Green packaging for durable engineering products in Iraqi markets

Luma A. H. Al-Kindi and Zainab Al-Baldawi
Department of Production Engineering and Metallurgy, University of Technology, Baghdad, Iraq
E-mail: 70213@uotechnology.edu.iq

Abstract. Packaging plays a significant role in the environmental influence of a product and packaging combination. The distribution and transportation around separate places in different times of the produced goods lead to packaging development. Nowadays supermarkets and shops focus upon modern expressive packaging for link connection between consumption and production. An extensive variety of materials is often used for packaging applications; such as glass, metal, wood, paper, ceramics, plastics or a combination of two or more materials as composites. The fourth source of pollution in China is due to the packing waste; this is one of the reasons that cause the development of green packaging in the packaging industry in many developed countries. In this paper Green packaging for durable engineering products is studied highlighting the four R’s; Reducing, Recovering, Recycling and Reusing material for sustainable packaging toward choosing an ecological package material and standardization of packaging for waste reduction. The research methodology takes into consideration three main factors categorization; these are eco-material selection, minimize waste and minimize cost, and then a choice is decided upon ten factors for assessment by applying analytical hierarchy process technique (AHP). A case study in Iraqi industrial companies is accomplished taking into consideration experts’ opinions for different affecting factors to compare different packaging materials and styles for green packaging. AHP is applied according to the predefined steps using excel sheets for calculations and plotting. Based on AHP assessment and discussion the choice is for Cartonas the most preferable green packaging material, followed by plastic.

1. Introduction
Waste disposal is a serious issue that faces any community and government where a lot of considerable amount of different wastes is generated, when consumers buy and use products [1]. Recently, The production and development of products in a more sustainable way has received special attention, the packaging materials range from single materials with simple designs and the complex ones that include different materials (woody, cardboard, boards, plastics, paper and others) [2]. The durable products such as refrigerator, oven, freeze always are being packaging using various materials for protective the product from damages during distribution and storage and other many reasons like; providing information about the content of the product to consumers, influencing consumers’ purchase decisions and contributing to loyal customers creations, build a brand, and differentiate for competitors in addition to advertising function. The Packaging decisions can have an important impact on sales [3]. The Packaging materials are manufactured from various materials, like; plastic, paper, cardboard, wood, metal, polymer, composite mixed material and other materials, these materials may consider waste and cause environment problem after customers received their product, so the industry continuously searches for solutions to decrease the environmental impact of the packaging materials, like lightweight of packaging, minimum size, environmental friendly packaging materials and, most importantly are sustainable[4]. Packaging can be defined as the covering materials that manufacturing from various materials to use it for containing, protection, handling, delivery and presentation of the goods from raw materials to finished products, from manufacturers to consumers [5]. The sustainable packaging is spread as a new concept with increase the environmental awareness to meet market expectations for
people and society, health, useful, safe, and cost effective throughout its life cycle [6]. Most scientific sources classify the types of the packaging into three categorize; primary, secondary and tertiary packaging, and other extended to more types like group, display, transport, retail and used packaging as illustrate in Figure 1 [7].

| Packaging type | Definition |
|----------------|------------|
| Primary packaging, consumer packaging or sales packaging | Packaging which is in contact with the product. The packaging that the consumer usually takes home is designed to contain several primary packages |
| Secondary packaging | Used when a number of primary or secondary packages are assembled on a pallet or roll container |
| Tertiary packaging | Packaging which is conceived to facilitate protection, display, handling and/or transport of a number of primary packages |
| Group packaging | Packaging which is conceived to facilitate protection, display, handling and/or transport of a number of primary packages |
| Transport packaging, industrial packaging, or distribution packaging | Packaging which is conceived to facilitate handling, transport and storage of a number of primary packages in order to provide efficient production and distribution as well as prevent physical handling and transport damage |
| Display packaging | Same as group packaging, quite often with an emphasis on display features |
| Retail packaging | Same as group packaging with a special emphasis on the design to fit in retail |
| Used packaging | Packaging/packaging material remaining after the removal of the product it contained |

Figure 1. The packaging types [7]

Nowadays, a broadly range of materials are used for the product packaging purpose like plastics, paper, wood, foam polymer, wood and composites. The paper packaging like carton boxes is easy to print on, a very effective and versatile packaging media and provide protection against breakage and contamination and easy to collect. It is fully recyclable material. The majority of plastic in packaging are thermoplastic organic polymers; plastic to be used in packaging are foils form (≤ 0.2 mm thick), or sheets (≥ 1 mm). Foils packages are used with flexible wall like bags, and for rigid wall packages sheets are used. The character of plastics used packaging is significant. Plastics denote 20% by weight for all packaging materials and are used to package 53 percent of all products. Wood is largely used in two form; crates and pallets. Pallets are a worldwide and serious part for the transportation of product. Composite is a combination of materials used to enhance the content protection. The composite usage has economic and technological advantages. Degradable Plastics is a useful disposable plastic and it is considered continues sustainment of life. It is designed to be lightweight and can be degraded and break down into basic under environmental conditions in waste disposal systems. The foams are a low-cost, moldable, synthetic polymer used to create components for automobiles and household appliances like refrigerators and microwaves so these industrial applied plastic foams highly grow the packaging waste volume. [8]

The packaging materials waste caused pollution to the environment and a hazard to health of both humans and animals, figure 2 illustrates the amount of waste in different countries.
Figure 2. Packaging waste generation in different countries [2]

Currently, many ways and techniques are available to deal with the removed packaging material after the durable product delivery to customers namely: reduce, reuse, recycle, recovery, Reclaim and Degradable. Reduce deal with minimizing if it allows the amount of packaging material both by reducing the weight (the product-to-package weight ratio) and minimizing the size. Reusing packaging materials will absolutely reduce the impact generated by the packaging as waste; Recycling is an essential part of the strategy of the sustainable packaging. Using materials with recycled content is sometimes cheaper than using virgin materials [9]. Reclaim, or recyclable means using waste of packaging combustion for obtaining new energy sources, without producing secondary pollution. Recycling of packaging waste produces renewable products, such as using of thermal incineration, composting and other measures to improving land condition, to attain reuse purposes [10]. Figure 3 illustrates the conversion ways the packaging waste to new item. Degradable is the ultimate packaging waste that cannot be reused, and it should be able to degrade, corrupt and do not form a permanent waste [10].

![Figure 3](image_url)  
Figure 3. The process of converting waste into new product [11]

Many methods for evaluation the sustainability of packaging system and materials is established and may be classified as qualitative and quantitative method. The use of earlier mostly contains interview inquest or questionnaire and the later mostly contains Life Cycle Assessment (LCA) or Analytic Hierarchy Process (AHP) [12].

2. Literature review

Many researchers studied the packaging material form environmental and sustainability point view, Eva Pomeracs (1998) studied and analyzed the effects of packaging on the environment for making a holistic view, this study is taking into account: the ecological, the technological, economic, legislative and social aspects and it is asserted that packaging plays an important role in sustainable development [13]. Susan Parra (2008) illustrated how the selection of packaging material plays a key role in developing industrial sustainable practices. It is evaluated the selection of materials importance during the design process of packaging and emphasis on the effects of the material decisions during the package life cycle [9]. Meneses, Montse et al. (2009) performed a case study using A life cycle assessment (LCA) to analysis and calculate environmental effect of various packaging materials (glasses, cans, plastics, tetra brick) with sizes (200 mlits., 1 lit., 5 lits, …etc.), to a local product (beverage). Additionally, dual
final disposal types namely, recycle and landfill are compared to assess the environment effect of each one [14]. Büsser S et al. (2009) evaluated the packaging’s environmental performance of different packaging materials and LCA is used to study the recycling or treatment of packaging wastes [15] Zhang G (2012) studied the green packaging principles in the form of government and establishments levels and suggested a specific strategy for management [10]. Zekiri J et al. (2015) studied the consumer’s buying behavior for finding out the most significant factors which have an effect and impacts consumer’s purchase decision that lead to success the brand in addition to identify the relationship between selected independent variables such as packaging material, packaging color, printing information, brand image, wrapping design, and innovation and realism that help clients in their decision purchasing process with the main variable namely, consumer buying process[16]. González-García S. et al. (2016) suggested a methodology that applies an environment criterion to develop a product and apply Design for Environment in the Eco design of packaging products where a wooden storage box is evaluated. Dissimilar types of materials, like plywood, timber, processed wood, brads, plastic, hood, or staple, may be taken into consideration in the production process, the final finding point out the importance of the raw materials selected, and their source, can impact the related environmental burdens, that may likewise be confirmed by LCA quantitatively [2]. Radhakrishnan S (2016) pointed out that many retailers and manufacturers use of excessive packaging. Reduce, reuse, and recycle are apparatuses that can use to reduce the harmful implications of engineering and deal with the environment. Challenges that face environment conscious production concepts; considering reuse and recycling for packaging, and the trends in green packaging. Challenges about waste may be different in different countries [1]. Magnier L. et al. (2017) illustrated that color and the material effect perceptions of packaging environment friendliness when the environment claim is either revealed on the package or absent from and tested the effects of the environmental claim and style elements on the assessment of social obligation for the brand also on inferences of product environment-friendliness [17]. Xie Y et al. (2019) suggested a routine depends the three-stage network Data Envelopment Analysis (DEA) to assess the product packaging systems sustainability for choosing a better product packaging options according to environmentally friendly point of view depending the following four steps: (i) defining (PSI) as a package sustainable indicator (PSI) (ii) to model a three-stage Network DEA model for the packaging system, (iii) to compute PSI depending the DEA model (iv) calculate result examination. Empirical test is performed for proving the feasibility of the suggested routine to select the three styles of milk packaging systems. This study provides an environmentally friendly evaluation method for product packaging systems, which is more intuitive than Life Cycle Assessment (LCA) [12]. Pauer E et al. (2019) proposed methods and a methodological framework to estimate the environmental sustainability for food packaging. The projected frame identified 3 sustainability features for food packaging, these are, packaging-related food losses and waste, direct environmental effects of packaging and circularity this led to provide a list of environmental performance indicators [18]. Petljak K et al. (2019) investigated the consumer opinion for the significance of food products green packaging using a questionnaire to investigate respondents’ behavior when selecting the food product packaging and the final result, recommend that concern for minimum risk for health and the environment are double key motivations for buying food products in ecologically sustainable packaging. The plaintiffs refer that paper and wood have minimum impact on the environment, but glass and plastic damage the environment [5]. David A et al. (2019) studied and compared the waste in India and in the world to highlight the environmental impacts on health of human and give suggestions for properly disposing the wasted products by recycling without harming the environment [11].

With increasing the awareness about green and sustainable packaging, many researchers studied the product packaging and its impact on environment, but most of them focused on the food packaging more than other products packaging, so this research will investigate and study packaging of the durable products because the continuously technology development and high increase the standard of living lead to increase buying these products that characteristic by highly number and quantity of materials that used for packaging it. So, these lead to create problem of various waste materials related to packaging of these durable products.
3. Packaging Sustainability

Packaging major function is to protect and contain products starting with manufacture, over the supply chain to the marketing store or end consumer. Attracting customers for buying a product to increase sales and providing product information are further important functions. ‘Sustainable packaging’ is packaging that accomplishes this major function besides lowering environmental effect related to the existing or conventional packaging [19].

When discussing packaging sustainability importance according to the views of proper definition, that means the value chain packing, ecological effect, and the value chain of food. Sustainable packaging is supposed to be an equivalent for the sustainably located materials or to enable recovery like recyclability or composites materials, but economic feasibility and social effects may often neglect and causes misleading for consumer communication [20].

Sustainable packaging focus on [21]:
1. Positive, healthy and safe for persons and society during the life cycle
2. Gathering market standards to good performance and budget minimization
3. Obtaining, manufacturing, transportation, and recycling focusing on renewable energy
4. Optimizing the usage of recycled base materials or renewable
5. Manufacture by adopting clean manufacture technology with finest practice
6. Depending material healthy through the life cycle
7. Optimizing materials and energy depending physical design
8. Effective recovering and utilization for biological and/or industrial close loop cycle

Sustainable Packaging Guidelines are central part of the co-regulatory framework by the National Environment Protectio. There are 10 Sustainable Packaging Principles that make up the SPGs, these are [19]:

a. Designing for recover;
b. Optimization of material efficiency;
c. Designing to reduce waste of products;
d. Eliminating hazardous material;
e. Using recycled material;
f. Using renewable material;
g. Designing for minimization of litter;
h. Designing for efficient transportation;
i. Designing to improve accessibility; and
j. Providing consumer information on sustainability.

Figure 4 shows Packaging process toward sustainability.

![Figure 4. Packaging process toward sustainability](Image)

4. Analytical hierarchy process technique AHP

Analytical hierarchy process technique AHP is a multicriteria decision making technique that decomposing the complex problem into a multilevel hierarchical structure, the hierarchical structure explains from the top to the bottom the relationships of the goal, criteria and alternatives [22]. AHP implements the comparisons of pairwise for deriving relative importance of the variable for all level of the hierarchy structure and/or assessment the options at the last level of the hierarchy for making the best decision from these options. It is based on 3 basics: firstly, the model structure; secondly,
comparative ruling of the options and/or criteria; finally, priorities synthesis [23]. An organized way is used to make a decision to generate priorities by decomposing the decision according to the followed steps:

1- Definition the problematic and determination the kind of information required.
2- Build up the hierarchy of the decision from the topmost illustrating the objective of the decision in the first level, then the second level is the objectives using criteria on which subsequent elements depend and the final level usually is a set of the alternatives, a sample is shown in Figure 5.
3- Setting pairwise comparing matrices are constructed. Every component in any higher level is compared with the components in the level directly beneath.
4- Priorities gotten from comparisons are used for weighing priorities in the level directly beneath so, to be done for each component. After that for all components in the level beneath adds its weighed values then calculate its total or overall priority. Continuing the procedure of weighing and adding till the last priorities of the options in the lowest level is gotten [25].

![Figure 5. Hierarchy tree][24]
research. Eight of the considered factors are green besides two key factors are considered due to their importance; these are Package Cost and Local Availability.

For packaging material sustainability assessment the decision tree is constructed depends the ten factors shown in table 1 to choose the most sustainable packaging material alternative, the decision tree is shown in figure 6. The selected packaging material alternative are plastic (Nylon), wood, polymer/Foam and paper (carton); for these packing materials are the most used and available in the Iraqi markets.

Table 1. Criteria factors

| Criteria                          | Symbol | Factors categorization | Green | Factors to be considered in this research |
|----------------------------------|--------|------------------------|-------|------------------------------------------|
| 1 Hazardous                      | H      | 1                      | y     | *                                        |
| 2 Weight to packaging material   | WR     | 2                      | n     |                                          |
| 3 Packaging weight               | W      | 3                      | y     | *                                        |
| 4 Volume (size)                  | V      | 2                      | y     | *                                        |
| 5 Recyclability%                 | RC     | 1                      | y     | *                                        |
| 6 Reuse%                         | RU     | 1                      | y     | *                                        |
| 7 Local Availability             | A      | 3                      | n     | *                                        |
| 8 Safety                         | S      | 1                      | y     | *                                        |
| 9 Manufacturability              | M      | 2                      | y     | *                                        |
| 10 Easiness to use               | E      | none                   | n     |                                          |
| 11 Appearance (colour, shape,    | AP     | none                   | n     |                                          |
| 12 Package Cost                  | C      | 3                      | n     | *                                        |
| 13 Biodegradable and Compostable | BC     | 1                      | y     | *                                        |
| 14 Labelling                      | L      | none                   | n     |                                          |
| 15 Package design                | D      | 2                      | n     |                                          |
| 16 Litter amount                 | LI     | 1                      | y     |                                          |

Figure 6. Decision Tree for sustainability material packaging assessment

Adopting the opinion of exerts committee the Criteria Pairwise Comparison and preferring according to Satti measures is accomplished the results are shown in Table 2 depending the
calculation and results in an Excel sheet designed by the authors for AHP calculations. Satti measures are shown in Table 3.

According to the calculation for Criteria Pairwise Comparison illustrated in Table 2 and the figures exported from the Excel sheet, a plotting diagram is constructed showing the Criteria’s importance in Figure 7.

Accordingly Criteria Importance for each Packaging Material is calculated and the results are shown in Table 4.

### Table 2. Criteria Pairwise Comparison

| Criteria | H | W | V | RC | RU | BC | A | S | M | C | Total | Average |
|----------|---|---|---|----|----|----|---|---|---|---|-------|--------|
| H        | 0.10 | 0.12 | 0.11 | 0.21 | 0.20 | 0.27 | 0.07 | 0.14 | 0.03 | 0.03 | 1.28 | 0.128  |
| W        | 0.05 | 0.06 | 0.03 | 0.05 | 0.05 | 0.07 | 0.07 | 0.14 | 0.06 | 0.03 | 0.61 | 0.061  |
| V        | 0.05 | 0.12 | 0.05 | 0.05 | 0.03 | 0.07 | 0.07 | 0.03 | 0.03 | 0.03 | 0.55 | 0.054  |
| RC       | 0.05 | 0.12 | 0.11 | 0.11 | 0.10 | 0.14 | 0.07 | 0.14 | 0.13 | 0.13 | 1.08 | 0.108  |
| RU       | 0.05 | 0.12 | 0.16 | 0.11 | 0.10 | 0.07 | 0.07 | 0.14 | 0.13 | 0.19 | 1.13 | 0.113  |
| BC       | 0.05 | 0.12 | 0.11 | 0.11 | 0.20 | 0.14 | 0.29 | 0.14 | 0.13 | 0.19 | 1.46 | 0.146  |
| A        | 0.20 | 0.12 | 0.11 | 0.21 | 0.20 | 0.07 | 0.15 | 0.14 | 0.19 | 0.13 | 1.50 | 0.150  |
| S        | 0.05 | 0.03 | 0.11 | 0.05 | 0.05 | 0.07 | 0.07 | 0.07 | 0.13 | 0.19 | 0.81 | 0.081  |
| M        | 0.20 | 0.06 | 0.11 | 0.05 | 0.05 | 0.07 | 0.05 | 0.03 | 0.06 | 0.03 | 0.72 | 0.071  |
| C        | 0.20 | 0.12 | 0.11 | 0.05 | 0.03 | 0.05 | 0.07 | 0.02 | 0.13 | 0.06 | 0.84 | 0.084  |
| Sum      | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

### Table 3. Satti measures

| Preference Level | Equally preferred | Equally to moderately preferred | Moderately preferred | Moderately to strongly preferred | Strongly preferred |
|------------------|-------------------|-------------------------------|---------------------|---------------------------------|-------------------|
| Numerical Value  | 1                 | 2                             | 3                   | 4                               | 5                 |
| Preference Level | Strongly to very strongly preferred | Very strongly to extremely preferred | Extremely preferred |                                |                    |
| Numerical Value  | 6                 | 7                             | 8                   | 9                               |                    |
Calculation of CI Consistency index is performed according to AHP steps and the results of Eigenvalue $\lambda$ is shown in table 5. CI is equal to (average-n) divided by (n-1). Then to calculate the ratio of CI/RI, random index shown in table 6 is adopted depending $n=10$ and RI=1.51.

Calculation of CI is shown in table 7, where CI/RI=0.09 which means that the criteria is fair and accepted.

**Table 4.** Criteria Importance for each Packaging Material

| Criteria    | H  | W  | V  | RC | RU | BC | A  | S  | M  | C  |
|-------------|----|----|----|----|----|----|----|----|----|----|
| Plastic     | 1.46| 0.93| 1.16| 0.83| 0.65| 0.68| 1.42| 0.88| 1.05| 1.77|
| Polymer/Foam| 1.16| 0.74| 0.61| 0.55| 0.23| 0.44| 1.03| 0.51| 1.12| 0.86|
| Wood        | 1.58| 0.28| 0.48| 0.20| 1.19| 0.18| 0.38| 0.18| 0.49| 0.21|
| Cartoon     | 0.22| 1.33| 1.23| 1.69| 1.22| 1.97| 0.49| 1.70| 0.67| 0.44|

**Table 5.** Calculation Eigenvalue $\lambda$

| Criteria          | Criteria Calculation | Criteria Calculation /Average |
|-------------------|----------------------|--------------------------------|
| Hazardous         | 1.41                 | 10.99                          |
| Packaging Weight  | 0.69                 | 11.21                          |
| Volume (Size)     | 0.60                 | 10.93                          |
| Recyclability%    | 1.21                 | 11.22                          |
| %Reuse            | 1.28                 | 11.33                          |
| Biodegradable and Compostable | 1.64 | 11.20 |
| Local Available   | 1.70                 | 11.32                          |
| Safety            | 0.94                 | 11.57                          |
| Manufacturability | 0.82                 | 11.40                          |
| Cost              | 0.96                 | 11.37                          |
| **Sum**           | **112.56**           |                                |
| **Average (Eigenvalue $\lambda$)** | **11.26** |
Table 6. Random Index (RI)

| n  | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| RI | 0.58| 0.90| 1.12| 1.24| 1.32| 1.41| 1.45| 1.51|

Table 7. The CI calculation

| Calculation CI | CI/RI<0.1 |
|----------------|-----------|
| CI             | 0.14      |
| RI             | 1.51      |
| CI/RI          | 0.09      |

6. Results, Discussion and Conclusion

The evolution of choosing the most suitable green packaging materials depends on many important factors; some of these factors could be defined as green factors. Many factors that are affecting on the packaging material are studied in literatures; its impact differs according to each case. In this work sixteen factors are named; but only ten of them are chosen to be studied and subjected to their influence on its usage as packaging materials. AHP is adopted to assist in analysing and taking appropriate decision according to mathematical calculation and scores. Criteria Pairwise Comparison and related calculations depending AHP which are mentioned in table 2 according to the Decision Tree for sustainability material packaging assessment, Criteria’s Importance is plotted in figure 7. Descending Criteria’s importance is demonstrated graphically in figure 8 which is plotted according to the calculated scores. According to the calculated criteria importance factor’s sequence starts with Local availability as the most affecting factor followed by Biodegradable and Compostable, then Hazardous, Reuse, Recyclability, Package Cost, Safety, Manufacturability, Packing Weight and Packing volume sequentially. This descending matter shows the most affecting factors for sustainability material packaging assessment and the selection of the four packaging material adopted in this work.

![Importance of Criteria](image)

**Figure 8.** Descending Criteria’s Importance

In accordance with experts committee opinion and following Satti measures, the importance of each of the ten factors for the four packaging material under study are verified. Ten tables are formed, then the weighted value is considered then normalized and their relative weights are calculated in order to adopt a fair decision about the most appropriate packaging material. These multi stage calculations are according to AHP steps and by using the Excel sheet for the relation of the criteria importance factors.
and the four packaging materials. CI/RI is calculated depending Average (Eigenvalue λ) for n=10 and the Random Index (RI) to insure that the criterion is fair and accepted and it was 0.09 which prove the criteria’s fairness for it is less than 0.1. Criteria Importance for each Packaging Material is demonstrated and the results show that Plastic and Carton has the same score (1.08) as shown in figure 9. These scores indicate that these packaging materials are preferable according to packaging material sustainability assessment; followed by foam and then wood.

Another point to be noticed in this assessment and according to the scores in table 4; carton has the maximum scores for six factors of ten i.e. 60%. Maximum scores for carton are noticed with Packing Weight, Packing volume, Recyclability, Reuse, Biodegradable and Compostable and Safety. All these factors are indicated as green in table 1, and four of them are categorized as eco-material selection. While plastic has maximum scores for only two factors i.e. 20%; these factors are Local availability and Package Cost. These two factors are not indicated as green in table 1, but they are categorised as minimize cost. Wood has the maximum scores for only one factor; it is Hazardous i.e. 10%. Polymer/foam also have the maximum scores for only one factor; it is Manufacturability i.e. 10%. Accordingly carton material is the most preferable green packaging material for durable products even it has the same scores with plastic. Therefore; based on AHP assessment and discussion taking into consideration green affecting factors Carton is the most preferable green packaging material, followed by plastic. For future work Life cycle assessment LCA could be further applied for green packaging material sustainability assessment as another tool for decision making.

![Assessment the Sustainability of Packaging Materials](image_url)

**Figure 9.** Ranking the Sustainability of Packaging Materials

### References

[1] Radhakrishnan S 2016 *Environmental Implications of Reuse and Recycling of Packaging* Environmental Footprints of Packaging, (Singapore –Verlag:Springer) 1: pp165-192

[2] González-García S, Sanye-Mengual E, Llorach-Masana P, Feijoo G, Gabarrell X, Rieradevall J and Teresa M M 2016 *Sustainable Design of Packaging Materials* Environmental Footprints of Packaging (Singapore –Verlag:Springer) 1: p23-46

[3] Kutz M 2007 *Environmentally Conscious Materials and Chemicals Processing* (Canada: John Wiley )

[4] Varun, Sharma A, Nautiyal H 2016 *Environmental Impacts of Packaging Materials* Environmental Footprints of Packaging, (Singapore –Verlag:Springer) 1: pp 115-37

[5] Petljak K, Naletina D and Bilogrević K 2019 Considering Ecologically Sustainable Packaging During Decision-Making While Buying Food Products *Econ. of Agric* 66:pp107-26
[6] Eker B, İçöz A 2016 *Packaging Materials and Effects on Quality of Life* 1st International conference on Quality of Life (Center for Quality, Faculty of Engineering, University of Kragujevac, Serbia)

[7] Dellis G 2016 *Green Packaging* (Greece -Thessaloniki: School of Economics Business, MSc)

[8] Colton K, Harmer C, Isom B and William F. Shughart 2018 *Plastic Pollution Bans vs. Recycling Solutions* Independent Institute Briefing

[9] Parra S 2008 *Guidelines for Material Selection for Sustainable Packaging Solutions, theses* (New York:Rochester Institute of Technology).

[10] Zhang A and Zhao Z 2012, *Green Packaging Management of Logistics Enterprises* International Conference on Applied Physics and Industrial Engineering Phy. Proc. 24: pp900 – 5

[11] Arokiaaraj D, Thangavel Y and Sankriti R 2019 Recover, Recycle and Reuse: an Efficient Way to Reduce the Waste *Int. J. of Mech. and Prod. Eng. Res. and Dev.*, 9(3):31-42

[12] Xie Y, Gao Y, Zhang S, Bai H and Liu Z 2019 Sustainability Evaluation of Product Packaging System with a Three-Stage Network Data Envelopment Analysis Methodology *Appl. Sci* 9(2) p 246

[13] Pongrácz E 1998 *The Environmental Effects of Packaging,theses* (Finnish Tampere: University of Technology, Department of Environmental Technology, Institute of Environmental)

[14] Meneses M, Pasqualino J and Castells F 2009 The sustainable consumption of domestic products: the environmental effect of packaging Rev. *Inter.Sost., Tecnología y Humanismo* 4:pp185-90

[15] Büsser S and Jungbluth N 2009 The role of flexible packaging in the life cycle of coffee and butter *Inte. J. Lif. Cyc. Asse.* 14: pp 80-91

[16] Zekiri J and jolca V H V 2015 The Role and Impact of the Packaging Effect on Consumer Buying Behaviour *Ecof.* 4

[17] Magnier L and Schoormans J 2017 How Do Packaging Material, Colour and Environmental Claim Influence Package, Brand and Product Evaluations *Packag. Technol. Sci* (wileyonlinelibrary.com, DOI: 10.1002/ppts.2318)

[18] Pauer E, Wohner B , Heinrich V and Tacker M 2019 Assessing the Environmental Sustainability of Food Packaging: An Extended Life Cycle Assessmentincluding Packaging-Related Food Losses and Waste and Circularity Assessment *Sust.* 11 p 925

[19] Sustainable Packaging Covenant Orginazation APCO 2020 *Sustainable Packaging Guidelines SPCs*

[20] Boz Z, Korhonen V and Koelsch Sand C 2020 Consumer Considerations for the Implementation of Sustainable Packaging: A Review *Sust.* 12 p 2192 (doi:10.3390/su12062192V2)

[21] Green Blue 2011 *Definition of Sustainable Packaging Sustainable Packaging*

[22] Bäuuyükýaz M and Sucu M 2003 The Analytical Hierarchy and Analytic Network Processes *Hac. J. of Math. and Stat.* 32 p 65 – 73

[23] GÖRENER A 2012 Comparing AHP and ANP: An Application of Strategic Decisions Making in a Manufacturing Company *Inte J. of Bus. and Soc. Scie* 3 p194-208

[24] Taherdoost H 2017 Decision Making Using the Analytic Hierarchy Process (AHP): A Step by Step Approach *Inte. J. of Eco. and Manag. Syst.* 2

[25] Saaty T 2008 Decision making with the analytic hierarchy process *Int. J. Serv. Sci.* 1 p 83-98

[26] Goossen J *Environmental impact of packaging Multiple functions of packaging*