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SUSTAINABLE PACKAGING MATERIALS FOR THE FOOD INDUSTRY: ROLE OF RADIATION TECHNOLOGY

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2nd International Conference on Applications of Radiation Science and Technology

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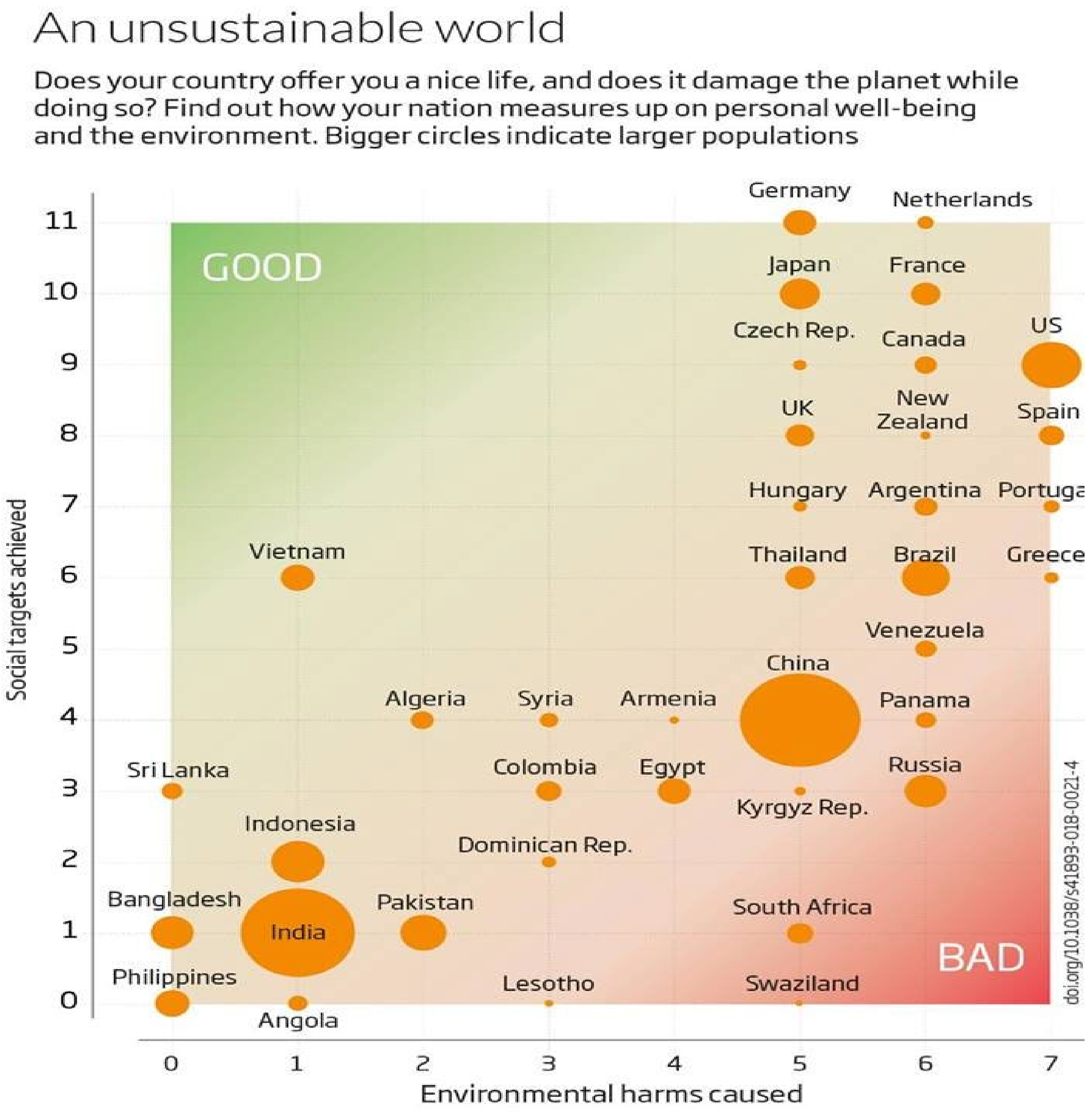
SOCIAL TARGETS ACHIEVED
vs
ENVIRONMENTAL HARMS CAUSED



No country meets basic needs for its citizens at a globally sustainable level of resource use

(O'Neill, D.W., Fanning, A.L., Lamb, W.F. *et al.* A good life for all within planetary boundaries. *Nat Sustain* **1,** 88–95 (2018). https://doi.org/10.1038/s41893-018-0021-4)

- Food packaging keeps food safe and fresh
- Protects products during transport, delivery, and storage.
- Packaging also fills trash containers and landfills, lasting far longer than the products it was made to contain.
- Can also transfer chemicals into our food, with unknown health effects.
- Disposing massive quantities of wastes generated by non-biodegradable packaging material pave ways for the study of
- **Biopolymers as alternative materials for food packaging, mainly as primary packaging.**

Use of irradiation in food packaging processing

- Health reasons ➡ Prevent foodborne illnesses
- Health/economic reasons ➡ Food poisoning outbreaks cause immense economic burdens
- Ethical reasons ➡ Reports by FAO state that **food availability** and **safety** are under threat and that by 2050 global production of safe and nutritious food must increase by 70% to feed the growing world population. A huge amount of food (~40%, ~1.3 billion tons/year) is lost between the stages of production and consumption.
- Use of natural polymers ➡ Unique characteristics like inherent biocompatibility, biodegradability and easy availability .
- Radiation processing (+ nanotechnology) ➡ improve the functionality of food packaging

Classification of edible film formed materials

Polysaccharides

- Cellulose
- Starch
- Pectins
- Seaweed extracts: alginates, carrageenan and agar
- Gums: acacia, tragacanth and guar
- Pullulan
- Chitosan

Proteins

- Animal source: casein, whey protein concentrate and isolate, gelatin, and egg albumin
- Plant source: corn, soybean, wheat, cottonseed, peanut, and rice

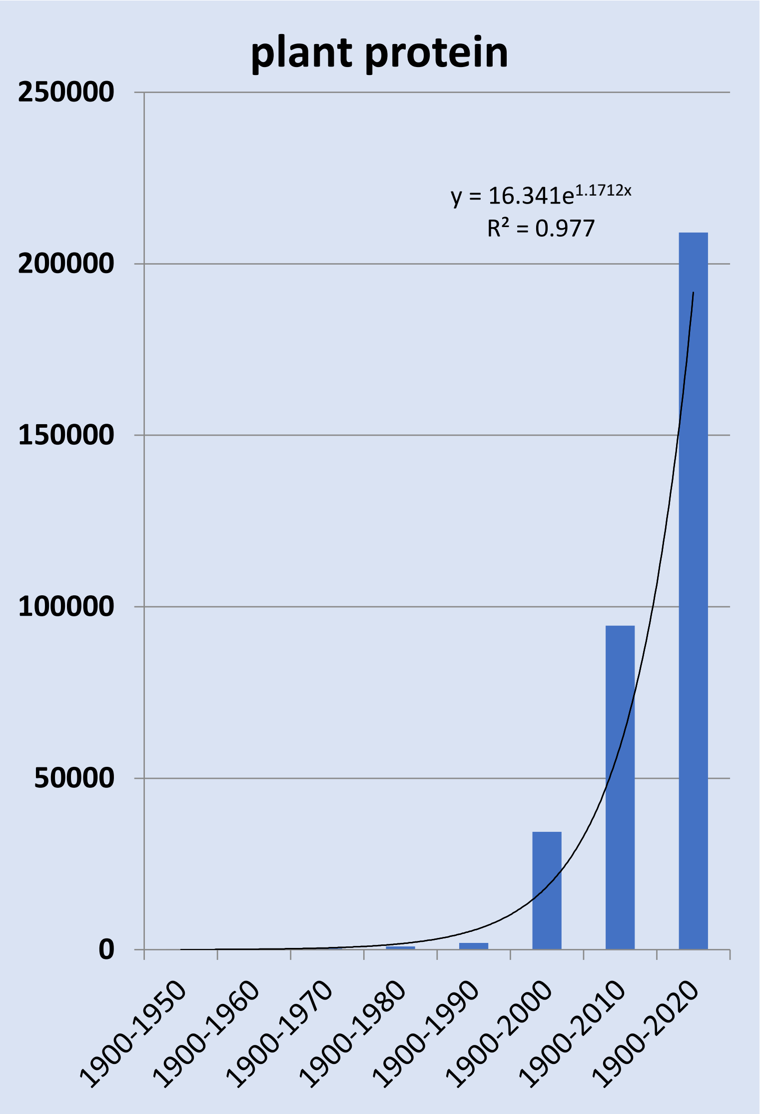
Lipids

- Animal and vegetable oils and fats: peanut, coconut, palm, cocoa, lard, butter, fatty acids, and mono-, di-, and triglycerides
- Waxes: candelilla, carnauba, beeswax, jojoba, and paraffin
- Natural resins: chicle, guarana, and olibanum
- Essential oils and extracts: camphor, mint, and citrus fruits essential oils
- Emulsifiers and surface active agents: lecithin, fatty alcohols, and fatty acids

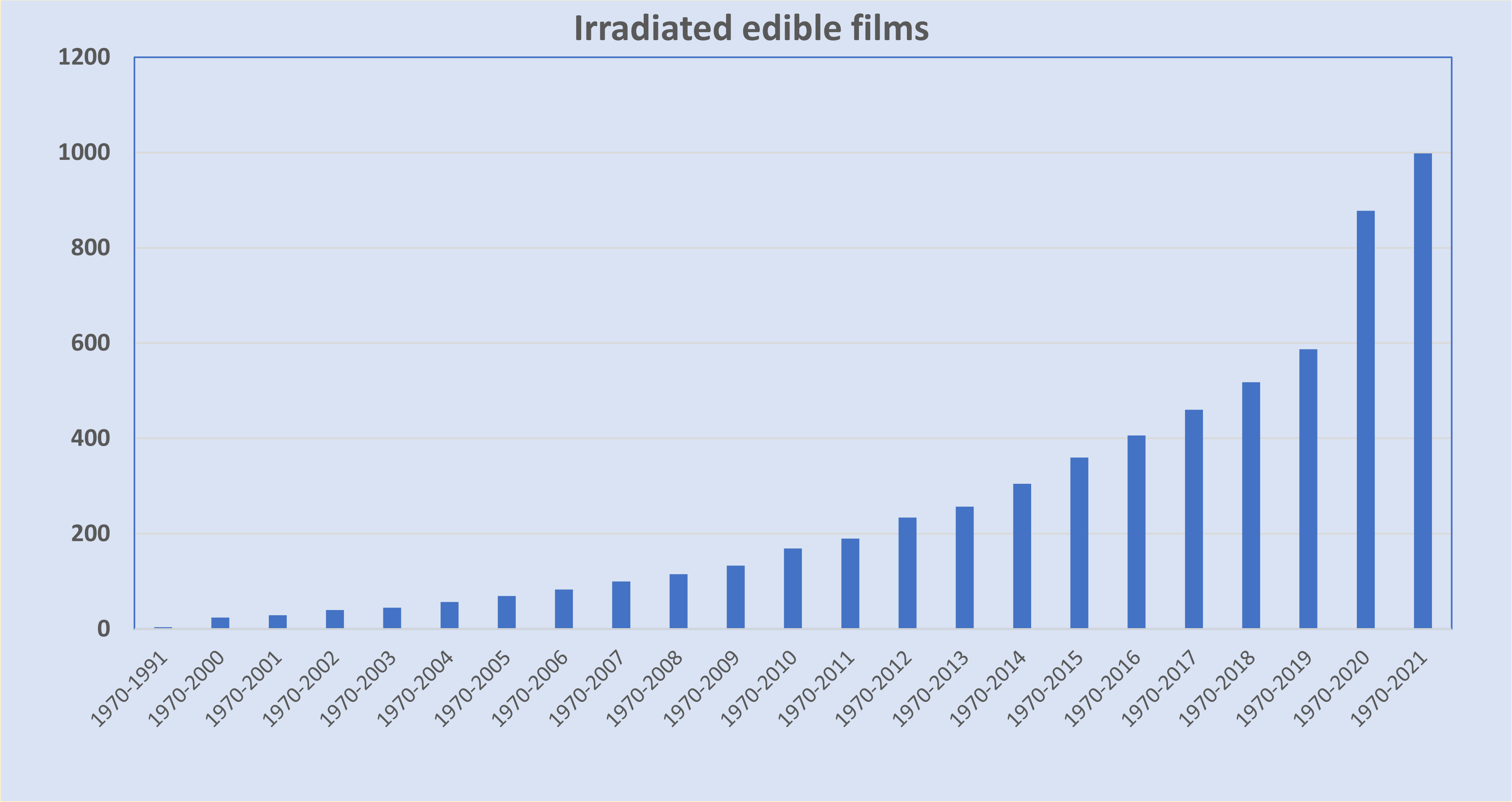
Plant protein vs animal protein

- Plant protein production generally requires less land, water and energy compared to producing animal protein and results in less green house emissions.
- Meat and other animal products require more life cycle inputs per kg of product than plant products.
- A switch to alternative proteins could be the cheapest and highest impact solution to climate crisis.
- Other environmental concern about animal protein is the rapidly depleting global supply of high-quality, mineable phosphorus.
- Plant-based diets (including generally less animal-food intensive, vegetarian, or vegan diets) represent a growing area of interest in the promotion of physical and environmental health.
- **Plant-based meat market worth $15.7 billion by 2027 (Food News Now).**

Number of published articles according to Web of Science database



Edible Films and Coatings: any type of material used for enrobing (i.e., coating or wrapping) various food to extend shelf life of the product that may be eaten together with food with or without further removal



Number of published articles on ionizing radiation (γ or EB) and protein/starch

from Web of Sciences database collected on 2017 and 2019 using different tags.

Tags	March 2017	December 2019
Coating + protein + starch	446	576
Films + protein + starch	625	851
Ionizing radiation + films or coating	484,596	598,468
I. Radiation + film or coating + protein or starch	135,876	197,106
I. Radiation + protein	10,370	40,240
I. Radiation + polysaccharides or starch	84,401	103,678

- **Edible packaging material or films** must have some functional and specific properties:

- 1. good water barrier efficiency; 2. control of gas exchanges; 3. retard solute transport; 4. retard oil and fat migration; 5. retard organic vapor transfers; 6. improve mechanical properties of food to facilitate handling and carriage; 7. Sensorial characteristics such as color, shininess, transparency, roughness or sticking can be improved; 8. Layers are not self-supporting.

- **Components** used for the preparation of **edible films**:

1. hydrocolloids (such as proteins, polysaccharides, and alginate)

2. lipids (such as fatty acids, acylglycerol, waxes) and

3. composites.

The formulation of films requires at least one component capable to form a structural matrix with a sufficient cohesiveness. Water soluble hydrocolloids, like polysaccharides and proteins, are low efficient barrier against water transfer; however, their permeability to gases is often lower than those of plastic films. Hydrocolloids usually provide higher mechanical properties to edible packaging than lipids and hydrophobic substances. Therefore, the advantages of all substances can be found in composite films.

Application of Edible and Biodegradable Starch-Based Films in Food Packaging

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- Starch is a proper substitute for polymers extracted from petroleum derivatives.
- Numerous factors, including starch source, extraction method, film formulation, processing methods, and curing procedures, drastically impact the ultimate material properties.
- In order to improve mechanical and barrier properties and the characteristics of the produced films, a high number of compounds can be added to the matrix, and variations can be applied during the processing.
- Functional starch-based films appeared as promising materials for primary packaging and are being developed at different laboratories containing antioxidant, antibacterial, or spoilage indicating components to prevent or signal the degradation of food products (smart films).
- Plant-derived additives are attractive due to their renewable nature as well as their biological compatibility, a chief concern when designing films for food packaging applications. As antioxidant additives can enter the food, the use of natural plant antioxidants as additives and are therefore safe for consumption.

DEVELOPMENT OF FILMS OF CASSAVA (MANIOC) STARCH + ISOLATED SOY PROTEIN

Starch-based films can produce biodegradable packaging for the food industry. However, the low mechanical properties of starch and its inherent water sensitivity restrict the use of starch films, especially in moist environments, and starch films are relatively brittle.

- In our laboratory we prepare films based on starch + vegetal protein. Samples of cassava starch and isolate soy protein in bulk were obtained at a local grocery store, analytical grade glycerol (used as plasticizer) and deionized water were used for the film preparation.
- Electron beam (EB) irradiation, at room temperature with doses of 20 and 40 kGy, an accelerator, Dynamitron II from Radiation Dynamics Inc., energy 1.202 MeV, beam current 0.62 mA was employed dose rate of 2.81 kGy s^{-1}.
- The films were prepared by casting of the filmogenic solution: 2.5% powder ISP, 7.5% cassava starch, 3% glycerol and 0.5% Ca propionate, heated in water bath at 70°C under constant stirring for 30 min. The solution was poured into glass dishes previously covered with polyethylene film.
- The plates were placed in an oven with forced air circulation at 30°C for 20 h until irradiation. The films were stored (58% RH, 25°C) in a desiccator containing silica gel for 48 h before the characterization. The thickness of the films was in the range of 1.95±0.05 mm.

Ionizing radiation sources

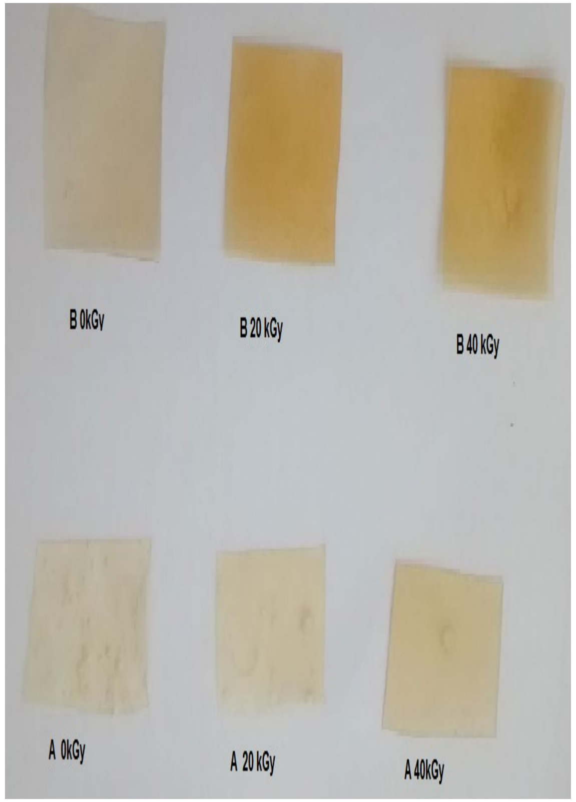
Gamma sources

Electron beam accelerator

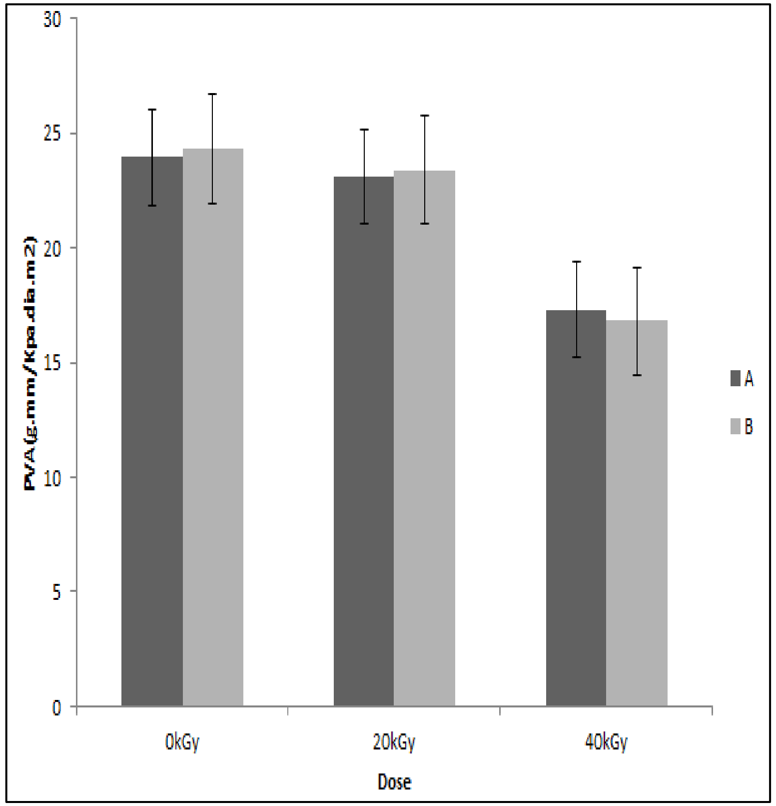
Pictures from the Center of Radiation Tecnology, IPEN, SP, Brazil

IRRADIATED FILMS OF CASSAVA (MANIOC) STARCH + ISOLATED SOY PROTEIN

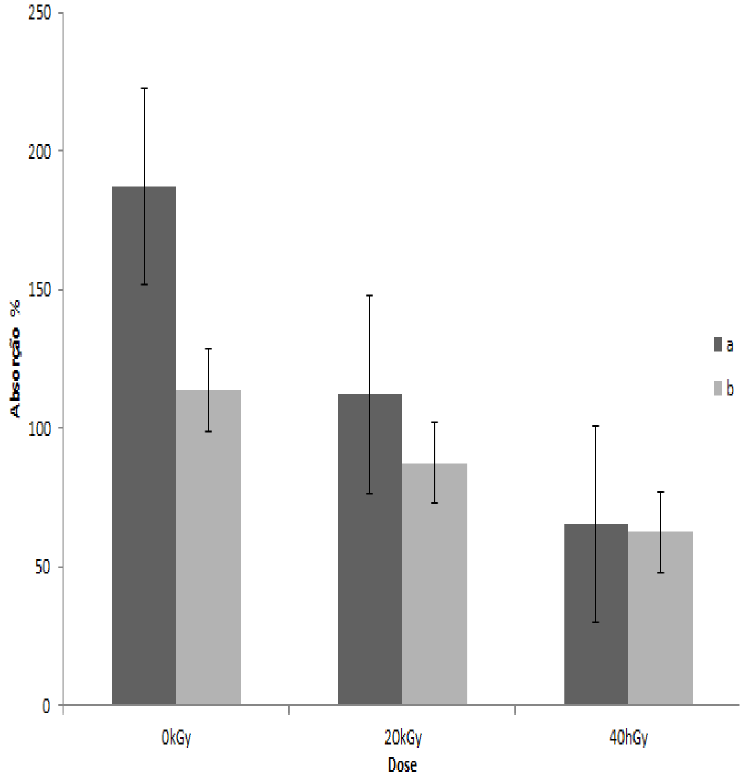
Color modification



Water permeability



Water absorption



Thank you!

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