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Development of biodegradable cups from pomegranate peel powder

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Abstract
Plastics are mixture of organic polymers that play a major role in environmental contamination worldwide. The demand for plastic containers was increasing over the past few decades. One way to reduce the waste arising from the use of plastics, especially disposable ones, can be to produce environmental friendly biodegradable materials. Biodegradable cutlery is an up coming line fruit waste utensils that are totally safe to be used and boon for eco-system. An attempt was made to prepare biodegradable cups using pomegranate peel powder. Glycerol was added as plasticizer. Where as, xanthan gum used as binding agent. The study was conducted to find out the standard cup made with different ratios of raw materials in each treatment. Quality analysis such as tensile strength, bursting strength, water leakage test and biodegradability test were studied for different treatments like T_1 with 50:25:25, T_2 with 70:15:15 and T_3 with 90:05:05.

Keywords: Biodegradable cups, pomegranate peel powder, plastics

Introduction
The result revealed higher tensile strength for the T_2 than T_1 and T_3. It was observed that higher glycerol content the lower will be the tensile strength. But the cup made with glycerol content of 15% which is in T_2 was observed to be strong. Increasing the xanthan gum also increases the bursting strength of cups. Highest bursting strength observed for T_1 i.e., 5.18kg/cm^2. Increased amount of glycerol increase the permeability of water in the cups. So, the T_2 cup resist more water than T_1 and T_3. Biodegradability test reported that the cup made with T_2 degrades faster than T_1 and T_3. Cups made with pomegranate waste have good biodegradability than the plastic cups.

Materials and Methods
This chapter deals with raw materials used, experimental methodology and measurement techniques adopted during the course of investigation. The systematic approach adopted for preparation of biodegradable cups with natural colors was presented. The study was carried out in the College of Food Science and Technology, Rudrur.

Procurement of raw materials
Pomegranate peel powder was extracted from the peels collected. Xanthan gum, glycerol and food colours were purchased from local market. Glassware and moulds were used for moulding of cups.

Extraction of peel powder from pomegranates
Pomegranates were collected from the local market. The collected pomegranate fruitswere washed with water and cleaned. The cleaned pomegranates were peeled and dried by using a hot air oven at a temperature of 104 °C for 5 h. Then the dried pomegranate peels were ground into fine powder. Fine powder was obtained by sieving.

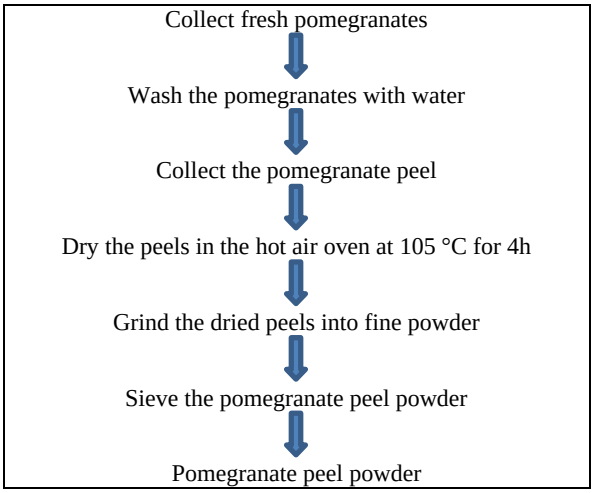


Fig 1: Flow chart for extraction of pomegranate peel powder

After extraction of pomegranate peel powder, xanthan gum and glycerol were added in different proportions. The different proportions for the preparation of biodegradable cups with addition of xanthan gum and glycerol were shown in Table 1

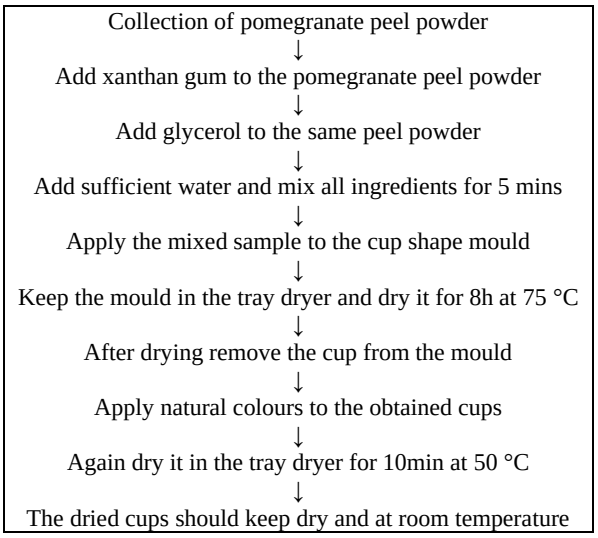
Table 1: Different proportions for preparation of biodegradable cups.

Proportions			
Treatments	**Pomegranate peel powder**	**Xanthan gum**	**Glycerol**
T_1	50	25	25
T_2	70	15	15
T_3	90	5	5

Preparation of biodegradable cups

The preparation of dough samples was made by addition of water to the composite mixture of pomegranate peel powder, xanthan gum, glycerol. The prepared dough was placed in moulds for moulding to form cups. Care was taken to get uniform thickness throughout the cup. Food colours were also incorporated in the dough to prepare different coloured cups. After moulding process, the mould with dough were placed in tray dryer at 75 ℃ for 8h for drying. After drying remove the cup from the mould. The time-temperature combination was decided based on preliminary trails. The different steps involved in preparation of biodegradable cups.

Preparation of bio degradable cups



Flow chart for preparation of biodegradable cups from pomegranate peel powder

Quality analysis

The quality analysis was conducted to the prepared biodegradable cups by using pomegranate peel powder and finding the standard cup among the cups made with different proportions of pomegranate peel powder, xanthan gum and glycerol.

Tensile strength test

The tensile strength of biodegradable cups was determined according to the procedure given by Buxoo *et al.*, (2020) [5] by using a tensile strength tester. The tensile strength test indicates the ability of the cup sample to resist a rupture force applied parallel to it. Grammage of the prepared cups was calculated by rolling to have uniform thickness. Then grammage value was entered at calibration board in the tester. Then pressing the start button on the screen to show the final reading of tensile strength values for the treatments made with different proportions.

Calculation

$$\text{Tensile strength (nominal)}, \text{kg}/cm^2 = \frac{\text{max. load}}{\text{Original min. Cross sectional area of specimen}}$$

Tensile strength (at break), kg/cm^2 = max. Load at break/ original min. Cross sectional area of specimen

Breaking factor (nominal), kg/cm^2 = max. Load/original thickness of specimen

Bursting strength tester

The bursting strength of biodegradable cups was determined according to Buxoo *et al.*, (2020) [5] by using the bursting strength tester. The bursting strength tester works based on the principle that the maximum hydrostatic pressure required to produce a rupture of the material when controlled and constantly increasing pressure is applied through a rubber diaphragm. The prepared dough sample sheet was kept under the bursting strength tester by entering the grammage value calculated. Then enter the start button on screen were showed the final obtained bursting strength values of prepared proportion. The higher the bursting strength the stronger will be the material.

Calculation

Bursting strength (kg/cm^2) = Burst factor*GSM (GM/m^2)/1000 Burst factor = bursting strength (Gm/m^2)/grammage (gm/m^2)

Biodegradability in soil

Biodegradation was tested in soil under controlled laboratory conditions (25 °C, Relative humidity 25% and pH=7). The film samples were placed in plastic container filled with soil.

Biodegradation was analysed by taking photographs regularly.

Results and Discussion

In this chapter, the results obtained for the biodegradable cups prepared by using pomegranate peel powder were presented. Quality analysis of biodegradable cups was evaluated and discussed

Tensile Strength

Tensile strength was evaluated for the biodegradable cups made with pomegranate peel powder with addition of xanthan gum and glycerol. The results were shown in Fig 2. It was observed that the treatment, T_2 recorded higher values of tensile strength of 5.7 kgf. The other two treatments T_1 and T_3 recorded 4.33 kgf and 4.25 kgf, respectively.

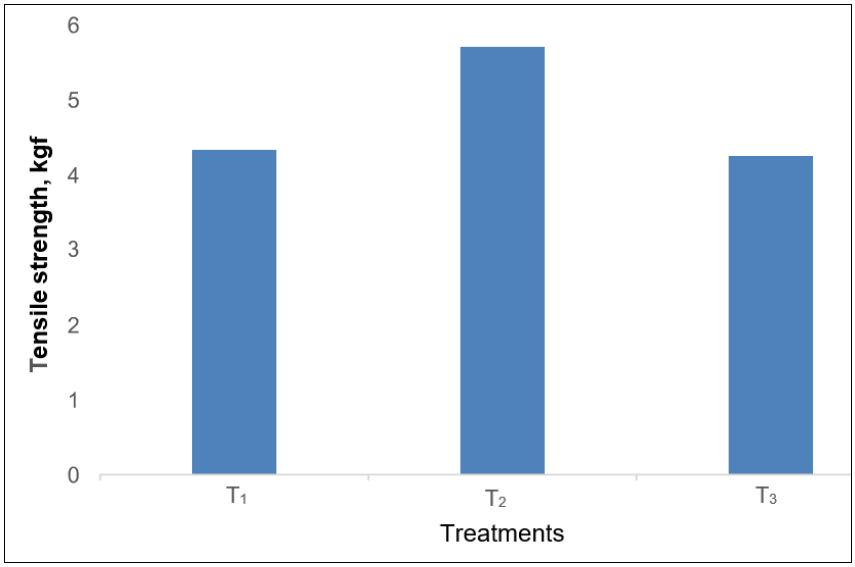


Fig 3: Changes of tensile strength of biodegradable cups prepared with pomegranate peel powder

Similar trend was observed by Pawinee *et al.* (2019) [11] when biodegradable film were prepared with incorporation of cassava starch. It was observed that increase in glycerol content decreased the tensile strength. Whereas, the lower amount of glycerol produced the brittle films, while the increased glycerol content resulted in sticky films.

Another trend was observed by Jiang *et al.* (2015) [13] when paper based plastics were prepared with incorporation of glycerol and chloride solution. It was observed that increase in glycerol content decrease the tensile strength.

Another trend was observed by Hidayati *et al.* (2021) [9] when biodegradable film was prepared by seaweed waste with incorporation of glycerol and carboxy methyl cellulose. It was observed that increase in glycerol content decrease the tensile strength whereas increased amount of carboxy methyl cellulose increase the tensile strength.

Bursting strength

Bursting strength was evaluated for the biodegradable cups made with pomegranate peel powder with addition of xanthan gum and glycerol. The results were shown in Fig 4. It was observed that the treatment, T_1 recorded higher values of bursting strength of 5.18kg/cm^2. The other two treatments T_2 and T_3 recorded 5.02kg/cm^2 and 4.37kg/cm^2, respectively

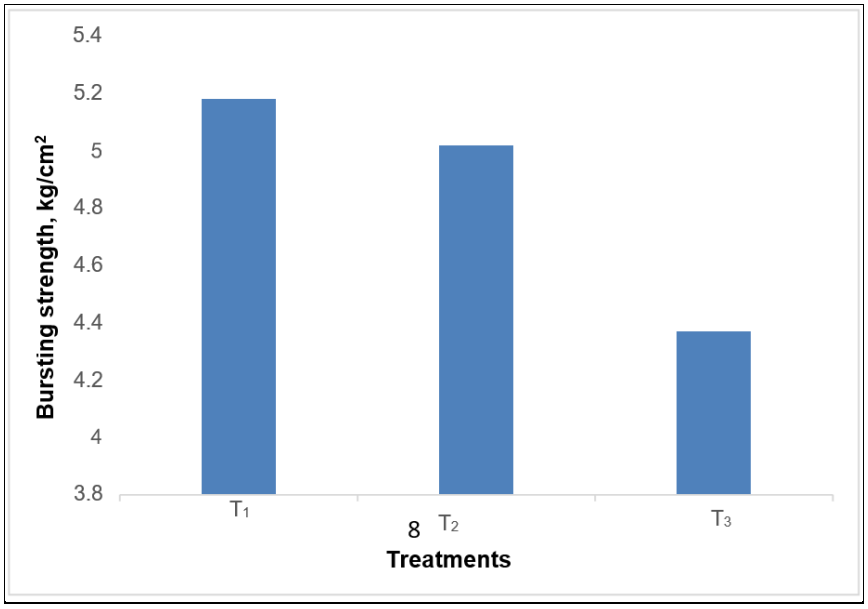


Fig 4: Changes of bursting strength of biodegradable cups prepared with pomegranate peel powder

Similar trend was observed by Jiang *et al*. (2015) [13] when paper based plastics were prepared with incorporation of glycerol and chloride solution. It was observed that without addition of glycerol and low glycerol content leads to low bursting strength.

Water leakage Test

Water leakage test was evaluated for the biodegradable cups made with pomegranate peel powder with addition of xanthan gum and glycerol. The results were shown in Fig. 5. It was observed that the Treatment, T_2 took more time to leak water i.e. 4h when compared to treatments, T_1 and T_3 i.e., 3h and 2h, respectively.

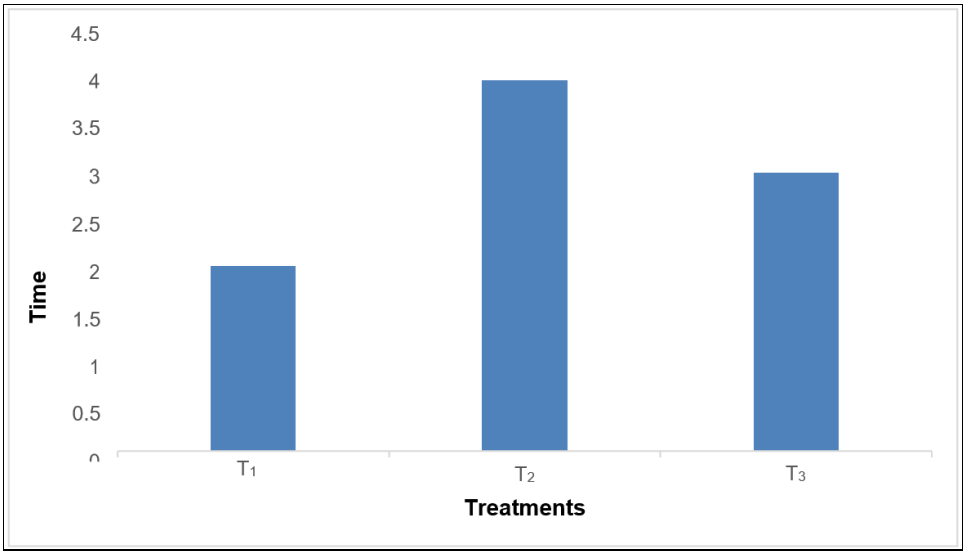


Fig 5: Changes in water leakage test of biodegradable cups prepared with pomegranate peel powder

Similar trend was observed by Pawinee Theamdee *et al.* (2019) [11] when films prepared with cassava starch with incorporation of glycerol. It was observed that with increasing in glycerol concentration the water vapour permeability increased. Also films with increasing glycerol exhibit hydrophilic character.

Biodegradability Test

The biodegradability test was performed by placing a sample of 5g from each different compositions in the soil at room temperature. The biodegradable cups prepared with different proportions of pomegranate peel powder, xanthan gum and glycerol were degraded completely after 1 month. Each sample was gradually disintegrated and started decaying within 4 to 5 days. The complete decay was observed within 1 month. The process of degradation of the cups prepared is due to the bacteria in the soil and organic substances present in it.

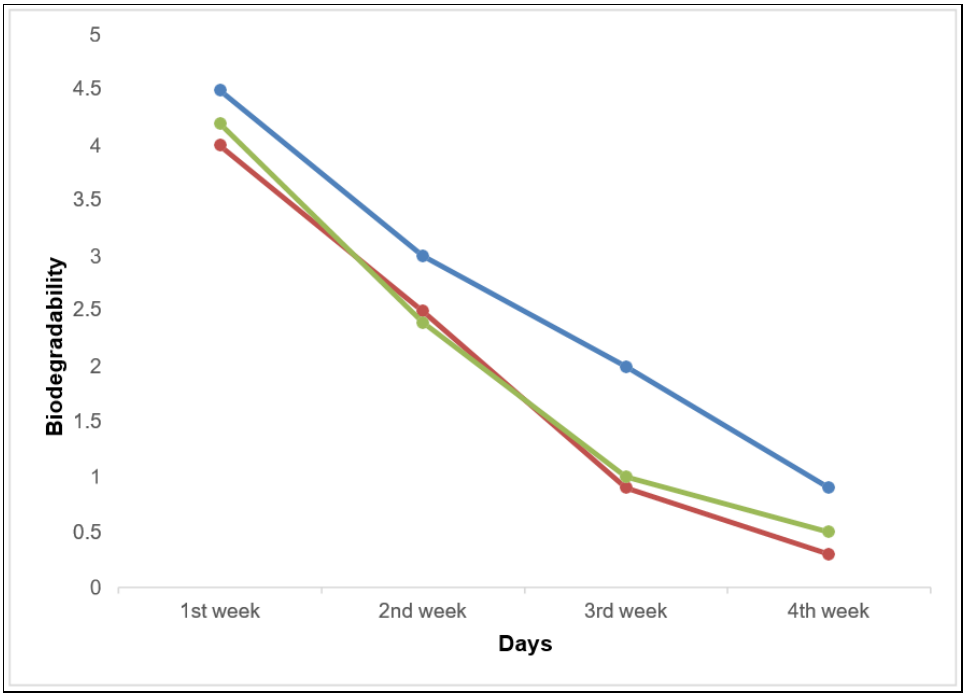


Fig 6: Changes in biodegradability of biodegradable cups prepared with pomegranate peel powder

Conclusions

The present study entitled with "Development of biodegradable cups with pomegranate peel powder" was carried out in college of Food Science and Technology, Rudrur. The study was conducted with the objectives to develop biodegradable cups made from pomegranate peels as an alternative to plastic cups and to reduce the fruit waste obtained from fruit processing industries.

Plastic waste disposal is a major cause of environmental pollution. Disposal of single use plastic has a tremendous impact on the surrounding environment. As an alternative to plastics, biodegradable cups were developed from pomegranate waste mostly from peels which are eco-friendly and biodegradable.

The biodegradable cups were developed by using pomegranate peel powder, Xanthan gum and Glycerol. Xanthan gum is an additive used as a binding agent also the glycerol used as binder and plasticizer. These samples were taken in different proportions to develop the standard cup which resist the water from leakage and not to react with the food material we use. T_1 having ppp, xanthan gum and glycerol in the ratio 50:25:25. Were T_2 in the ratio 70:15:15 and finally the T3 in the ratio 90:5:5. were mixing ppp, xanthan gum &glycerol well together with sufficient water to make dough so that it should ready to mould. Then applying it to the cup mould shape and drying it in tray dryer for 8h at 75 ºC. After drying the cup was coated with natural food colour and stored at cool and dry place.

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