**Research Journal of Chemical and Environmental Sciences**
Res J. Chem. Environ. Sci. Vol 4 [4S] 2016: 102-106
Online ISSN 2321-1040
CODEN: RJCEA2 [USA]

Website: www.aelsindia.com/rjces.htm

RJCES

**FULL LENGTH ARTICLE**

# Production of eco-friendly adhesive from jackfruit seed

**Maneeshi Shetty[1], Candida Mavis Fernandes[1], Suraksha P[1]., Nireeksha Karkera[1],Karthik Hegde[2],Vinayaka B. Shet[1], C. Vaman Rao[1]**

[1]NMAM Institute of technology (Affiliated to V.T.U, Belagavi), [1]Department Biotechnology Engineering, Nitte 574110,Udupi District,Karnataka, India.

[2]Maxibond , Peenya 2nd Stage, Bangaluru – 560091

**ABSTRACT**

*Jackfruit seeds are abundant and they contain high amount of starch. Attempt was made to prepare the eco friendly adhesive using underutilized starchy material. Methods were developed to prepare the adhesive from jackfruit seed with desirable viscosity and bursting strength. Different combination of ingredients was incorporated to achieve the desirable viscosity and bursting strength. Industrial protocol was scale downed to prepare the adhesive in lab scale. Viscosity of the adhesives was between 46 to 66s.Maximum bursting strength of 12 kg / in$^2$ was achieved. Roasting of jackfruit seed was promising process step to achieve ecofriendly adhesive suitable for industry.*

## INTRODUCTION

Starch is one of the most important carbohydrates in human diets. It has been extensively used as a food ingredient. Starch-derived adhesives are used in the paper and textile industries as binders and sizing materials. Exploring the underutilized source of starch for the production of ecofriendly adhesives is need of the hour. Corrugated cardboard packaging is produced out of renewable raw materials, which can be optimally integrated into cycles of valuable substances. Jackfruit seed starch has high starch content and proteins. There have been studies on the properties and isolation of the starch extracted from jackfruit seeds to verify its applicability in food, pharmaceutics and other uses. Jackfruit seed starch has high amylose content[1].Jackfruit seed starch has significantly higher gelatinization temperature and lower breakdown viscosity as compared with other starches.It is suggested that this starch can be used to products where a high level of gelatinization is not desirable during cooking [2][3]& It is a long standing tradition that the starch and starch derivatives are used as adhesive raw materials. These adhesives had little resistance against humidity and temperature variations, yet it had a low bonding strength. It can be assumed that the molecular weight is extraordinarily high in starch as compared with other adhesive raw materials. It is necessary to convert the starch into a liquid, wettable system for its application as an adhesive. The high viscosity colloidal solutions are obtained when heating aqueous starch suspensions above the so called gelatinization temperature since the native starch is insoluble in cold water. The interpretation of the gelatinization must be in such a way that at a given temperature the high cohesion of the starch is dissolved. The reason for the arising of a colloidal system is the interaction of the hydroxyl groups of starch with water. Such solutions are suitable as adhesives and are used for simple paper bonds. In the current investigation jackfruit seed has been used as source of starch to prepare eco-friendly adhesive and determine its properties suitable for the industrial requirement.

## MATERIALS AND METHOD

### Processing of jack fruit seed

Jackfruit seed was dried in hot air oven for 14 hours at 70$^0$C. Dried seed was powdered using size reduction unit operation. It was seived using Tylor series mesh number 8. It was stored in a plastic container and kept in the freezer to prevent from the microbial attack till the further use.

### Preparation of adhesive

### With heating method (Sample A):

Jackfruit seed powder weighing 33.3g and 0.66g of borax was mixed together and added to 200 ml of water .The magnetic heater at 60$^0$C-70$^0$C was turned on. After 5 minutes 3.33g of caustic soda prills were added and allowed to stir in magnetic stirrer. After 15 minutes the glue solution obtained was highly viscous in order to reduce viscosity, 98 ml of water was added. Which resulted in the viscosity of 65s.[4]

**Without heating method (Sample B):**
Jackfruit seed powder weighing 33.3g and 0.66g of borax was mixed together and added to 200 ml of water .The magnetic stirrer was turned on. After 5 minutes 3.33g of caustic soda prills were added and allowed to stir in magnetic stirrer. After 15 minutes the gum solution obtained was more viscous. So,113 ml of water and 1g of caustic soda prill was added. Which resulted in the viscosity of 66s.[4]
**Roasting of the raw material (Sample C):**
Jackfruit seed powder weighing 33.3g was roasted directly on the magnetic heater. It was mixed with 0.66g of borax and added to 200ml of water. The magnetic stirrer was turned on.After 5 minutes 3.33g of caustic soda prills were added and allowed to stir in the magnetic stirrer.After 15 minutes the gum solution obtained was more viscous so 25ml of water and 0.5g of caustic soda was added.Which resulted in the viscosity of 55s.[5]
**Roasting of the raw material (Sample D):**
Jackfruit seed powder weighing 33.3g was roasted directly on the magnetic heater. It was mixed with 0.66g of borax and was added to 200 ml of water. The magnetic stirrer was turned on.After 5 minutes 3.33g of caustic soda prills were added and allowed to stir in the magnetic stirrer. After 15 minutes the gum solution obtained was more viscousso,113ml of water and 1g of caustic soda was added. Which resulted in the viscosity of 26s.After two days the viscosity turned to 46s.[5]
**Roasting of the raw materal with HCl (Sample E):**
Jackfruit seed powder weighing 33.3g was roasted with 1mlof HCl and 0.66g of borax was mixed together.This mixture was added to 200ml of water and the magnetic stirrer was turned on.After 5 minutes 3.33g of caustic soda prills were added.After 20 minutes 1 g of caustic soda prill and 113mlof water was added.Which resulted in the viscosity of 47s.[5]
**Roasting of the raw material with HCl and $H_2SO_4$ (Sample F):**
Jackfruit seed powder weighing 30g was roasted with 0.3ml of HCl and 0.1 ml of $H_2SO_4$.To this 120ml of water and 0.2g of caustic soda was added andstirred.The gum solution obtained was more viscous,so 60ml of water was added to it.Which resulted in the viscosity of 61s.[5]
**Roasting of the raw material with HCl and $H_2SO_4$ (Sample G):**
Jackfruit seed powder weighing 30g was roasted with 0.2ml of HCl and 0.2 ml of $H_2SO_4$.To this 120ml of water and 0.2g of caustic soda was added and stirred. Which resulted in the viscosity of 62s.[5]
**Industrial scale adhesive preparation**

***600 liters of water*** is taken in the barrel and mixer is turned on

↓

***Blended powder*** is added to it (i.e Dextrin and Borax)

↓

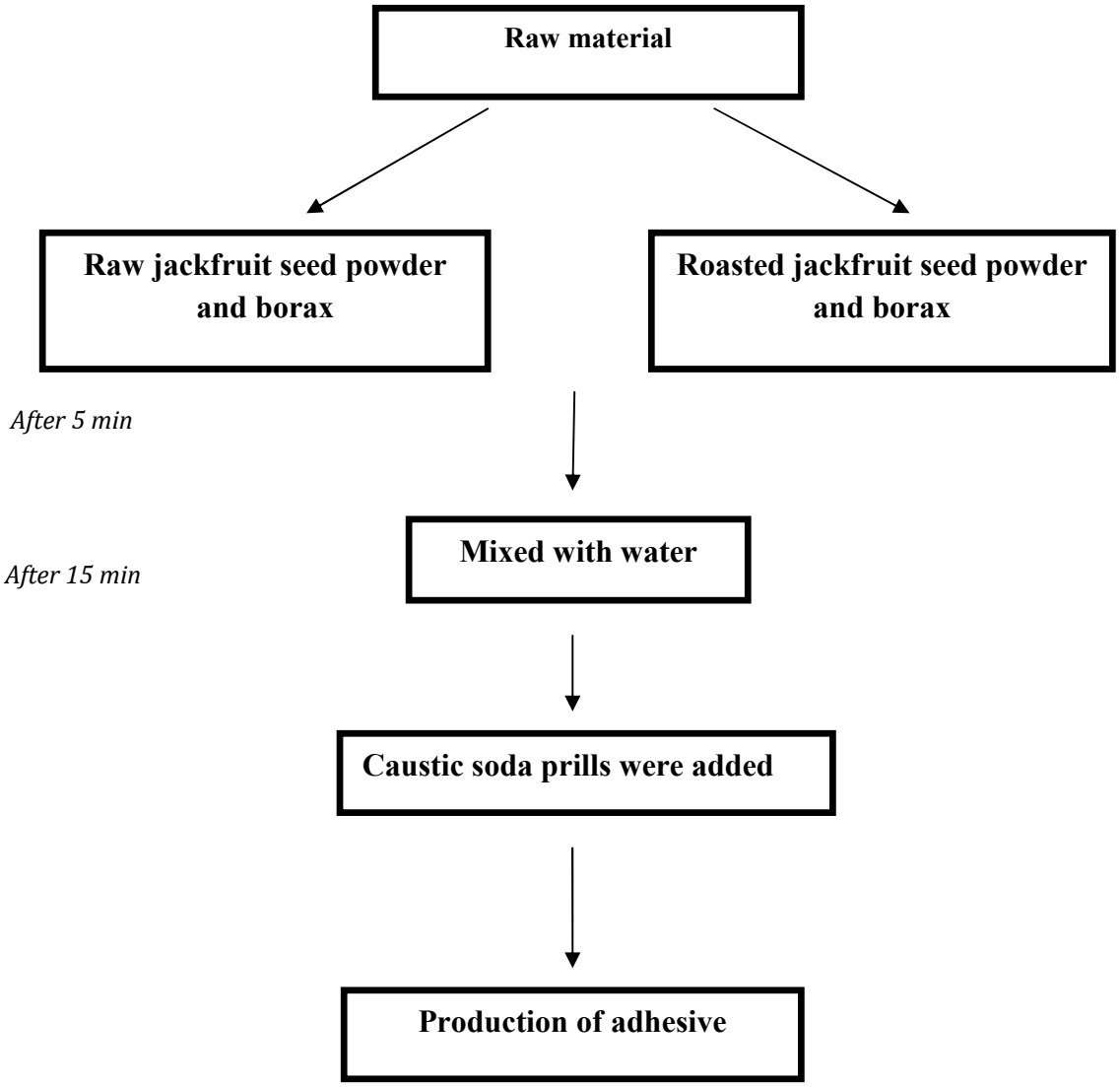
After 5 mins,***Caustic Soda prills*** is added to it .

↓

After 15 mins, adhesive solution is prepared bearing a pH of 14.

This adhesive solution is applied to the papers using a machine called as Corrugation Machine.
**Lab scale adhesive preparation**




Viscosity was measured using B4 cup and it should be between the range of 50-60s.

**Table 1: Composition of the adhesive**

| | Jackfruit seed powder(g) | Borax (g) | Caustic soda prill (g) | Water (ml) | HCl (ml) | $H_2SO_4$(ml) | Viscosity (s) |
|---|---|---|---|---|---|---|---|
| **Sample A** | 33.33 | 0.66 | 3.33 | 298 | - | - | 65 |
| **Sample B** | 33.3 | 0.66 | 4.33 | 313 | - | - | 68 |
| **Sample C** | 33.3 | 0.66 | 3.83 | 225 | - | - | 56 |
| **Sample D** | 33.3 | 0.66 | 4.33 | 313 | - | - | 46 |
| **Sample E** | 33.3 | 0.66 | 1.0 | 113 | 1.0 | - | 47 |
| **Sample F** | 30 | 0.66 | 0.2 | 180 | 0.3 | 0.1 | 61 |
| **Sample G** | 30 | 0.66 | 0.2 | 120 | 0.2 | 0.2 | 62 |

**Determination of viscosity**

The B4 cup is used to determine the viscosity of the adhesive. The B4 cup was filled with the adhesive solution till the rim. Stop watch was started and time was noted down till the entire adhesive solution was let out of the B4 cup. The viscosity is supposed to be in the range of 50-60s.

**Fig.1: B4 cup**

**Determination of bursting strength**

The Carton board is cut in the square shape form having 10 * 10 centimetres. The board is placed on the bursting strength measurement equipment. The results are displayed in the digital monitor screen implanted to the same.

**Fig. 2: Bursting strength measuring device**

**RESULT AND DISCUSSION**

**Viscosity**

Viscosity of the samples was ranging from 42s to 66s. The desirable viscosity between 50s to 60s was exhibited by sample A, B, C, E and G.

**Bursting strength:**

Raw starch with heating method was found to be better than without heating method. Sample C has exhibited highest bursting strength of 12kg/in$^2$. Sample B has lowest bursting strength. Considering the both viscosity and bursting strength sample C is suitable more commercial adhesive production. Higher bursting strength was exhibited by roasted raw material. Sample A and B have bursting strength 7 and 6 kg / in$^2$ respectively. Results clearly indicate formation of polymer by roasted raw material.

| | **Viscosity (s)** | **Bursting strength (kg/ in$^2$)** |
|---|---|---|
| **Sample A** | 65 | 07 |
| **Sample B** | 66 | 06 |
| **Sample C** | 55 | 12 |
| **Sample D** | 46 | 10.5 |
| **Sample E** | 62 | - |
| **Sample F** | 47 | - |
| **Sample G** | 61 | - |
| **Commercial adhesive** | 60 | 9.9 |

**CONCLUSION**

Based on the viscosity Sample E, C is preferred. Considering only bursting strength sample C and D are suitable. Since both viscosity and bursting strength are essential to commercial use the adhesive, sample C suitable.Referring to the results that has been mentioned earlier, it is clearly indicating that Roasted

Jack seeds (Sample C and Sample D) exhibits higher bursting strength than the Raw Jack Seeds. Sample C > Sample D., reason being the water content is inversely proportional to the bursting strength of the board.

**ACKNOWLEDGMENT**

We acknowledge the inputs and guidance provided by the Maxibond, Bangalore.

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Maneeshi Shetty, Candida Mavis Fernandes, Suraksha P., Nireeksha Karkera,Karthik Hegde,Vinayaka B. Shet, C. Vaman Rao**.** Production of eco friendly adhesive from jackfruit seed Res. J. Chem. Env. Sci. Vol 4 [4S] 2016.102-106