Packaging optimization in supply chain

The main role of food packaging is to protect the product and to prevent food losses. Also, packaging has to match consumer demands with different portion sizes and promote the product itself. Therefore, it should provide protection against theft, make logistics more efficient and preserve product's quality. All of the packaging steps should be achieved with minimum amounts of resources. Due to this, producers decide to optimize packaging using different methods and concepts [11].

The objective of the paper is to present packaging optimization methods, the Precision Packaging Concept developed by VTT Technical Research Centre of Finland, and to identify the opportunities related to the optimized packages in food supply chain. Additionally, all types of barriers were distinguished and classified.

Optimum Pack Design

The main method of packaging optimization is packaging weight reduction, however this process has its limits as the optimum quantity of packaging material is needed to ensure product protection [8]. Due to this, in the analysis of the packaging costs and in search the optimum solution, the following packaging perspectives should be considered [2]:

- **overdesigned packaging** – when a too high level of protection is provided to packaging design. In this case, there is possibility to reduce the cost of some of this protection.
- **underdesigned packaging** – when the level of product protection is too low. In this situation, it is necessary to design the product to provide higher level of protection, which will cause the higher increase in packaging cost. However, the cost in packaging protection will effect in less product damage, which finally will lead to decrease of total cost.

The optimum quantity of material usage in the packaging that ensure the most sustainable balance between reducing wastage or resource loss of the product and reducing packaging is presented by Innventia AB model in figure 1. [11]. The Innventia diagram was taken as a starting point by two global projects (ISO and GPPS) with the aim of creating new rules for the environmental packaging evaluation [9]. The model indicates that the environmental consequences of product losses caused by excessive reduction of packaging are far greater than guaranteeing adequate protection through an incremental excess of packaging. It should be pointed out, that overpacking by 10% means that 10% of the resources needed in packaging and transport are unnecessary, i.e. wasted. However, when it is 10% of underpacking, the result may be a packaging failure and 100% waste of resources [15].
Finding the balance between food underpacking and overpacking is a very crucial area for producers, and that is why there are varied concepts presented in the literature which help to design optimized packaging. One of these concepts is the VTT Precision packaging Concept developed in the Technical Research Centre of Finland [1].

### VTT Precision Packaging Concept

VTT Precision Packaging Concept, presented in figure 2, is a unique tool used to design efficient, cost-effective and functional packages which sway consumers to buy a product. Basics elements of this concept are logistics, market-driven thinking and required shelf-life [1, 10].

![Fig. 2. The Precision Packaging Concept developed by VTT Technical Research Centre of Finland](Source: [1].)

The concept stresses the importance of environmental issues and packaging process cost effectiveness. That is why these areas are included in the model with the following factors [1]:

- covering the performance in logistics,
- costs,
- environmental stresses,
- marketing properties,
- consumer convenience.

One of the most important role of the food packaging is to provide protection from environmental conditions. Therefore, the packaging should have sufficient mechanical strength and barrier properties to be able to protect the product during distribution and storage, i.e. should covert the performance in logistics. Downsized package has not only influence on environmental issues but also on total costs. What is more, in the packaging selection process the package dimension should be considered wisely in order to fit the secondary package and pallet [1].

In order to optimize storage space, the container shape should also be analyzed. The palletization could be improved by 25% over if the producer decided to use square-round containers instead of equivalent-capacity cylindrical package. In this case, the change of packaging shape has influence on the total production costs. However, in some situations the compromise between savings and shapes should be considered wisely, as a standard, square packaging shape could not sway the consumers to buy the product. Therefore, both low productions costs and shelf appeal should be combined [13].

Optimized packaging refers also the adaptation to a specific distribution channel and packaging system which includes primary, secondary and tertiary packaging [8]. It can be done by using modular sizes for consumer and transportation units [3].

In terms of packaging costs, the manufacturer focuses on packaging materials and the cost related to storage, transportation, labor and energy consumption, as they should be at the lowest possible level. What is more, on the competitive market, the costs of innovation should also be added to the total cost of packaging as they can distinguish the product amongst the others. Changes in packaging material, weight and volume of packages have crucial influence on the environmental aspect as, for instance, they cause reduction in energy consumption [15].

Consumer convenience is an important part of the packaging design process. Packages, depending on the purpose and the packaged product, should have properties which, for instance, help consumer to handle it, carry or store at home and do not degrade when opened. Finally, marketing properties are related to keeping up the brand image of a product which should be
taken into consideration during the packaging design process. They should be fulfilled as well as necessary, not as well as possible [1].

The VTT Concept based on mathematical modeling to determine the minimum package requirements and it is performed in the following steps [1]:
- factors and responses selection,
- experimental design method selection,
- tests running,
- results analysis,
- shelf-life predictions process,
- minimum package requirements determination.

One of the examples of increasing sustainability by changing the packaging design is the package of “Great Value” yogurt (fig. 3). The characteristics of original and re-designed packaging were presented in table 1.

![Fig. 3. Packaging of yogurt before and after changing design](source: [4])

Due to cube shape, the re-designed container is more efficient and 31% lighter as a lesser quantity of plastic is used. Additionally, Multi-Pack Format caused reduction in labor costs at stores. By the use of the Form, Fill & Seal system (FFS) instead of preformed packaging, the manufacturer obtained 200,000 more cups per pallet. According to internal Walmark research, the new packaging also has influence on the reduction of lid weight by 50% [4]. All in all, business results of the new packaging were [4]:
- in inbound materials:
  - primary package material savings: 31%,
  - freight savings: 60%.
- in outbound products:
  - operational savings>30%,
  - freight savings: 28%,
  - pallet savings $90,000.

<table>
<thead>
<tr>
<th>Material</th>
<th>Original packaging</th>
<th>Re-designed packaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cups origin</td>
<td>shipped to plant</td>
<td>“stamped” at Yogurt plant</td>
</tr>
<tr>
<td>Shape</td>
<td>Circular</td>
<td>Cube</td>
</tr>
<tr>
<td>Sales unit</td>
<td>Individual</td>
<td>Multi-pack format</td>
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Source: [4].
Packaging optimization advantages and barriers

Packaging optimization can lead a producer to crucial savings, increase in competitive position and at the same time protect the consumers. As it is presented in the paper, amongst other advantages, efficient and optimized packaging minimizes resource consumption and provides economic, social and environmental benefits such as resource costs reduction, increased supply chain efficiency, more affordable products, reduces weight or volume and product waste [15].

In case of savings in supply chain, the packaging adaptation helps in transport and storage by using fewer vehicles. To manage the shipping, the companies could use programs, for instance Algorithm for 3D Box packing. This kind of programs can be a great opportunity for obtaining significant increase in company efficiency [7].

Amongst other methods of competing for consumers through extended product shelf life, the active and intelligent packages should be distinguish as they help to substantially reduce product losses and control product quality. Some of the devices for monitoring quality are in the firm of labels or tags [6]. Additionally, as a part of packaging, the RFID tags or holograms can be applied in order to prevent product counterfeit and protect the brand [1, 12].

However, the packaging optimization process is a very complex one. Therefore the following potential barriers should be considered [14]:
- economics,
- market,
- technological,
- knowledge,
- environmental,
- social,
- legislation and regulation.

One of these are economic barriers, which are connected with the increase of investment costs caused by changing the existing packaging line. Due to high expenses lead to inertia in technological developments within the packaging industry. Another factor which has influence on packaging optimization are market barriers related to market mechanisms and anticipated profit margins, as a large fraction of packaging is determined by the material price. In case of the use of innovative material or those under development, e.g. bio-plastic, the price is higher than the price of conventional materials considered [1, 14].

Technological barriers are downstream and upstream in the supply chain. Downstream barriers are related to quantity limiting, potential end-markets and complications in packaging material recycling. Second barrier, upstream, should be analyzed from two sides: one, in which additional packaging material is inevitable for instance due to oxygen required for the product and from the second- optimization opportunities are considered difficult. Also, legislations and regulations concerning packaging have a large range. Complication could be created, for instance, by international legislations and standardizations which, all in all, can lead to considerable overpacking [14].

Next barrier are knowledge difficulties considered as lack of communication along the supply chain and limited understanding of packaging specifications which can lead to an inability to identify and adopt crucial changes that support innovation in the packaging sector.

Environmental barriers: In some cases, high source reduction in packaging can have influence on the entire energy balance. Wastage of the product and increased environmental damage may be caused by not fulfilling the packaging core functions, for instance shelf-life, transport and high-speed filling. Although the packaging waste is perceived as a negative environmental aspect of packaging which is related to social barriers, it still remains an inferior concept for consumer products in terms of hygiene and convenience. According to Marsh and Bugusu, consumers do not perceived increased material intensity as an environmental problem as they justified this action as a requirement of good quality and luxury [1, 14].

Although the barriers in some situations can block the development of new, optimized packaging designs in the first place, the advantages are packaging optimization credit.

Conclusions

The main role of food packaging is to protect the product, however, in the competitive market, all of the packaging functions should be achieved with minimum amounts of resources. Due to this, producers decide to optimize packaging using different methods and concepts.

The Innventia AB system and VTT precision Packaging Concept can benefit the packaging industry by providing help in packaging optimization in food industries as they take into account the demands of logistics, cost savings, shelf-life requirements and competitiveness. As an example shows, the changes in packaging based on these concepts can lead to better financial and environmental results.
As the paper presents, packaging optimization can lead a producer to crucial savings, increase in competitive position and at the same time protect the consumers. However, as the optimization in packaging is a very complex process, the barriers and obstacles should be taken into account in order to obtain new, efficient and optimized packaging.

Abstract

The main role of food packaging is to protect the product, however, in the competitive market, all of the packaging functions should be achieved with minimum amounts of resources. Due to this, producers decide to optimize packaging using different methods and concepts.

The objective of the paper is to present packaging optimization methods, the Precision Packaging Concept, and to identify the advantages related to the optimized packages in supply chain. Additionally, barriers faced by manufacturers during new packaging project implementation were distinguish.

REFERENCES