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A Case Study and Perspectives of Human Wisdom on Eco-Friendly Food Packaging Materials in India

Sahu CK*, Dave U, Sukrutha S, Bayineni K and Kadeppagari RK

Food Science and Technology Division, Centre for Emerging Technologies, Jain University, Jain Global Campus, Jakkasandra, Karnataka – 562112, India

***Corresponding author:** Sahu CK, Food Science and Technology Division, Centre for Emerging Technologies, Jain University, Jain Global Campus, Jakkasandra, Karnataka – 562112, India, Tel: +91 7795129265; E-mail: 348kumarchandan@gmail.com

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Abstract

Pollution is a global problem and nowadays worldwide revolution is going on to minimize the pollutions level. In India, 43% pollution is happening due to use of non-biodegradable plastic packaging materials. In our throw-away way of life, the use of plastic has become so indispensable that we have dented the environment inadequately. Hence, there is a soaring necessitate of producing materials that can be recycled, biodegradable packaging is one of the new-fangled trends for green living. But, the depressing part is that public is not aware of using eco-friendly packaging materials. In our studies, we have done a survey on people of India to identify the awareness of usage of biodegradable packaging materials. In this case study, we found that the people with high education gave importance to eco-friendly biodegradable packaging materials as they care for the environment but, at the same time they solicit for its strength and cheap availability. Therefore, the government needs to acquire tough assessment to reduce the uses of non- biodegradable plastic packaging materials and make it cheaply available. It is anticipated that use of biodegradable materials will add to sustainability and diminution in the environmental impact associated with disposal of non-biodegradable polymers.

***Keywords:** Biodegradable plastic; Human health; Food packaging; Environmental pollution; Public awareness*

Introduction

Processing and packaging are the two important phases of operations in the food industry. An enormous covenant of automation strategies is persistently being utilized in every phase of processing and packaging. The correct food packaging can impede product deterioration, maintain the advantageous property of processing, lengthen shelf-life, and retain quality and safety of food. Consequently, packaging provides safeguard from three major classes of exterior influences: chemical, biological and physical [1]. A lot of diverse materials are used for packaging including metals, glass, wood, paper or pulp, plastics or combinations of more than one material as composites. Plastic has happened to be an integral part of life for

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providing since its invention 50 years ago. The very qualities of durability that make the plastic convenient to use, however, make it a persistent, non- degradable, everlasting presence in the environment. When discarded, lost, or dumped in the environment, plastic debris harmfully affects living being [2].

Use of plastics as a packaging material is harmful to human health due to Phthalates, the chemical compounds used in plastics. Human exposure to these components occurs via food intake and may be related with adverse health effects, especially a disruption of hormonal system [3]. The threat of plastics to the marine environment has been a serious issue [4]. Even the animals feed on plastics by mistake and hence it has entered in the food chain. The studies revealed the presence of PCBs in the Shearwaters birds, tissues due to ingested plastic particles [5]. Their study offered the initial indication that seabirds can assimilate chemicals from plastic particles in their stomachs, representing a hazardous pathway for potentially destructive pollutants. On the other hand, biodegradable plastics with functionalities and process abilities similar to traditional petrochemical based plastic have been developed for packaging applications. Classically, they are made from renewable raw materials such as starch or cellulose [6]. In adding up to performance and cost, biodegradable plastics have even got to offer advantages for waste management systems in order to understand large benefits to the environment [7].

Percentage of plastic usage by different industries in India

There are three stages of plastic life cycle: first stage is manufacturing, second stage is usage, and the third stage is recycling and/or disposal. The deployment of plastics is in different industries ranging from toys to aircrafts, from hosepipes to dolls, from soft drink bottles to refrigerators, from gramophone records to television sets. Packaging stands out for the major solitary segment of plastics utilization. This subdivision reports for 35% of plastic use and plastic is the material of preference in virtually half of the entire packaged goods. Use of plastics by different industries in India is shown in FIG. 1 [8]. The recycling of plastics also usually results in the lower-quality products that have higher leachable levels of toxic additives [9]. The incomplete combustion of polyethylene during recycling releases carbon monoxide.

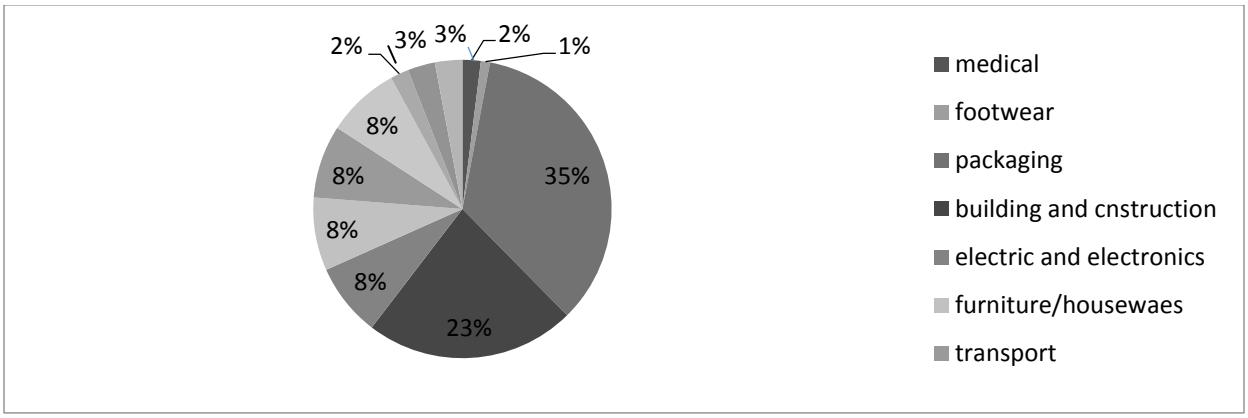

FIG. 1. **Percentage of plastic used by different industries in India [8].**

Not only industries but, common people in India also are not aware to manage the waste. For example, keeping wet, dry, biodegradable waste, non- biodegradable waste, electronics waste in separate bags and processing them separately. Hence, the dump yard will have all the wastes in the ground and controlling the land pollution will become tough. Also, people

throw plastics in the rivers, ponds, lakes and create water pollution. For illustration, shopping bags lynching above the waterline of streams, ponds, lakes and rivers are a much publicized form of plastic litter.

Effect on human and animal health due to use of non-biodegradable plastics

Some harmful compounds are used in plastics, such as phthalates, bisphenol A (BPA), and poly brominate diphenyl ether (PBDE). Phthalates are plasticizers —softeners— used to compose plastic products less fragile. The traces are found in medical devices, food packaging, automobile upholstery, flooring materials, and computers as well as in pharmaceuticals, perfumes, and cosmetics. They are also detected in humans and are recognized to interrupt the endocrine system. Phthalates operate against male hormones and are hence termed as anti-androgens. BPA mimics the usual female hormone estrogen; and PBDE has been shown to interrupt thyroid hormones in adding to being an anti-androgen [10].

Most recent science details about the decomposition of polystyrene plastics showed that Bisphenol A (BPA) impede with the reproductive systems of animals. PS oligomers and BPA from plastic decomposition are toxic and can be metabolized, while styrene monomer is a suspected carcinogen. Low levels of BPA and PS oligomers have been proven to cause hormone disruption in animals [11].

The cross-sectional study of 1,500 people was assessed to the exposure to bisphenol. By looking at levels of the chemicals in urine, the authors found higher levels of bisphenol, which was significantly associated with heart diseases, diabetes, and abnormally high levels of certain liver enzymes [12].

Effect on agricultural crops due to use of non-biodegradable plastics

The use of black polyethylene plastic materials for mulching is a very regular practice for farmers in growing vegetable crops used due to its exceptional properties and low cost. However, the colossal use of these materials creates an environmental risk. In the last few years, the use of starch-based biodegradable films has been launched as a substitute to usual conventional mulches. These materials can be integrated into the soil at the ending of the crop season and undertake biodegradation by soil microorganisms.

Effect on environment due to use of non-biodegradable plastics

Low doses of biphenyl A, a chemical used in water bottles, food containers and hard plastics leach into foods and water over time and are carcinogenic, cause insulin resistance and interfere with conception [11]. Increased intake of plastic packaging materials and lightweight bags caused visual distress to wildlife. Flora and fauna losses are subject matter for the protection of biodiversity, and losses due to litter have caused public apprehension. Hence, there is a need that industrialists, government and common people of India be aware of the lethal effects of use of non- biodegradable plastics. In general, plastics have dented environment by air, water and soil pollution.

Air pollution: Plastic causes ‘air pollution’ in much the same way, it pollutes water supplies. Constant exposure of heat melts the plastic, emitting gases into the atmosphere in a process known as out gassing. Incinerating of plastic causes toxic fumes to be released into the atmosphere. The same problem happens with plastics exposed to constant sunlight. The nitrogen-containing polymers pollute by forming cyanides, nitrogen-oxides and ammonia. The PTFE (Polytetrafluoroethylene) gives

off high concentrations of fluoride into the air. PMMA (Poly-(methyl methacrylate)) decomposes in its monomer methyl methacrylate and forms large amounts of aliphatic aldehydes. ABS (Acrylonitrile Butadiene Styrene) and SBR (styrene-butadiene) cause styrene pollution [13]. Recycling of plastics is a best way to reduce the environmental risks but, recycling requires burning of plastics which causes emission of carbon dioxide and thus increased greenhouse gases [14].

Water pollution: Plastics have a major role to play even in the case of 'water pollution'. Plastic pollution in marine environments can result in the degradation of aquatic ecosystems, algal blooms and death of marine species that ingest them. Turtles can die of starvation as plastic bags block the alimentary canal. Ethylene glycol, which is one of the plasticizers, is a recognized environmental pollutant. Direct exposure to the compound can cause skin and eye damage in humans, with a lethal dose if ingested of 100 mL. The lethal concentration for fish has been found to be 100 mg/L [15].

Soil pollution: The plastics may cause a serious problem of land filling and this result in soil pollution. Plastic degradation by-products, such as dyes, plasticizers or catalyst residues, in landfills or compost can potentially migrate to groundwater and surface water bodies via run-off and leach-ate. However, fragments from partially biodegraded plastics will accumulate in cultivated soils and fragments such as polyethylene (which has a specific gravity less than one) could float and potentially block drains. Even the soil flora cannot breathe and dies.

Eco-friendly packaging materials

Fortunately, there are many biodegradable and recyclable packaging material alternatives available. Edible and biodegradable films are excellent substitute packaging options. Their main advantage over synthetic packaging polymers is that they do not put in to long-term environmental pollution [16]. A further attractive expansion is the application of edible plastics directly on food products or food ingredients that extend the shelf life by providing physical shield as well as a semi-permeable barrier toward gases and water vapor in resemblance to packaging. These biodegradable packaging materials give the protection to products against temperature, light, moisture, humidity, compression, impact, vibration, and biological contaminations and it contains the information regarding the product to identify the products [17].

Varieties of biodegradable & degradable plastics have also been anticipated as per ASTM D-6400

Compostable plastic: Degradation of a plastic by biological processes through composting to yield inorganic compounds, CO_2, water and biomass at a rate constant with other recognized compostable materials and depart no noticeable, apparent or toxic residue.

Photodegradable/Oxo-degradable plastics: Photodegradable/Oxodegradable plastics break up into small pieces when out in the open to sunlight (due to addition of a sun-sensitive factor to the plastic to activate degradation).

Biopolymers are classified according to their renewability substances (fully or partially bio-based or oil-based) [18]. Another attempt to classify biodegradable polymers into two main groups as shown in FIG. 2 is, i) the agro-polymers gained by biomass fragmentation processes (polysaccharides, proteins, etc.), and ii) the bio-polyesters gained either by synthesis from bio-derived monomers (poly-lactic acid – PLA) or by extraction from microorganisms (polyhydroxy-alkanoate – PHA) or by synthesis from synthetic monomers (poly-capro-lactone – PCL, aromatic and aliphatic copolyesters – PBAT, PBSA, etc.) [19].

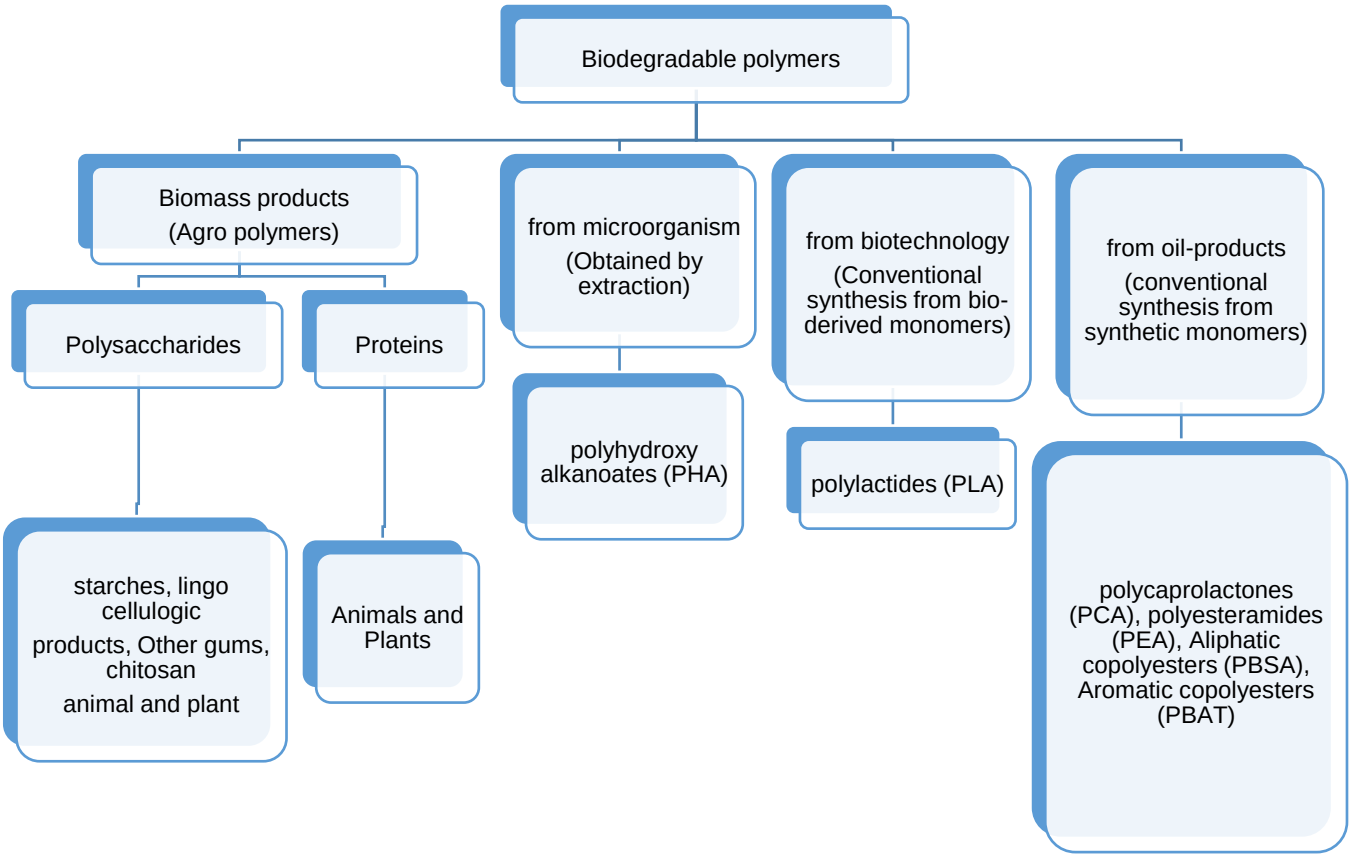

FIG. 2. **Classification of biodegradable polymers.**

The range of biodegradable plastics existing includes:

- Starch based products including thermoplastic starch, starch and synthetic aliphatic polyester blends, and starch and PVOH blends.
- Naturally produced polyesters including PVB, PHB and PHBH.
- Renewable resource polyesters such as PLA.
- Synthetic aliphatic polyesters including PCL and PBS.
- Aliphatic-aromatic (AAC) co-polyesters.
- Hydro-biodegradable polyester such as modified PET.
- Water soluble polymer such as polyvinyl alcohol and ethylene vinyl alcohol.
- Photo-biodegradable plastics.
- Controlled degradation additive master-batches.

Natural polymers: A wide variety of naturally occurring polymers were known to humans. The natural polymers comprise four broad groups: 1. Polysaccharides — Starch, Cellulose, 2. Proteins — Gelatin, Casein, Silk, Wool, 3. Polyesters — Polyhyroxyalkanoates, 4. others — Lignin, Shellac, Natural Rubber.

Synthesized biodegradable polymers: There are scores of polymers produced from petrochemical or biological resources that are biodegradable synthetic resins. The list includes: polyalkylene esters, polylatic acid and its copolymers, Polyamide esters, polyvinyl esters, polyvinyl alcohol and polyanhydrides.

Blends of natural and synthetic polymers: This is low cost procedure to make biodegradable packaging materials by blending of natural polymers in to improved mechanical properties. The generally target for preparing an advanced blend of two or more polymers is not easy because the properties of compound will not change drastically, but capitalize on the maximum possible performance of the blend. Gutta-percha or 1, 4- trans-polysoprene is a natural polymer having several applications, as compared to endodontic filling material. Starch is also one of the most important natural polymers because it has implicit biodegradability. Blends of natural–synthetic polymers have been considered promising for preparing polymers with "tailor-made" properties [17,20,21].

Material and Methods

The case study was done among the people from different part of India to identify the awareness of use of biodegradable packaging materials with reference to environment consideration. Different age groups and different society of people on the basis of their yearly income and education were considered to do this case study. This case study was conducted in different parts of India with different culture to get the overall idea about people wisdom on eco-friendly packaging of food materials.

People selected for case study were educated regarding the importance of survey and this data might be helpful for food industries, industries those are working in field of manufacturing of biodegradable packaging and scientist/ researcher working on development of biodegradable packing materials.

Important instructions were given to the subject groups to before filling survey form:

- This case study is conducted to know the human wisdom on eco-friendly packaging of food materials.
- Please give the correct information regarding your income and education.
- If possible, please give the reason against your choice.
- Make sure that you have chosen the packaging materials according to your own confidence and you have not been influenced by any other person.
- The meaning for your choice is given in below table, please read the details before filling the survey form.
- There are two groups for survey, Group "A" (basis on yearly income) and Group "B" (basis on Education).
- Please put cross sign (x) against your choice.
- The people involved in survey were asked to give suggestions to enhance the eco-friendly packaging materials for high strength, larger size capacity etc.

Results and Discussion

The Aim of this survey was to increase the use of eco-friendly packaging materials. We have grouped our survey based on the income (Group A) and education levels (Group B). We had surveyed 600 people of different age groups and their age was between 20 to 55 years.

The group “A” was sub-grouped as A1, A2, A3, A4, A5 and A6 on the basis of their annual income and group “B” was sub-grouped as B1, B2, B3, B4, B5, B6 and B7 on the basis of the education of people. The justification of the classification of subgroups is given in TABLE 1.

TABLE. 1. **Showing the details about survey form descriptions.**

S. No.	**Particular Details**	
	Legends used	**Details**
	Attractive Design, light weight and good strength of packaging	There is prime importance on the strength of the packaging bags
	Economics of packaging (lower price packaging)	Preference will be given to the packaging materials those are available at low prices
	Environmental impact of packaging (eco-friendly packaging)	The packaging materials should be eco-friendly
	Economics (affordable price) and Environmental impact (eco-friendly) of packaging	The packaging materials is Eco-friendly and economical (low price)
	Attractive Design, light weight, good strength and economics (low price) of package	Packaging materials should be Lower price, attractive design and high strength
1.	Name	
2.	Age (in year) and Gender (male-M, female-F)	
3.	Working field	
4.	Group “A” (basis on yearly income)	
	Family income (per year)	A1.50000-150000/- A2.150000-250000/- A3.250000-350000/- A4.350000-450000/- A5.450000-550000/- A6.550000 and above
5.	Group “B” (basis on Education)	
	Education	B1. Primary education B2. 8^{th} to 10th B3. 10^{th}-12^{th} B4. Bachelor Degree (medical/ Engineering/ science) B5. Master and PhD degree (engineering/science/medical) B6. Food specialists/ food scientist
6.	Your most preferable group	
	A	B
7.	Do you have detailed knowledge about biodegradable packaging materials?	
	Yes	No

8.	During selection of food packaging materials, what is your preferred selection?	1. Attractive Design, light weight and good strength of packaging 2. Economics of packaging (lower price packaging) 3. Environmental impact of packaging (eco-friendly packaging) 4. Economics (affordable price) and Environmental impact (eco-friendly) of packaging 5. Attractive Design, light weight, good strength and economics (low price) of package
9.	What will be your suggestion to increase the use of biodegradable packaging and control the pollutions happening due to non-biodegradable packaging of food?	
	1. only education is sufficient 2. education, attractive and high strength biodegradable packaging material should be developed 3. economical (low price), attractive and high strength biodegradable packaging material should be developed with proper education 4. any others.	

The survey form had five options as mentioned in TABLE 1 to choose from and the subjects had to choose one of the five options. The survey results based on income of people is shown in FIG. 3 and 4.

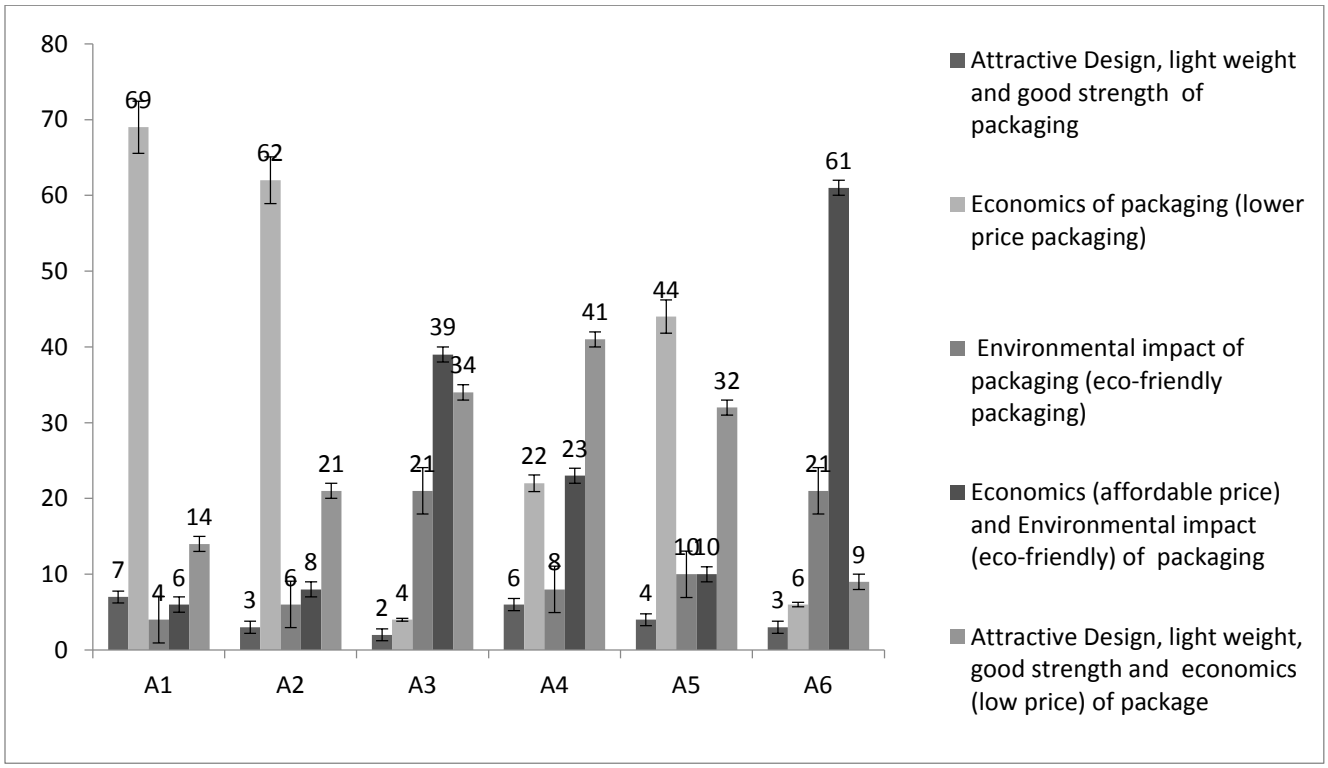

FIG. 3. **Wisdom of group "A" regarding selection of packaging materials.**

The survey results show that the people with very low income (A1, A2) gave importance to the economic price of the packaging materials. People with average income (A3, A4 and A5) gave importance to all the aspects of biodegradable materials as they are educated enough to know the hazards caused to environment due to uses of the non-biodegradable plastics but, at the same time they aren't reach enough to afford the costly biodegradable plastics. People with high income (A6) gave more importance to environmental impacts as they are educated and have enough money.

The survey of group A shows that most of the people are giving more importance to the economics of packaging materials instead of environment, so that there is a necessitate to develop effortless and cheaper techniques to manufacture financially economical biodegradable packaging materials to catch the attention of all the income groups for using biodegradable packaging materials.

In group B, the results show that highly educated people have given emphasis to environmental issues. But, if we compare group A and group B results, it is evident that even though people are very educated, they have given preference to the economical availability of the biodegradable plastics as they are not highly rich. Many people have given preferences to all the aspects e.g. price, environment and strength.

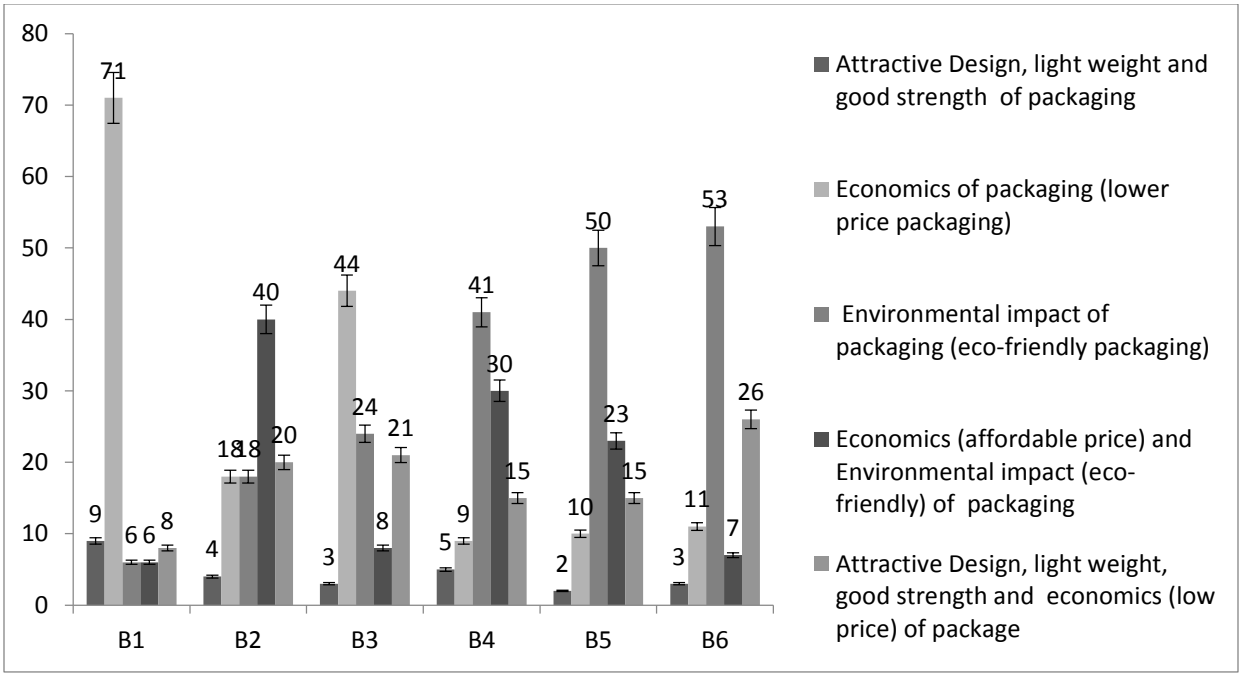

FIG. 4. **Wisdom of group "B" regarding selection of packaging materials.**

Conclusion

To develop the Eco-friendly packaging materials on the basis of given guidelines, countless research works are going on. It is important that people should know the importance of eco-friendly packaging materials. For this, government and private industries should involve to develop economically cheaper eco-friendly packaging materials. Our research data is showing that in society many sections are still not aware about eco-friendly food packaging materials, hence there is a need to educate the society about environmental impacts of packaging, along with novel technologies in this field, has led to discussions on

how to provide accurate information to different sections of society like labor, engineer, academic staff, middle class family etc., when shelling “green” products.

Another important objective while using biodegradable plastics is that even biodegradable coatings pose some environmental risks, where the conditions required for full degradation are not met and consequently no complete degradation. Effective education is required with the opening of biodegradable plastics into the consumer packaging market. It is important for public to be acquainted with biodegradable plastics that even they do not degrade instantaneously and hence circumvent the potential to increase the incidence of littering. Hence, novel technologies should be employed in future for complete biodegradation of the biodegradable materials. Catalysts like proteases, esterase, glycosidase, and manganese peroxides and also, presence of microbes can be employed in order to have complete biodegradation. Therefore, there is a scope to do research on biodegradation of biodegradable plastics.

One more potential biodegradable packaging material is jute bags. Also, use of fibers of the agro-wastes can be used to prepare packaging boxes for instance; banana leaves fibers, coconut shell fibers, wastes of sugar cane, etc. In this paper, we highly advocate to do sincere research on them and practice them since they are not only eco- friendly but, also serves counter for the waste management. In addition, Indian government should make it compulsory to have clear and separate disposal routes for discrete wastes and make them available to consumers to manage this waste streams appropriately.

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