Renewable, Sustainable and Natural Materials on Food Packaging: Primary Data for Robotically Detect Packaging Shape in Logistics

Thanapong Chaichana
College of Maritime Study and Management, Chiang Mai University, Thailand
E-mail: thanapong.c@cmu.ac.th

Abstract. In the past decades, plastic packaging was a key material to preserve, protect, store, and transport food products. It was shown in food logistics from the manufacturers to consumers. The cost of making plastics is cheap. It was determined by the energy input that used to process them. Ingredients used to create plastics are very inexpensive. Furthermore, food packaging is a container. If it made from plastic material, it was also durable and last long over the shelf life of foods. Due to the sustainability concerns, using plastic packaging will cause the environment issues. Recovering the environment will help the earth to remain supporting life. This research aims to summarise the findings of smart packaging using different types of materials consisted of renewable, sustainable, and natural materials. A state-of-the-art food packaging geometry is explained. The data trends of intelligent food packaging were found to associate with sustainable development goals.

1. Introduction
Food packaging generally referred to tradition method that covers foods from microbial spoilage and oxidation. The field of food packing consists of food science, multidiscipline engineering, computer science, microbiology and chemistry. Predominately, sensory elements play a key role in packaging industry [1]. Traditional food packaging is a passive technique to protect foods and preserve the quality of foods and extend the shelf life of foods. Intelligent food packaging is an active technique that works alongside an inactive packaging. It is an extension of traditional packaging to communicate with the consumers by providing food product information. Thus, the significant factor in modern packaging is to provide data to consumers including a sense and chance to detect the changes in food products, and report packaging itself how it will cause environmental problems [2]. Figure 1 demonstrates a graphic visualisation of traditional and smart food packaging.
Currently, there are three terms comprised of “smart packaging”, “intelligent packaging”, and “active packaging”. These terms refer to a new system of food packaging, pharmaceuticals and other products [3]. In addition, electronic sensor and nanomaterial have been studied their potentials to support the success in this new system. Apparently, technology and innovation applications on an active packaging significantly focused on quality detection of food storage, shelf life extension, pH parameters, and fermentation. Nonetheless, all types of food packaging should be considered their influences on sustainable development goals. Especially, the key goal is a climate change or climate action. Thus, the purpose of this research is to further explore three kinds of food packaging that involve natural, renewable and sustainable packaging materials, and their shapes in logistics. The hypothesis of this current investigation is that food packaging with its shapes was strictly governed by logistics management and operation. The consequence of this work is a baseline data for future work to automatically detect packaging shape in logistics.

2. Natural Packaging

In an existing investigation, natural packaging is that the packaging materials are made from and made by the nature. For instance, a square-shaped box container can be made of agricultural waste, tree leaves, mushrooms, hay, as well as coconut fibres. These natural materials alternatively provide new replacements of plastic packaging enter the market. Thus, this passive method heavily relies on traditional food packaging. The design of packaging shape is finally modelled by using sensory elements information of foods [4-8]. Figure 2 illustrates examples of natural food packaging.

Figure 2. Food packaging made of natural materials from left to right: hay, coconut fibres, banana leaves tied with bamboo wires, and areca catechu leaves.

3. Renewable Packaging

Renewable packaging means the packaging is made by raw materials (in part or whole) obtained from natural resources and/or resources that can be renewed, for example, wood pulp. Additionally, a packaging in this category committed to promote a circular economy. It is economic system aimed to reduce wastes, and to continuously utilise the resources [4-8]. Figure 3 previews a diagram of
economic models. Hence, food packaging completely counted in this group should be reusable, recyclable, and finally compostable.

![Diagram of economic models]

**Figure 3.** Renewable packaging linking economic models.

### 4. Sustainable Packaging

Sustainable packaging means the packaging is eco-friendly. Packaging materials used in this type committed to address their impact on the environments and/or minimise their negative impact on the environments. The key characteristics of sustainable packaging totally included compostable, recyclable, and renewable materials. Compostable materials are obtained from natural resources, such as, tree bark, leaves, biological waste (green waste), food scraps (parts of foods are normally unwanted, e.g. eggshells, coffee grounds and seeds), brush trimmings, grass clippings, etc.

Besides, a few facts lead to confuse the terms of compostable and biodegradable materials in the marketplaces. In fact, a difference between them is that biodegradable materials are not necessarily compostable and have ability to decompose through microbial activities [4-8]. In contrast, compostable materials are always biodegradable in enough periods in the conditions of composting process. Figure 4 depicts clearly a difference of both materials.

![Virtual sign of compostable and biodegradable materials]

**Figure 4.** A virtual sign of compostable and biodegradable materials.

Recyclable material is an inversion of waste materials into a new material and object. In this case, it is an alternative way to reuse material rather than throwing them away. For example, recyclable materials include metal, glasses, papers, cardboard, and electronics. In addition, reusable material is reuse and/or reprocessing of waste materials, which is being met the criteria for chemical or physical characteristics, concentration, and quantity. Figure 5 demonstrates a practical sign of both materials.
Figure 5. Symbols of sustainable, recyclable and reusable materials, respectively.

The principle of sustainable packaging was previously mentioned. In fact, sustainable packaging is in part of logistics in business administration and processes. It believed that business successfully addresses environmental concerns linked to a sustainable packaging system. Therefore, there are 8 criteria economically characterised the life cycle of packaging in a closed-loop system [8]. The flows of packaging activities provide economic benefits through its life cycle, as shown in Table 1.

Table 1. Definition of sustainable packaging

| Criteria* | Details |
|-----------|---------|
| 1         | Meets the market standards for cost and performance. |
| 2         | Physically designed to optimize the usages of energy and materials. |
| 3         | Optimizes the usages of recyclable and/or renewable or source materials. |
| 4         | Made from the materials healthy through the life cycle. |
| 5         | Manufactured using the best practice, and clean production technology. |
| 6         | Manufactured, transported, recycled, and sourced, using renewable energy. |
| 7         | Efficiently utilized and recovered in biological and/or industrial closed-loop cycles. |
| 8         | Safe, healthy, and beneficial for community and individuals through its life cycle. |

*Ranking is impliedly ordered to the criteria.

5. Key Shape of Food Packaging

Food packaging shape was designed and created from simple mathematics geometries, as well as, information on sensory elements [9]. Materials used to create food packaging are also impact on the design. Present investigation classified packaging shapes into two categories namely are food-preservation (f-preservation) and food-freshness (f-freshness). These two types depend on economic factors, logistics and business processes. The f-preservation is easily seen in mass production, such as, canned tunas, canned foods, boxed cereals, and a bag of chips. In contrast, the f-freshness is normally man-made, and often its shape is non-uniform, and changing using sensory elements. Figure 6 demonstrates food packaging shapes and its binary images (bottom row) retrieved from digital image analysis. As a result, this primary data is an input for automatic detection of food packaging in logistics process.
Figure 6. A key shape of food packaging; (left to right), f-preservation consisted of, cylinder, square, and rectangle; lastly, non-uniform is a shape of f-freshness.

6. Discussion
This research demonstrates that food packaging materials and its shapes depended on global context and policy in environmental management and business administration. Results of a practical review improve our understanding of data trends in food packaging, which could lead to sustainable development and environmental recovery. It can be predicted that smart/intelligent packaging is digital data and electronics-based businesses. Innovation and technology in packaging field will serve the consumers to perceive real-time data monitoring of food freshness and quality inside the packaging itself. Natural resources are key ingredients to create sustainable materials. Basically, this review results pointed out that compostable materials are alternative replacement of plastics. For instance, corn, cassava and coconut are natural ingredients to manufacture compostable materials. Recent review previews that researchers showed compostable materials can obtain from cassava and coconut wastes [10]. They utilised food wastes using biological techniques to prototype a bioplastic. In consequence, their outcomes can create biodegradable injection-moulded and bio-based packaging products. Moreover, manufacturers must provide further information on food packaging materials relating to environmental problems and types of materials (e.g. using texts/logos from Figure 3, 4 and 5). There are a few limitations that should be addressed. This work is a review to describe key concepts in modern packaging integrating sustainable materials, and is an individual attitude research on food packaging. Lastly, this work is a primary data for artificial intelligence in logistics.

7. Conclusion
This investigation conducted reviews of research on characterisation of natural, renewable and sustainable materials connecting smart food packaging and its shapes. There is a direct influence of business administration and environment strategy in food packaging production. The results of this analysis indicate that compostable materials can be replaced plastics. Intelligent food packaging is digital information and electronics-based technology and innovation. Sustainable materials address environmental issues to reach sustainable development goals. Further research based on automatic classification of packaging shapes in logistics to enhance business model of food production admin

Acknowledgments
This research was supported by CMU Junior Research Fellowship Program. The author gratefully acknowledges the funding.

References
[1] Topuz F and Uyar T 2020 Antioxidant, antibacterial and antifungal electrospun nanofibers for food packaging applications Food Res. Int. 130 108927.
[2] Kalpana S, Priyadarshini S R, Maria Leena M, Moses J A and Anandharamakrishnan C 2019 Intelligent packaging: Trends and applications in food systems Trends Food Sci. Technol. 93 145-157.
[3] Madhusudan P, Chellukuri N and Shivakumar N 2018 Smart packaging of food for the 21st century – A review with futuristic trends, their feasibility and economics Mater. Today Proc. 5 21018-21022.
[4] Information on https://eea-greens.eu
[5] Information on https://www.smethailandclub.com
[6] Information on https://www.trendhunter.com
[7] Information on https://sustainablepackaging.org
[8] Information on https://www.packagingnews.co.uk
[9] Gunaratne N M, Fuentes S, Gunaratne T M, Torrico DD, Francis C, Ashman H, Viejo C G and Dunshea F R 2019 Effects of packaging design on sensory liking and willingness to purchase: A study using novel chocolate packaging. Helio
[
1] on 5 e01696.
[10] Chotiprayon P, Chaisawad B and Yoksan R 2020 Thermoplastic cassava starch/poly (lactic acid) blend reinforced with coir fibres Int. J. Biol. Macromol. 156 960-968.