skin. Nonwoven has very minute pores on its surface that allows the moisture to pass through it.

Thermal stability test:

The Agar -MC hydrogel is prepared and the initial weight W_1 is noted. Then the hydrogel is placed in the water bath for the duration of 1 hour and then taken out. The final weight W_2 after 1 hour is measured. Then the weight loss and weight loss percentage was measured.

- Weight loss = $W_2 - W_1$
- Weight loss percentage = $(W_2 - W_1 / W_1) \times 100$
- Weight loss = $55.63 - 35.15 = 20.48\text{grams}$
- Weight loss percentage = $(\frac{20.48}{55.36}) \times 100 = 36.81\%$

The weight loss after heating in high temperature is 36.81% of the original weight. It is found that Agar-MC gel remains in the same state (gel) after heating and did not melt down into liquid. Hence we can say that the gel can be used in crack healing band and the state of the banana peel gel will not change due to the body temperature and external temperature offering durability to the end product.

Survey results:

The developed products were provided to 25 subjects with heel cracking issue and the performance of the developed heel band was evaluated against the parameters like moisturization, softness, healing ability and also about wearers comfort. The results were reported as shown in Figure 6.

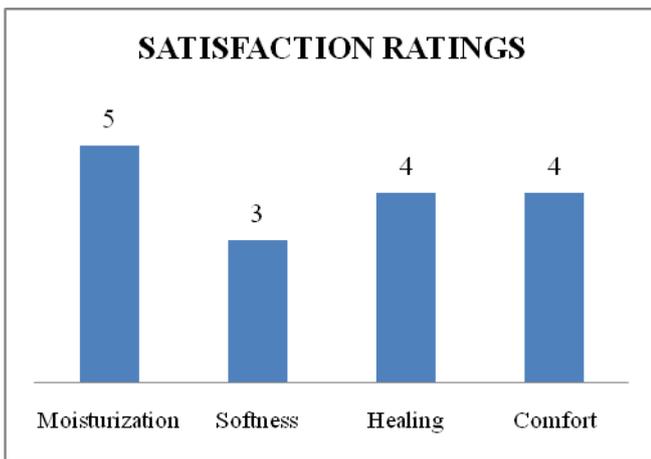


Fig 6. Wearers rating on the developed product in 5 point scale

Moisturization- Average rating 3-Dryness in skin results in reduction of skin elasticity which can be retained by moisturizers. This moisturizer is used to prevent excessive water loss from the skin. Generally banana peel acts as the moisturizer to hydrate skin. Banana peels are rich in potassium and vitamin A,B,C. Banana peels are highly packed with potassium content in it, which will help to hydrate and moisturize the dry skin in order to retain elasticity. Agar is a polymer made up of sugar galactose, this compound is used in many skin care products to provide moisturization. This high concentration of galactose residues work as the good emulsifier. Agar in banana peel gel helps to stabilize moisturization and it is speculated to provide improved moisture-retention, which may help to reduce skin dryness.

Softness- Average rating 2-Banana peel are loaded with many nutrients which will provide moisturization and softness to skin over period of time. Vitamin A in banana peel restores moisture and smoothens out the rough texture of the skin. Potassium content in banana peel also helps to moisture dry skin and making it soft and supple. This product releases banana peel extract continuously due to the principle of compressive leakage so continuous moisturization is given which result in improved softness in the heel.

Healing- Average rating 2-Banana peel has the phenolic compounds like gallic acid, catechism, epicatechin, tannins and anthocyanins. This phenolic compounds has the antioxidant properties that helps in self healing of skin. Banana peel has high amount of tannin content when compared to its fruit, in addition to that tannin content will be higher in dry banana peel I.e.30 to 40 percent than that of fresh banana peel. Here banana peel extract is taken by using dry banana peel. The sugars in banana peel helps to

draw the fluid out of itchy area to avoid skin irritation. Banana peel has anti-inflammatory properties due to the presence of vitamin A, zinc and manganese which will help in healing of cracks.

Comfort- Average rating 2-The heel pad consists of three layers i.e. top cotton non-woven, middle banana peel gel and bottom polypropylene layer. The top cotton non-woven layer is closer to skin, so it feels soft and comfortable for the user. This heel pad works on the principle of compressive leakage. Due to the presence of polypropylene layer at the bottom there will not be any kind of leakage at the bottom of the heel pad. Banana peel gel in the middle layer is made up of banana peel extract, agar and methyl cellulose. Both banana peel extract and agar provides improved moisture-retention. The methyl cellulose used in banana peel gel is non allergen and non toxic, so it is user friendly for skin irritations. Since rib fabric is used in band region it provides good elasticity and drapes well over the heel part due to cross wise elongation. Overall this product provides cushioning effect which decreases pressure on the flat pad under the heel so it is comfortable to use. This product is only made from natural compound like agar, methyl cellulose and banana peel extract which are bio degradable whereas other heel pad product like silicon gel heel pad socks consist of compound like silicon which is non-biodegradable and toxic. Silicon gel heel pad is only used to provide cushioning effect to the heel in order to avoid the cracked heel but it will not heal the crack which is already formed. This banana peel anti-heel crack band is used to heal the cracks by moisturization in addition to that it will also provide cushioning effect to the heel. Silicon gel heel pad socks can easily tear on usage whereas this banana peel heel band product is strong and durable due to the presence of rib fabric. Thus this product is comfortable and effective than other crack healing product.

According to feedback from survey, this product provides moisturization for the three consecutive days. This product provides great result for the person with hard dry skin as they experienced the softness over the period of time due to banana peel gel which was present in this product. Some even experienced healing within these days of usage because heel crack portion is moisturised continuously for long time. It is convenient to protect the skin from painful irritation. This product is more durable than other heel pad product, since the other commercially product will tear easily on movement. This product is suitable for daily usage. They feel that in this product the heel pad region is soft and comfortable due to presence of cotton material and banana peel gel but the elastic band is somewhat uncomfortable due to the quality of material used in that region. Some suggested that this product must be made with

standard size in order to make it readily available for everyone

IV. CONCLUSION

The study evaluated the potential of banana peel extract to treat heal cracks. The developed banana peel hydrogel showed that it can withstand high temperatures and did not condense on higher temperatures. During the application, the developed banana peel hydrogel gradually releases the active ingredients on application of pressure for the treatment of heal crack. Also it is evident from the survey results and feedbacks, anti heel crack band using banana peel gel can be used as an efficient remedy for heel fissures compared like other commercially available products. Further studies on the proposed concept will elucidate the commercialisation possibilities of developed banana peel extract hydrogel.

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