

Development of egg packets and silica from rice husk

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The extraction of nano-size silica and development of hard packets for egg storage from rice husk (RH) using chemical method has been carried out. The obtained silica and egg packets have been characterized using Infra red spectrometer (FT-IR), X-ray diffraction (XRD), Scanning electron microcopy (SEM) and Shore D. The result reveals the formation of nano size silica with size 50-60 nm with surface area of 542 m² g/L. The physical hardness of egg packets is found 52 D, suitable for egg storage. The efficacy of developed packets on fresh market egg quality during storage at ambient temperature is investigated in terms of weight loss, pH and albumen quality. The developed packets show 35% lesser weight loss and pH 0.3 during 4 weeks of storage time.

Keywords: Rice husk, Extraction, Egg packet, Silica

Rice husk (RH) is a major agricultural waste product of rice milling industries and approximately 600 million tons RH is produced annually around the world¹. The chemical composition of RH is 35% cellulose, 25% hemicellulose, 20% lignin and 17% ash (mainly 94% silica by weight)²⁻⁵. Advantageous feature of RH is low bulk density, nonabrasive nature, reasonable strength and stiffness. In respond, RH has been also used to prepare many environmentally friendly composites of different polymers such as poly (lactic acid), poly butylene succinate (PBS), polypropylene (PP)⁶. These composites have been used in automobile industry, building profile, decking and railing products⁷.

Furthermore, different individual constituents (cellulose, lignin, silica) of RH had been widely used in electronics, packaging, medical science, sensors and source different chemicals⁷⁻⁹. However, due to lack of appropriate technology, still major amount of RH is used as crude source of energy in furnaces and

boilers. Another destination of RH is disposal in river, which releases green house gases during decomposition as well as creates a serious environmental problems. The open dumping of RH also creates disease in animals and occupy large space in land fill sites¹⁰. In this regard, the extraction and suitable use of chemical constituents of RH seems very important. The extraction of chemical component from RH has attracted attention of many researchers^{11,12}. Different strategy adopted such as alkali treatment, acidic leaching, hydrolysis are adopted for extraction and every method has its own merit and demerits¹³⁻¹⁷.

Real *et al.*¹⁸ extracted homogeneous size distributed nano size silica by burning rice husk at 873-1073 K in a pure oxygen atmosphere. Della *et al.*¹⁹ observed that active silica with a high specific area could be produced from rice husk ash after heat-treating at 973K in air. Shukla *et al.*^{20,21} has isolated cellulose from rice husk and used in drug delivery and also used RH for water purification. Cellulose whisker has separated by RH using chlorine free solvents by Rosa *et al.*²². The obtained cellulose has potential application in packaging and coating materials for different food items^{23,24}. Suppakul *et al.*²⁵ have reported, that methyl cellulose based coating to egg is a good storage of eggs. The coating lowers the weight loss about 50% than uncoated eggs when stored at ambient conditions of temperature 26 ± 3°C and relative humidity 65 ± 2%. Similar kind of coating had been developed by other scientists but they all added towards the cost to eggs^{26,28}. Further, most of the reported works are used for individual component and thus complete materials management is still need to develop. Thus, in the light of above development, present piece of work reports the use of RH for extraction of nano-size silica along with development of hard packets for eggs storage by simple method.

Experimental Section

Rice husk from Kundan Rice Mill, India, sodium hydroxide (99.9%), sodium hypo chloride (AR) grade purity from E- Merck were procured and use without further purifications. Further, double distilled water and analytical grade solvent were used during entire investigation.

Isolation of silica

Finely grinded dried RH with 100 mesh size was washed with distilled water to remove physical impurities and then dried at 100°C. 20 g of dried RH was treated with 100 mL of 10% NaOH aqueous solution along with stirring on a magnetic stirrer for half hour at 60°C temperature. The obtained solution was filtered and both residue and filtrate were collected separately. The solution was neutralized and then obtained residue was heated at 400°C in muffle furnace and a white colour product was obtained, which was characterized as silica. The silica was also prepared for comparison by simple burning of RH in muffle furnace at 800°C in ambient atmosphere.

Development of egg packets

Initially, collected filtrate was washed with distilled water and then treated with hydrogen peroxide. 2 g of this obtained residue was dispersed in 20 mL of 10% of PVA solution on a magnetic stirrer after stirring for 60 min at ambient (~25°C). The resultant solution was used to cast egg container on a ceramic mould by simple dip and dry method. The picture of developed container is shown in Fig. 1.

Characterization

FTIR spectra were recorded on a Perkin-Elmer (RK-1310) FT-IR spectrometer in the KBr phase with an accumulation of 16 scan and a resolution of 2 cm⁻¹ in the range of 4000 to 400 cm⁻¹. The particle phase, size and structure of synthesized materials were studied using X-ray powder diffraction pattern on Rigaku Rotaflex, RAD/Max-200B model X-ray diffractometer with Cu K α ($\lambda = 1.5405$ Å) radiation at a scanning rate of 2° per min. The surface morphology was examined by S-3700, Hitachi, model scanning electron microscope after sputter coated with gold.



Fig. 1 — The photograph of developed container.

Further, surface area of extracted silica and hardness of egg packets was measured with the help by titrametric method reported by Sears²⁹ and durometer (shore D) respectively.

Shelf life studies

The shelf life of eggs was evaluated by measuring the change in weight loss and pH at definite intervals of time. The batch of twelve eggs were packed in developed packets at ambient condition and temperature. The weight was measured using Shimadzu electronic balance, with least count 0.1 mg at different duration in triplicate and mean is reported. The change in weight (Δw) of eggs was calculated using equation 1:

$$\Delta w = \frac{W_1 - W_2}{W_1} \times 100 \quad \dots (1)$$

where W_1 and W_2 are initial and final weight in gm.

For pH measurement, the eggs were broken and the albumin contents were separated manually by glass spatula. The separated albumin contents were spread in a beaker and pH was measured at three places using pH meter and mean of three pH is reported.

Results and Discussion

Extraction of silica

The treatment of RH with sodium hydroxide make silica soluble due to the formation of sodium salt and separated from other constituents as organic residue. The overall scheme is given in Fig. 2. However residue contains mostly cellulose and other organic components.

XRD

The XRD spectra of extracted silica and RH is shown in Fig 3. The XRD of silica is showed broad and prominent peak at ~23° of two theta value, which

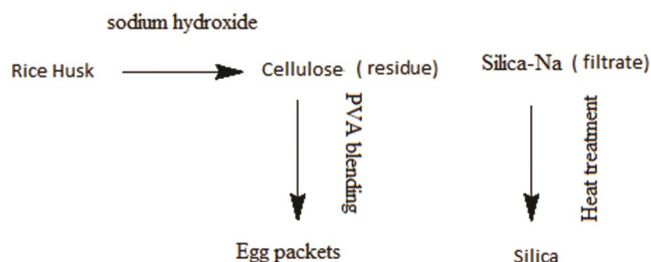


Fig. 2 — Extraction method for silica and development of egg packets.

signifies the formation of amorphous silica from RH³⁰. But, XRD of RH is showed a set of peaks including peak at 23° due to presence of many components including silica.

Morphological study

The SEM picture by extracted silica using present method and prepared by direct burning of RH is shown in Figs 4a and b. Figure 4a confirmed the formation of silica in 70-80 nm with uniform size and morphology, while silica produced by simple burning in muffle furnace showed particle of 900 nm. It may be because after extraction silica separated individually and produces small particle.

Surface area

The surface area of isolated silica has been 542 sq m per g better than many of earlier values³¹. The reason is due to formation nano size silica and also confirming the formation of nano particles. The ratio between the surface area and volume of materials particle has an enormous impact on their application. The high surface area supports the use of

silica in cementitious materials as well as a better supports catalyst.

Egg packet

FT-IR spectra of pure RH and developed egg packet film were shown in Fig. 5. The band occurring at 854 cm⁻¹ due to C-O-C ($\beta 1 \rightarrow 4$), is responsible for amorphous nature of cellulose³². The intensity of this peak increased along with red shift than RH. This indicates the increase in amorphous nature in extracted cellulose after alkali treatment. The increase in amorphous nature supports the processing behavior of obtained materials as well as its suitability to use as packaging than RH, which is the effect of alkali treatment. However, IR peak at 3431 cm⁻¹ in RH for hydrogen bonding show considerable shift than RH due to chemical treatment³³.

The micro photograph of developed egg packets film is shown in Fig. 6. It revealed the formation of regular morphology with homogeneous surface.

The hardness of packets was found 52 D at ambient condition, which supports its use hard packets for egg packing.

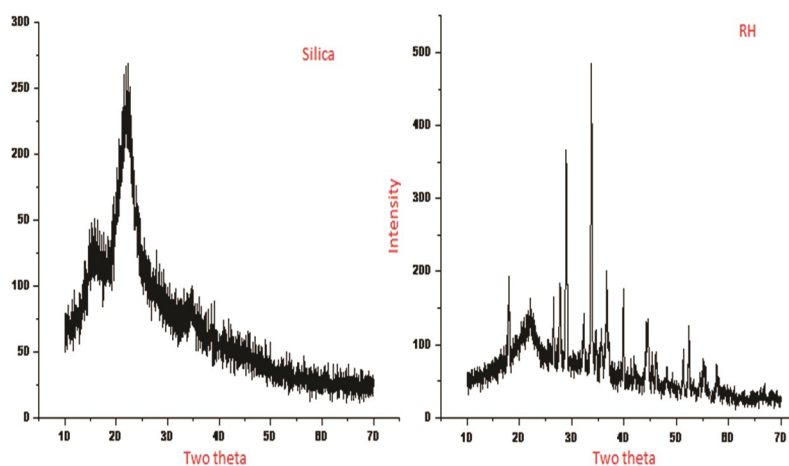


Fig. 3 — XRD curve of silica and rice husk.

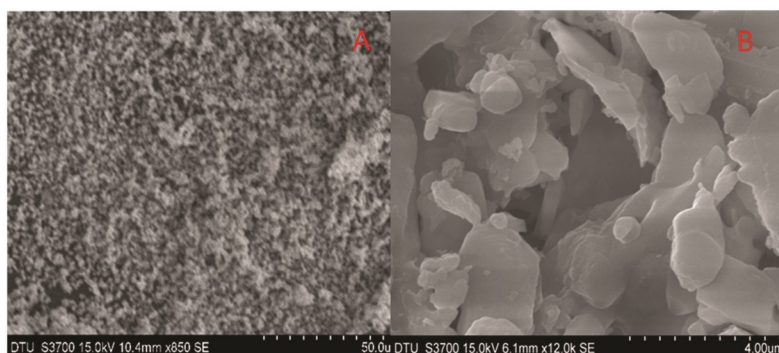


Fig. 4 — SEM picture: a) extracted silica and b) produced direct burning of RH.

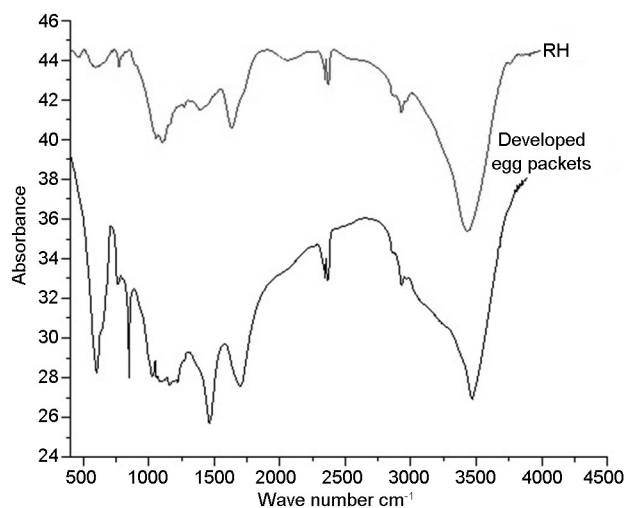


Fig. 5 — FT-IR spectra of RH and developed packet film.

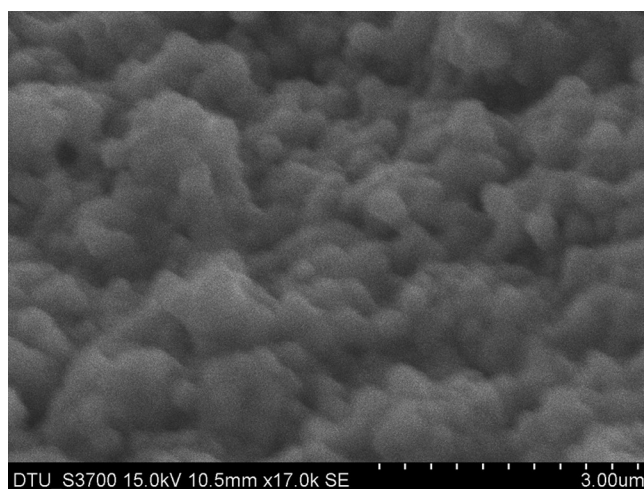


Fig. 6 — SEM picture developed egg packets

Shelf life studies on eggs

The shelf life of eggs is related to the rate of weight loss due to the loss of moisture. After oviposition, the egg begins to lose water to the environment owing to the pressure difference. The albumen contains the highest amount of in all egg components and loses its water to both the environment as well as to yolk. Due to water movement, the osmolarity of the albumen and yolk change. The loss of water to the environment is influenced by the environmental temperature, relative humidity, egg storage duration, and age of the breeder flock. Initially, water that evaporates through the pores of the avian egg comes from the shell membrane. This is replaced, to some extent, by recruitment of water from the albumen. The amount of water in the shell membrane depends on the equilibrium between the capillary tension of the

membrane and the colloid osmotic tension of the albumen. It is stated that water loss from the albumen have a negative impact on its viscosity, albumen pH and it deteriorates the shelf life of egg.

The average weight loss during study using (a) developed rice husk based packaging material coated was 14.14%, (b) using paper board packaging was 18.06% and (c) without packaging was 20.66%. The lowering in weight loss is basic requirement for a packaging material to enhance the shelf life of eggs. The loss of water causes imbalance in composition of nutrients and water present in egg in colloidal stage, change in colloidal stability (zeta potential). This changes the stability and hence results in degradation of egg protein.

The albumen pH data also shows increase from 8.5 (fresh egg) to 9 (in developed packet) and 9.3 (without packaging) after 30 days of storage. The lowering in mass loss and lesser pH change supports the effectiveness of the developed packets for egg storage. At oviposition, albumen pH is around 7.6. Later, carbon dioxide is released from the egg and due to the release of carbon dioxide, the equilibrium of the carbonate-bicarbonate buffer system is thought to be shifted towards production of carbon dioxide consequently, albumen pH rises. In the present case, the removal of silica decreases the hydrophilicity of film and increases the hydrophobicity. This is responsible for lowering the rate of water loss from prepared packaging materials. The above developed film will serve better than presently available paper board packaging in market.

Conclusion

The egg packets and nano size silica have been prepared from rice husk in order to explore sustainable application of RH, a technically important material from an agricultural waste. The developed packets suggested that rice husk based packaging is efficacious against egg quality deterioration, and may therefore be promising to extend the shelf-life of fresh eggs during storage at ambient conditions. It also designed a defined waste management technology due to their rich contents for exclusive purpose. The high surface area of developed silica revealed its application as support catalyst and better adsorbent.

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