MANAGEMENT AND SAFETY IN FOOD CHAIN

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CONTENTS

INTRODUCTION

We give you a scientific monograph, which is the result of the International Conference on Production and Packaging Management (ICPM-PP2016), entitled Management and Safety in the Food Chain.

The issues presented in monographs characterize the universality and relevance of the topic, dictated by the great interest of society and the changing conditions, including trends and legal norms. Food saf

ety management is also an area with many barriers to functioning, including the ability to recreate the history of a food product or the process of food counterfeiting. Food is a very responsible business subject for all participants in the food chain, from primary producers and ending with the seller of the product to the consumer. The importance of the topic of food safety management can be even more evident in the international standards developed for this topic. The process of globalization forces standardization of activities such as transport and food storage, which, together with social responsibility, provide the public with safe food products.

The articles published in this paper can be categorized into thematic groups covering agriculture and its impact on the food chain and environment, food chain processing, transport, storage and sale of food products, food packaging and food products, and innovation for the development of the food chain. We hope that the results of research, case studies and literary studies included in the monograph will provide you with added value.

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BUSINESS ANALYTICS IN SUPPLY CHAIN MANAGEMENT

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1. Introduction

Advanced business intelligence solutions (BI) integrated with supply chain management systems (SCM) provide companies with insight and analysis on the overall health of their supply chains. The top SCM and BI vendors, ranked by Gartner, understand that their solutions need to be compatible with other systems in order to allow integration. They track changes and trends in the SCM environment and technology to offer suitable products and services.

Today's food supply chain is more globalised than ever before. Even a small change in the supply chain can have a large global impact. The food production industry is experiencing a very challenging period. Manufacturers are increasingly moving toward demand-driven supply-chain solutions to reduce time-to-market, stock-outs, overstocks, inventory levels and improve forecast accuracy and overall performance, including slow movers and new products. This trend affects the IT sector. SCM systems and BI solutions have to ensure a complex view of true demand signals across a network, predict demand across a product lifecycle, capture a demand signal closer to its source, analyse and steer demand in line with business objectives and apply proper strategy to demand classes and DFU (demand forecasting unit) segments.

The article presents the list of current top IT vendors and their solutions in the area of the food supply chain and the possibility of integrating various SCM and BI tools to ensure efficient business management. It describes a very customised solution - demand segmentation, which is something new, recently implemented for one of the most well-known companies in the beverage sector. This paper describes the implementation project, its results and recommendations for future development of SCM and BI systems.

2. Top SCM and BI solutions ranked by Gartner

Gartner is the world's leading information technology research and consultancy company. They are one of the most respected research firms in IT. Their experts, using Gartner's knowledge, experience and scientific mapping technology, have developed a new methodology, called Gartner Magic Quadrant, to position companies in technology markets.

Vendors are selected based on Gartner's rules and then evaluated considering criteria in two categories: completeness of stated vision and ability to execute this

vision. In the result each player is allocated to one of four quadrants, described below.

1. Leaders, scored high in both categories.
2. Visionaries, scored high in completeness of vision and low in ability to execute.
3. Niche Players, scored low in both categories.
4. Challengers, scored low in completeness of vision and high in ability to execute.

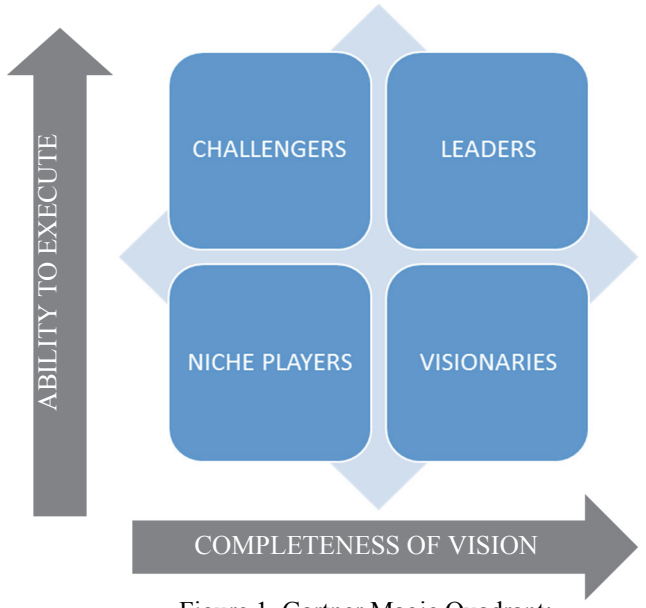

Figure 1. Gartner Magic Quadrant[1]
Source: own study based on [1] accessed on 19.10.2016.

This is a general design that is applied to all Gartner's Magic Quadrants. The list of these reports is available on their website. In the directory we can find two that are relevant to SCM and BI:

1. Magic Quadrant for Supply Chain Planning System of Record (SCP SOR),
2. Magic Quadrant for Business Intelligence and Analytics Platforms.[2]

Magic Quadrant for Supply Chain Planning System of Record from 2015 analyses 21 SCP IT players that represent approximately 2.6 billion USD in annual revenue, about 70% of the global SCP market (Figure 2). Were selected and evaluated only those SCP SORs vendors that have a minimum:

- SCP annual revenue of 13 million USD,
- 35 customers using more than 2 functional modules from a given SCP solution
- and 15% of their SCP license revenue from outside their headquarters' region (e.g. EMEA).

[1] http://www.gartner.com/technology/research/methodologies/research_mq.jsp accessed on 19.10.2016.
[2] http://www.gartner.com/technology/research/methodologies/magicQuadrants.jsp#s accessed on 19.10.2016.

Additionally, there was a condition that their SCP SORs:

- support and integrate planning processes of:
  - demand, inventory and replenishment planning, including collaborative planning,
  - order planning and promising,
  - production planning,
  - scheduling
- offer the key technical capabilities listed below to ensure that this planning functionality is effective across the whole supply chain:
  - unified data, process and analytical models,
  - process management,
  - performance management and analytics support,
  - scalability to handle global planning models,
  - collaboration support,
  - ability to deploy segmented SCP models,
  - master data management (MDM),
  - integration to transaction systems,
  - ability to publish plan changes easily in a 24/7 environment. [3]

Figure 2. Magic Quadrant for Supply Chain Planning System of Record
Source: [3] accessed on 19.10.2016.

[3] https://www.gartner.com/doc/3187427/magic-quadrant-supply-chain-planning / or http://blueridgeglobal.com/gartner-supply-chain-planning-magic-quadrant-2016-report/ accessed on 19.10.2016.

In the group of leaders is a company, let's call it vendor Z, whose SCP system was used to deliver, as mentioned before, a very customised solution – demand segmentation, for one of the top manufacturers of alcoholic drinks in the global beverage industry.

The final design of this specific product required additionally a BI solution. One of the best in the market was used – IBM Cognos. IBM was positioned as a visionary by Gartner.[4] Figure 3 illustrates the Magic Quadrant for Business Intelligence and Analytics Platforms for 2016.

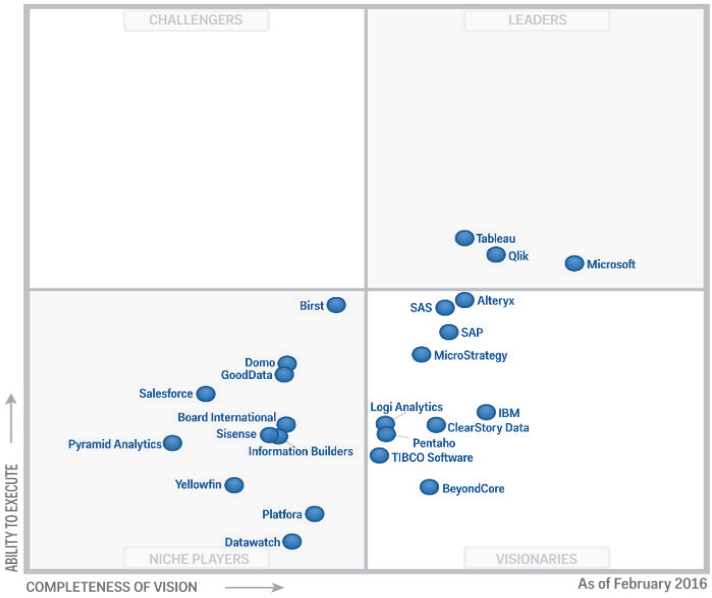

Figure 3. Magic Quadrant for Business Intelligence and Analytics Platforms
Source: [4] accessed on 19.10.2016.

IBM, to be included in the Magic Quadrant, had to meet the criteria listed in Table 1.

Table 1. Gartner's inclusion criteria for selection of vendors to Magic Quadrant for Business Intelligence and Analytics Platforms

Vendor-Level Criteria	Product Level Criteria
1. **Tier 1. Market Presence** — A composite metric assessing both the interest of Gartner's client base and that of the broader market, through Internet search volume and trend analysis, was conducted for each vendor. 2. **Tier 2. Revenue** — For those vendors meeting the market presence criteria (Tier 1), BI and analytics revenue for each vendor was assessed and evaluated. Revenue inclusion levels are as follows:	4. **Tier 4. Survey Reference Submission** — The vendor must have provided a minimum of 40 survey references demonstrating breadth across vertical industries and geographic regions as specified by Gartner. 5. **Tier 5. Product Scoring and Ranking** — Products that progressed to this final tier were assessed by Gartner analysts

[4] https://www.gartner.com/doc/reprints?id=1-2XXKCD7&ct=160204&st=sb accessed on 19.10.2016.

2.1. $25 million 2015 (estimated) combined revenue + 2015 (estimated) ACV (Annual Contract Value), or 2.2. $15 million 2015 (estimated) combined revenue + 2015 (estimated) ACV with 50% year-over-year growth, or 2.3. $10 million 2015 (estimated) combined revenue + 2015 (estimated) ACV with 100% year-over-year growth, or 2.4. $5 million 2015 (estimated) combined revenue + 2015 (estimated) ACV with 200% year-over-year growth. * Gartner defines total software revenue as revenue that is generated from appliances, new licenses, updates, subscriptions and hosting, technical support and maintenance. Professional services revenue and hardware revenue are not included in total software revenue. 3. **Tier 3. Magic Quadrant Process Participation** — The vendor must have participated in all data collection activities, including: 3.1. completing and providing documentation for a RFP-style questionnaire of detailed critical capabilities, 3.2. completing an online questionnaire around market presence, growth, go-to-market strategy and differentiation, 3.3. submission of a video up to one-hour long demonstrating how included products deliver on the predefined analytic scenarios defined by Gartner, 3.4. verification of final BI and analytics revenue for 2014 (actual) and 2015 (estimated), 3.5. providing references for an online customer and OEM survey, 3.6. providing a vendor briefing for the Magic Quadrant authors, 3.7. providing access to evaluation software, 3.8. providing a factual review of its sections in both the Magic Quadrant and Critical Capabilities research.	using the information provided by each vendor in the data collection exercise outlined above. The vendors ranked in the top 24 following this step were included in the Magic Quadrant.

Source: [4] accessed on 19.10.2016.

Moreover, the IBM solution was assessed according to capabilities listed in Table 2 below.

Table 2. Gartner's critical business intelligence (BI) and analytics platform capabilities

Infrastructure	Data Management	Analysis and Content Creation	Sharing of Findings
• **BI Platform Administration.** Capabilities that enable scaling the platform, optimizing performance and ensuring high availability and disaster recovery. • **Cloud BI.** Platform-as-a-service and analytic-application-as-a-service capabilities for building, deploying and managing analytics and analytic applications in the cloud, based on data both in the cloud and on-premises. • **Security and User Administration.** Capabilities that enable platform security, administering users, and auditing platform access and utilization. • **Data Source Connectivity.** Capabilities that allow users to connect to the structured and unstructured data contained within various types of storage platforms, both on-premises and in the cloud.	• **Governance and Metadata Management.** Tools for enabling users to share the same systems-of-record semantic model and metadata. These should provide a robust and centralized way for administrators to search, capture, store, reuse and publish metadata objects, such as dimensions, hierarchies, measures, performance metrics/key performance indicators (KPIs) and report layout objects, parameters and so on. Administrators should have the ability to promote a business-user-defined data model to a system-of-record metadata object. • **Self-Contained Extraction, Transformation and Loading (ETL) and Data Storage.** Platform capabilities for accessing, integrating, transforming and loading data into a self-contained storage layer, with the ability to index data and manage data loads and refresh scheduling.	• **Embedded Advanced Analytics.** Enables users to easily access advanced analytics capabilities that are self-contained within the platform itself or available through the import and integration of externally developed models. • **Analytic Dashboards.** The ability to create highly interactive dashboards and content, with visual exploration and embedded advanced and geospatial analytics, to be consumed by others. • **Interactive Visual Exploration.** Enables the exploration of data via the manipulation of chart images, with the colour, brightness, size, shape and motion of visual objects representing aspects of the dataset being analysed. This includes an array of visualization options that go beyond those of pie, bar and line charts, to include heat and tree maps, geographic maps, scatter plots and other special-purpose visuals.	• **Embedding Analytic Content.** Capabilities including a software developer's kit with APIs and support for open standards for creating and modifying analytic content, visualizations and applications, embedding them into a business process, and/or an application or portal. These capabilities can reside outside the application (reusing the analytic infrastructure), but must be easily and seamlessly accessible from inside the application without forcing users to switch between systems. The capabilities for integrating BI and analytics with the application architecture will enable users to choose where in the business process the analytics should be embedded. • **Publishing Analytic Content.** Capabilities that allow users to publish, deploy and operationalize analytic content through various output types and distribution methods, with

	• **Self-Service Data Preparation.** The drag-and-drop, user-driven data combination of different sources, and the creation of analytic models such as user-defined measures, sets, groups and hierarchies. Advanced capabilities include semantic auto discovery, intelligent joins, intelligent profiling, hierarchy generation, data lineage and data blending on varied data sources, including multistructured data.	These tools enable users to analyse the data by interacting directly with a visual representation of it. • **Mobile Exploration and Authoring.** Enables organizations to develop and deliver content to mobile devices in a publishing and/or interactive mode, and takes advantage of mobile devices' native capabilities, such as touchscreen, camera, location awareness and natural-language query.	support for content search, storytelling, scheduling and alerts. • **Collaboration and Social BI.** Enables users to share and discuss information, analysis, analytic via discussion threads, chat and annotations.

Source: [4] accessed on 19.10.2016].

IBM is strong in all three categories. From the beverage manufacturer perspective, who required a custom solution, it was very important that the IBM BI tool was embedded in vendor Z's SCP system. It was used to deliver the demand segmentation solution.

3. Implementation of the demand segmentation solution

3.1. Problem statement

The aforementioned beverages manufacturer, let's call them company X, realized that in order to operate efficiently in the market, remain competitive and achieve more, needed a change in how they currently ran the business. It was realized that their supply chain management required a transformation and improvements. The aim was to attain the third degree of Gartner's maturity model, whose general characteristics was presented in the previous section – requirements for SCP SORs.

Implementation of this objective required a redesign of current solution architecture, including the development of demand segmentation, in order to enhance the effectiveness of decision-making in demand planning, define forecasting strategy for different DFUs and improve demand control processes.

It was decided that all DFUs would be segmented in to one of seven pre-defined segments on the basis of their lifecycle stage and/or their importance and volatility. It was established that this step would be the starting point for forecasting.

3.2. Prerequisites, general requirements and assumptions

Company X, in order to improve supply chain management, decided to implement several vendor Z systems. Analysis showed that the aforementioned demand segmentation required development of a specific solution, using some of selected vendor Z applications for further implementation such as:

- Demand with its forecast error calculation functionality,
- Inventory Optimisation (IO) with its segmentation capability and
- Reporting, including IBM Cognos BI tool.

It was found that to deliver this custom-made product, the project team had to create:

- user-defined tables,
- user-defined columns,
- user-defined processes and procedures.

As the result of analysis not just a list of prerequisites was developed but also some general requirements and assumptions were written down. They are presented below.

1. Standard functionality will be used wherever possible.
2. Non-standard functionality will be allowed upon approval.
3. A new solution will be integrated with other existing systems.
4. The solution will be in English.
5. The solution will be documented.
6. Batch processing requirements will be defined.
7. All master data relevant for the solution will be standardized, cleansed and harmonized in the relevant systems.
8. Any additional support regarding different systems will be provided.
9. DFUs segmentation process will to be done at Item level within Operative Country (OpCo) organizations level.
10. The results will be reviewed at Operative Country organisation level, using a custom report (scatter plot). Users will have to select a reporting entity (group of OpCos) and then OpCo.
11. Many Operative Country organisations can be linked with one reporting entity.
12. One specific Operative Country organisation can only belong to one specific reporting entity.
13. All new DFUs will be segmented and assigned to one of seven categories of product (Figure 4):
    - NPI (New Product Introduction),
    - Promotion,
    - Mad Bulls,
    - Horses,

- Rabbits,
- Turtles and
- EOL (End Of Life).

14. IO will be the core engine for performing demand segmentation, defining Mad Bulls, Horses, Rabbits and Turtles.
15. NPI, EOL and Promotion will be defined based on the product classes as part of the post-processing, outside IO.
16. Input data will be fed from multiple systems to IO.
    - Forecast error data will be calculated in Demand and sent to IO (2 years of shipment history data).
      - It is a volatility criterion with two user-defined ranges e.g. High for >= 50 and Low for < 50.
    - Revenue will be available in the staging area (average unit price multiplied by average shipment volume over 1 year).
      - It is an importance criterion, classified on cumulative percentage with two ranges defined e.g. High for <= 80% and Low for > 80%.
17. All input data will be stored in staging user-defined table.

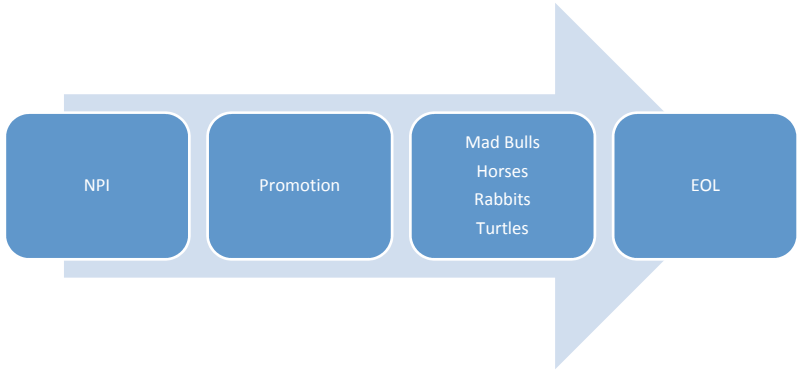

Figure 4. Allocation of product categories in lifecycle
Source: own study.

3.3. Solution

The Demand segmentation solution requires a custom two-step workflow to be designed and executed. The first step is called demand segmentation and the second one – demand post-segmentation.

The Demand Segmentation process requires a custom procedure to be executed. The role of the script is to insert proper data from the user-defined staging table into proper IO tables. It is only for DFUs which should be assigned to one of the four categories: Mad Bulls, Horses, Rabbits or Turtles., The criticality matrix is generated only for these items and results can be reviewed.

The outputs can be analysed in IO itself. There is a custom-made Demand Segmentation report that can be accessed directly from IO. It is a scatter plot chart designed using the Reporting tool with its IBM Cognos BI. A very good

integration of both vendor Z and IBM solutions ensures an easy link between the reports created in IO and designed in IBM Cognos.

To build this report several prerequisites have to be met. All relevant tables need to exist in the corresponding IBM Cognos IO package with relevant input data. Moreover, plenty of user-defined columns in existing tables and/or user-defined queries have to be created. This can be done using Framework Manager – a Windows client application provided by IBM Cognos that is used to develop and publish models (representations of the tables and columns available in the applications that are the basis for designing and building reports and queries). The second option is to access IBM Cognos via a browser to create all relevant objects.[5] These queries are used to define filters or specific elements of the scatter plot such as: X-axis, Y-axis, series, baselines, coloured regions etc.

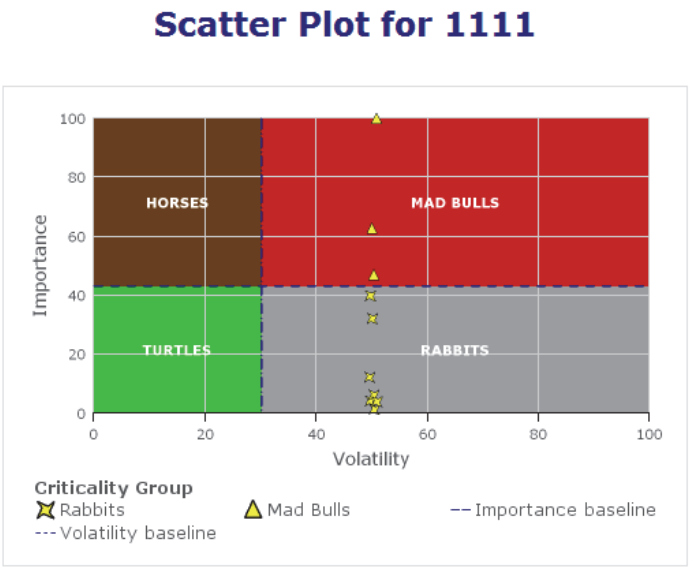

Figure 5. Scatter plot
Source: own study.

An example of designed Demand Segmentation report is illustrated in Figure 5. Users can review data for a given OpCo, in this case 1111. Layout elements such as background colour or font are user-defined.

Firstly, a prompt page is open to define filters. Users have to select the reporting entity from the drop down list. Their choice is auto-submitted. Automatically the second drop down list for Operative Country organisation, is updated to show only OpCos linked with a given reporting entity. A selection of the second filter is also required. After this the report page is open with scatter plot chart. Users can review results.

[5] Browne D., Desmeijter B., Dumont R.F., Kamal A., Leahy J., Masson S., Rusak K., Yamamoto S., Keen M.: IBM Cognos Business Intelligence V10.1 Handbook, IBM. International Technical Support Organization, USA 2010.

As previously mentioned it is only for four of the seven categories of product. To see the complete list of all DFUs with its categories, the second step – demand post-segmentation needs to be executed.

There is a custom procedure written to update category information in the user-defined staging table. It is executed for all DFUs within a given reporting entity. NPI, Promotion and EOL will be defined based on product class information stored in the staging table, the rest based on data stored in IO tables.

3.4. Conclusions

Different DFUs categories require different management and control. A custom-designed solution enables DFU differentiation. It allows optimisation and implementation of various demand specific strategies for each DFU category with different control mechanisms. Planners receive a tool which tells them on what group/s of DFUs they should focus to improve forecast accuracy. Management effort started being addressed properly.

The design of this solution also resulted in another report being developed. The supply planning team asked about a tool to compare the output from demand segmentation with safety stock recommendations. The reason behind this was to have a report identifying additional items which may require improvements in forecast accuracy. From the supply perspective this was a very important thing. Generally, good forecast accuracy means lower inventory levels. High forecast errors cause high safety stock to reduce stock-outs. A new report has allowed the supply team to challenge and control the priorities of the demand team.

Both reports have facilitated a dialogue between the demand and supply sides. They enabled an effective balancing of demand and supply, reducing mismatch between the two sides – one of the most common problems facing manufacturers across all industries, not only in the beverage sector. Designing these two custom solutions was a very good decision for further successful growth of the supply chain.

4. Summary

The information presented in this elaboration underlines the urgent need to continue research within the analysed extent, SCM and BI solutions with their capacity to integrate with other systems in order to perform product segmentation and present its results.

Supply chains have become more globalized and IT systems more critical to company success.[6] A growing number of firms are now realizing how investment in SCM can improve existing processes and bring benefits in the future.

Nowadays it is impossible to operate an efficient large supply chain without adequate IT solutions behind it. Advanced SCM systems with analytic functionalities have made actionable information more easily attainable and user-friendly. New

[6] Rainer Jr. R.K., Prince B., Cegielski C.: Introduction to Information Systems – International Student Version. Fifth Edition, John Wiley and Sons, Hoboken, NJ 2015.

technologies have enabled customer expectations to be met better than ever. They are more compatible with other existing solutions in the market. It is very important. Modern IT products offer the option of customizing by means of configuration. Even for large, integrated business applications it is best to remain as close to a standard product as possible in order to benefit from new software updates, developments, documentation etc. However, there are cases for which parameterization doesn't suffice and custom adaptations are needed. Configuration of existing applications to meet individual customer requirements and preferences is usually only possible to a limited degree. The described case of demand segmentation led to an innovative solution meeting next generation unique requirements and challenges.

The product was developed for company X using several SCM applications and BI solutions. It required a creation of user-defined tables, columns, processes and procedures. This design was costly but an inefficient and poorly functioning supply chain could negatively impact every aspect of the business, reduce the company's ability to achieve fundamental, sustainable improvement and therefore the company X made a decision to invest in this. The management was aware that SCM technology investment and the overall approach to supply chain management must change and keep pace. To achieve and sustain excellence in supply chain, companies, just as company X, have to be open. They should regularly re-evaluate their current architecture, how their current supply chain structure supports the business, having in mind future trends in given specific areas. They have to keep their supply chain aligned with the overall strategy.

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SUPPLY CHAIN ENTITIES' AWARENESS OF CORRECT FOOD LABELING AS AN ELEMENT CONTRIBUTING TO THE SAFETY OF THE PACKAGED PRODUCT

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1. Introduction

The vast majority of foods offered to consumers is marketed in packaged form. The development of food production technology as well as retail sales demands drive continuous improvement in packaging. The main areas of improvement are: ensuring product safety, providing relevant information, streamlining the distribution process and facilitating end-use. The obligation to meet consumer requirements and expectations in those areas falls on food producers; however, all other entities forming the food supply chain should take part, and some responsibility, in the process of adapting the packaging to consumer needs.

In view of numerous irregularities regarding a low level of consumer satisfaction with food product packaging presented in literature, the aim of the study was to assess the awareness of supply chain entities in terms of validity of correct food labeling on a selected group of foodstuffs.

2. The role of supply chain in meeting consumer expectations concerning food

The supply chain is a network of manufacturers and service providers who work together to process and transfer goods – from raw material to the end-user. All these entities should be linked together by the flow of goods, information and cash [2].

Responsible businesses are aware that placing any food product on the market requires timely and reliable information, which is only obtained under close integration with other participants along the supply chain [4]. The aim of thus acquired data should not be merely to forecast and determine the level of demand. The scope of information necessary to do business on the food market should also include the observed preferences and expectations of customers towards the product. Relationships resulting from cooperation within the framework of existing supply chains need to be oriented towards the identification and fulfillment of consumer needs and expectations.

According to P.R. Murphy i D.F. Wood [13], the awareness – understood as knowledge and discernment of consumer needs – is one of the main benefits of

the effective use of information in the supply chain. On the other hand, M. Christopher [3] points out that inside the supply chain not only the integration of business processes with suppliers is necessary, but with product distributors and consumers as well. A smooth operation of the food supply chain should also include processes that adapt the product packaging to customer needs.

However, research results indicate a low level of consumer satisfaction regarding information conveyed through the packaging of a food product [20], [16], [9], [10]. The most common irregularities are associated with low visibility of information on the packaging. Moreover, consumers seem to have difficulty reading and understanding targeted content. Another confirmation of relatively low involvement of food producers in correct labeling of products are annual reports of IJHARS (Inspekcja Jakości Handlowej Artykułów Rolno-Spożywczych – eng. Food and Agricultural Products Quality Control Inspectorate). According to the data for 2015, among all products checked, irregularities in the labeling were reported in as many as 26% of them. In comparison with the data for the year 2014, the number of improperly labeled products increased by 1.9 percent. The most common irregularities related to information such as product name, its composition or misstatements regarding its certain properties [19].

Properly selected and designed packaging contributes to its functionality as well as ensures the safety and comfort of product use. According to the currently prevailing views, the packaging should fulfill three main functions: protection, comfort (utility), and communication [12].

Labeling, as an element affecting all of the above functions of packaging, is an essential factor reflecting consumer expectations for food products. It shapes the overall quality of the product and the safety of its use [15]. Food labeling plays an important role in informing consumers about the characteristics of the product. Full and reliable information is necessary to make an informed and appropriate purchasing decision, but it also determines the safety of product use [8], [9].

The packaging, through its spatial form (shape), size, color and graphics, performs the function associated with conveying information. The informative aspect of packaging means: the presence and legibility of the mandatory and optional information important in terms of consumer rights, needs and expectations; the ability of the packaging, through its visual layer, to suggest the product's use; readability and accessibility of information through an appropriate use of visual elements [11].

Following a recent increase in the range and supply of food products, the consumers are becoming ever more informed, aware and demanding. That is why, the processes of packaging design must reflect the growing demands and expectations of consumers in terms of labeling [9]. In this study, it was assumed that the awareness of entities in the supply chain is essential to meet consumer needs and ensure product safety, including its packaging.

3. Empirical studies

The study was conducted among representatives of various entities in the supply chain of dietary supplements. This particular group of foodstuffs has been selected due to the surge in popularity of dietary supplements in all age groups and optimistic forecasts for further sales growth. Based on the analysis of supply chains for dietary supplements, the following entities have been selected for further investigation: producers and distributors (pharmacists, wholesalers, retailers) of these products.

The research was carried out with the use of questionnaires [14], [17]. The survey had quantitative character and covered the whole country. The method of entity selection for study was characterized by non-random, accidental (sampling) approach [1]. The questionnaires were delivered to the supply chain entities of food supplements by mail and in a few cases face-to-face. The study was carried out on a sample of 255 representatives of distributors and 82 employees of companies producing dietary supplements. A detailed characteristic of the population studied is presented in Table 1 and 2.

The assessment of the level of awareness of supply chain entities was based on collecting their opinions about: the need for further research to improve informative function of packaging, the necessity of introducing design procedures concerning proper labeling, and the analysis of the packaging design process for dietary supplements.

The results obtained were evaluated with the use of descriptive statistics and statistical inference methods. The data was analyzed using chi-square test ($\chi 2$) [18]. The statistical dependence was determined based on the residual value [5].

Table 1. The structure of the surveyed population – distributors of dietary supplements

Independent variables	**Categories**	**Population surveyed n = 255**	
		n	**%**
Range of business activities	Pharmacies and wholesalers	236	92,5
	Grocery store	4	1,6
	Medical and herb shop	15	5,9
Location of business	Rural area	30	11,8
	City up to 99 000 residents	64	25,1
	City 100-500 000 residents	42	16,4
	City above 500 000 residents	119	46,7
Number of employees	Up to 9	149	58,4
	10 to 49	34	13,3
	50 to 249	19	7,5
	Above 250	18	7,1
	No answer	35	13,7
Education	Secondary	100	39,2
	University level	132	51,8
	No answer	23	9,0
Position	Manager	44	17,3
	Sales assistant	194	76,1
	No answer	17	6,6

Years of service	Up to 5 years	83	32,5
	6 to 15 years	100	39,3
	16 to 40 years	40	15,7
	No answer	32	12,5

Source: own elaboration.

The research on companies involved in the distribution of dietary supplements was conducted among employees of these entities. More than 90% of respondents were employed in pharmacies and by wholesalers. This was mainly due to the fact that through these distribution channels most of the dietary supplements are sold to consumers. The study was conducted in outlets located in rural areas (30%) and in large cities (46%). They were mostly micro-enterprises contracting fewer than 9 employees (58%).

Table 2. The structure of the surveyed population – manufacturers of dietary supplements

Independent variables	**Categories**	**Population surveyed n = 82**	
		n	**%**
Production scope - the share of dietary supplements in the whole range of manufactured products [%]	10-40	18	22,0
	50-90	33	40,2
	100	29	35,4
	No answer	2	2,4
Sources of financing	Foreign or joint venture	15	18,3
	Polish only	66	80,5
	No answer	1	1,2
Range of business activity	National	50	61,0
	International	32	39,0
Number of employees	Up to 9	26	31,7
	10 to 49	25	30,5
	50 to 249	24	29,3
	250 and more	7	8,5
Level of education	Secondary, Bachelor's, Engineer	17	20,7
	Master's degree	65	79,3
Position	Owners and Directors	7	8,5
	Senior Managers	22	26,8
	Junior Managers	34	41,5
	Clerks and Administrative Workers	7	8,4
	No answer	12	14,6
Years of service (seniority)	Up to 5 years	49	59,8
	6 to 15 years	25	30,5
	Above 15 years	7	8,5
	No answer	1	1,2
Type of education	Technical	10	12,2
	Economics	32	39,0
	Pharmaceutical	13	15,9
	Other	12	14,6
	No answer	15	18,3

Source: own elaboration.

The research on manufacturers of dietary supplements included companies of different sizes and numbers of employees. The percentage of companies analyzed, from the smallest – up to 9 people, through the ones with the number of employees ranging from 10 to 49, and finally from 50 to 249, was almost equal and amounted to approx. 30% of total share in each group. As many as 80% of the entities that participated in the study were financed by Polish capital only. Most companies declared the percentage share of the production of dietary supplements at the level of 50-90% of the total of its production range.

4. Results and discussion

The assessment of the level of awareness of supply chain entities regarding the need for further research to improve informative function of packaging was carried out first. The analysis conducted in both groups of supply chain entities has shown that the vast majority of respondents confirm the necessity of carrying out further research to improve the informative function of packaging. Image 1 presents the obtained results.

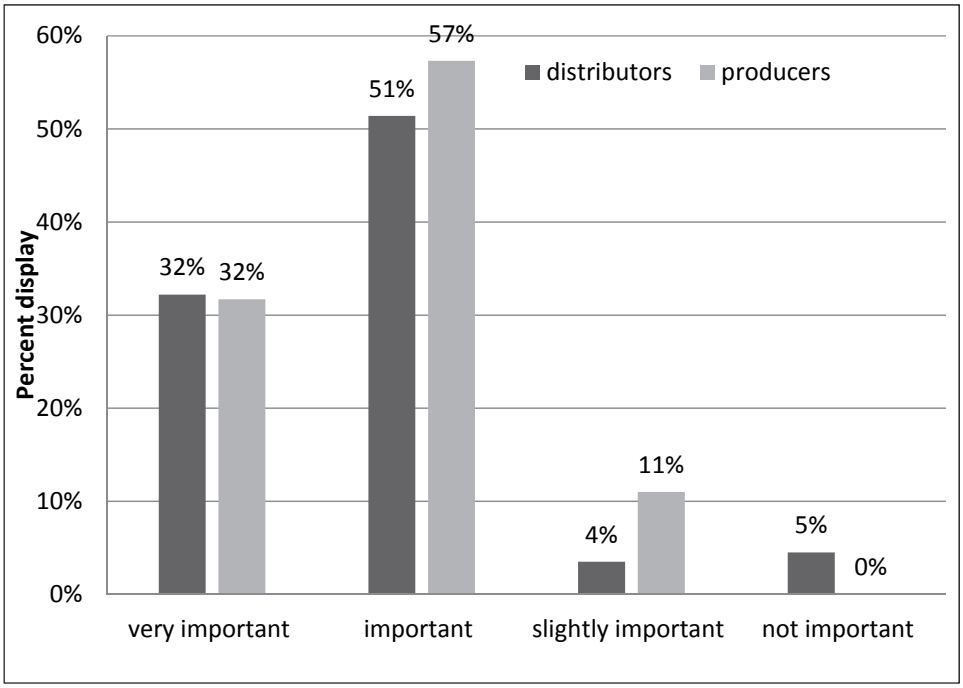

Image 1. The need for further research to improve informative function of packaging (for dietary supplements)
Source: own elaboration.

As many as 32% of respondents said that it is very important to conduct further studies to improve the informative function of packaging. Among producers, 57% claimed such research to be essential as opposed to 51% of distributors. Upon

analyzing the distribution of the responses received (presented in Image 1), it was found that manufacturers of dietary supplements consider the informative function of packaging to be more important in general compared with the responses of the other group. About 5% of retailers deemed the need to study the informative function of the packaging completely unnecessary. Such extreme opinions did not occur among the manufacturers.

The second stage of the assessment focused on the necessity of introducing design procedures concerning proper labeling of dietary supplements. Also in this issue, both groups expressed similar views. Distributors as well as manufacturers of dietary supplements fully acknowledged the need to prepare advanced design procedures concerning product packaging and they found them equally useful. Only about 12% of distributors and 19% of manufacturers were against the development of such procedures. In their opinion, they would be completely useless in the process of preparing the labeling of dietary supplements. The study revealed that distributors are more inclined towards developing and implementing design procedures than the manufacturers. This may be due to the observed difficulties the consumers face when making their purchasing decisions. On the other hand, the manufacturers tend to be more skeptical when it comes to the usefulness of design procedures.

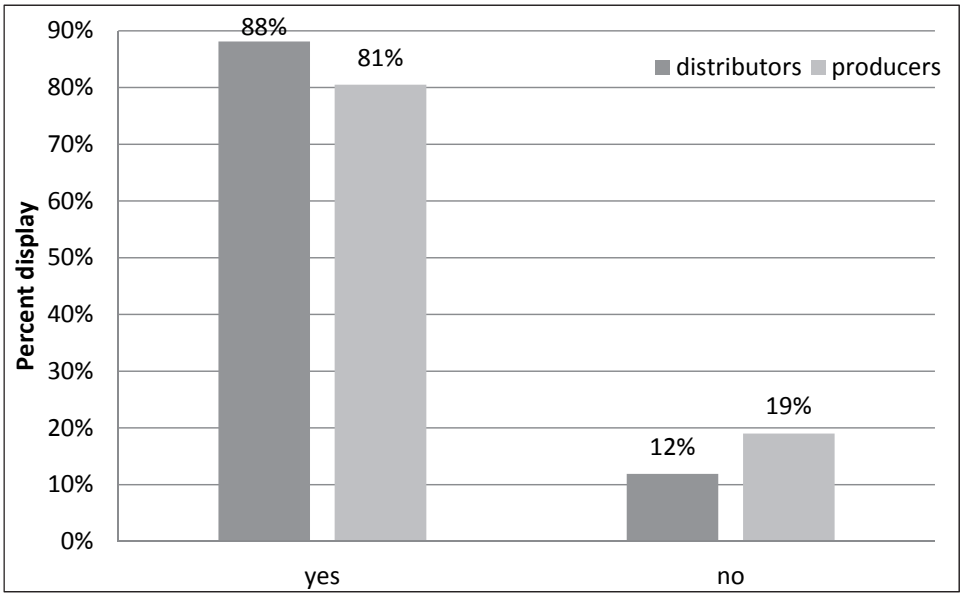

Image 2. The need to introduce design procedures concerning proper labeling of dietary supplements
Source: own elaboration.

In this study, the process of designing food supplement packaging, for which the manufacturers are generally responsible, has been thoroughly assessed. Upon analyzing the data obtained, it was found that in approx. 40% of the surveyed

enterprises the packaging design processes were implemented by manufacturers alone (Image 3). Here, in up to 85% of cases, that task was performed by relevant departments, and in the remaining 15% – it was the responsibility of a special team made up of employees from different business units (e.g. marketing, production etc.). The results showed that 60% of companies supported themselves, to a greater or lesser extent, with external services. Most often, in 43% of cases studied, manufacturers of dietary supplements carried out the process of packaging design by partly collaborating with other companies. In 17% of cases the task was entirely outsourced to an external company.

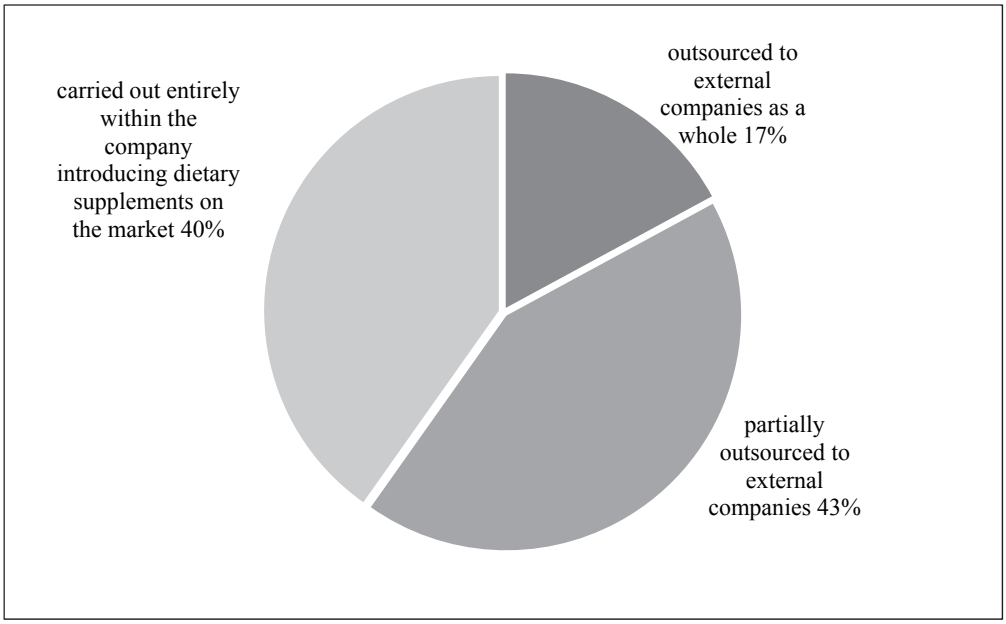

Image 3. The process of designing food supplement packaging
Source: own elaboration.

The chi-square test was used to analyze the collected data [18], thus enabling the determination of relationships related to the process of packaging design in the surveyed organizations. Based on the obtained results, it was found that the range of business activities of the company and number of employees are variables that differentiate the process of preparing food supplement packaging (Table. 3).

Table 3. Statistical dependence of the process of packaging design on the variables characterizing the surveyed companies

Independent variables	χ^2	P
Range of business activities	5,99*	0,050
Number of employees	13,66*	0,030

Explanation: The * symbol indicates that the hypothesis of independence of variables should be rejected (at the level of $\alpha = 0.05$).
Source: own elaboration.

The use of residual value to analyze the process of packaging design [5] provided more insights into its character and particular stages. As a result, it was found that national companies, more than other ones, carry out designing projects almost entirely inside the company. International companies, on the other hand, tend to collaborate with external businesses to achieve this end.

Based on the residual value analysis, statistical dependence of the packaging design process on the range of business activities and number of employees has revealed what follows. The smallest companies with up to 9 employees are more likely to outsource the packaging design project. Medium and large companies with more than 50 employees are more likely than other companies to partially implement projects in cooperation with external companies. On the other hand, the businesses with the number of employees 10-49 more often carry out packaging design projects entirely inside their company.

When cooperation with external companies in terms of dietary supplement packaging design was declared by respondents, their satisfaction with the results of such collaboration was also investigated. They were asked to evaluate the incidence of possible behaviors that concerned the projects submitted to them. These were: the overall project approval, introduction of minor changes, and the introduction of major changes in the project. The respondents evaluated the occurrence of each situation by choosing one of the following: frequently, rarely, never. The results show that according to respondents, the projects were frequently approved without introducing any changes (57%), the projects were frequently approved with minor changes (55%), and the projects were but rarely approved after major changes (42%).

The results of the final stage of the research show that manufacturers generally accept the packaging design proposals for dietary supplements developed by external companies and introduce but minor changes in the designs.

5. Conclusion

The results of this study indicate that the key entities in the supply chain of dietary supplements recognize the need to conduct further research on the informative function of packaging as far as the products they place on the market are concerned. They consider it to be important for the general safety of products and consumers.

Particularly relevant and useful may be the research results concerning introduction of design procedures for proper labeling of dietary supplements. Distributors as well as manufacturers of dietary supplements fully acknowledged the need to prepare advanced design procedures, which might serve as a starting point for the scientific community and professional organizations to initiate the preparation of appropriate guidelines since there are none as yet.

Besides the preparation of design procedures, consumer satisfaction regarding the labeling of dietary supplements may be improved by the newly developed methods and research tools enabling verification of product labeling [6]. Not

without significance will be their dissemination and popularization among food producers and companies specializing in packaging design.

Another step to be taken in order to improve consumer satisfaction regarding product labeling is to strengthen cooperation between entities within existing supply chains. A better integration of information systems and extending their functionality by introducing new solutions, such as the transfer of data associated with the observed needs and expectations of end-customers might also help improve consumer satisfaction. Within the established channels of information flow, the possibility of transferring such data up the chain – to the food manufacturers and its suppliers – should be taken into account, thereby intending to improve the competitiveness of the supply chain as a whole.

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ECONOMICS OF AGRICULTURAL LAND DEGRADATION AND SOIL PROTECTION: A CASE STUDY OF UKRAINE

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1. Economic estimation of the impact of soil degradation on crop production

The new version of the World Charter of Soils, which was adopted on the 39-th session of the FAO Conference (13 June 2015) by countries – members unanimously as a tool to promote and institutionalize sustainable use of soil resources at all levels indicated that soils play a major role for life in the Earth, but human pressure on soil resources is coming to a critical level. Careful use of soils is one of the essential elements of sustainable agriculture, as well as a valuable instrument for regulating the climate and way of conservation of ecosystem services and biodiversity [1]. Final document of the United Nations Conference on Sustainable Development, held in Rio de Janeiro (Brazil) in June 2012, „The future we want", recognizes the economic and social importance of rational land use, including soil use in particular its contribution to economic growth, biodiversity, sustainable agriculture and food security, poverty eradication, climate change [1].

Land degradation and desertification threaten fertile land and the benefits human society derives from it throughout the world. On a global scale, around 10-20% of drylands and 24% of the world's productive lands are degraded. The consequences are alarming: food insecurity, poverty, reduced availability of clean water, and increased vulnerability of affected areas to climate change. It is estimated that 1.5 billion people across the world are already directly affected through reduced income or food security. The annual economic losses due to deforestation and land degradation were estimated at 1.5-3.4 trillion Euro in 2008, equaling 3.3-7.5% of the global GDP in 2008. Competition for the scarce resources of soil and water is further intensified by the growing world population and increasing demand for alternative land management products [2]. It is estimated that more than 500 million tons of soil are eroded annually from arable land in Ukraine resulting in loss of soil fertility across 32.5 million hectares and equivalent to around 5 bln USD in nutrient equivalent. The value of eroded soil each year is around one-third of the agricultural gross domestic product. This means that for each dollar of added agricultural value generated, one-third is lost through erosion; or ten tons of soil is eroded for each ton of grain produced [3].

Now the problem of intensive farming v the environment is particularly urgent. The agri-chemicals industry has tended to see nature as an enemy to be tamed or, in some of its aspects, obliterated. This has resulted in the loss of

diversity and the lower yields. Overuse of chemical farming techniques is more likely to be self-destructive than the ecological approach. As E.F. Schumacher, expressed it: „If we win the battle with nature, we shall be on the losing side". At the same time it is believed that intensity and diversity are not opposites. Monoculture and diversity are intensive and extensive. Many peasant farming systems are intensive and diverse for example, some industrial monocultures are extensive [4].

Table 1. Calculation of economic losses from spreading soil degradation in agricultural enterprises of Ukraine (data of 2013)

Indicators	Degree of soil degradation			Total
	weak	medium	strong	
Approximate area of land degradation distribution, million ha	2.8	7.0	0.2	10.0
Loss of productivity of major crops, centners/ha				
Cereals and legumes	4.0	8.0	20.0	7.1
Sugar beets	39.7	79.4	198.7	67.1
Sunflower	2.2	4.3	10.9	4.0
Rape	2.4	4.7	11.8	4.4
Potato	16.0	31.9	79.9	27.2
Vegetables	20.0	40.0	100.0	34.0
Fruits and berries	10.4	20.8	51.9	17.9
Loss of income (revenue) from sale of agricultural products due to lower yields, UAH/ha				
Cereals and legumes	520	1040	2600	925
Sugar beets	1579	3159	7904	2669
Sunflower	650	1270	3220	1189
Rape	738	1446	3631	1342
Potato	2977	5936	14869	5064
Vegetables	4708	9416	23540	8004
Fruits and berries	3131	6262	15626	5381
Average economic losses (loss of income from sales) after harvest shortfall, UAH/ha	792	1576	3951	1396
Total economic loss (loss of income (revenue) from sales) after harvest shortfall, million UAH				13960
The total amount of lost profits due to shortage of harvest (in actual profitability level in 2013), million UAH				1400
Share of lost profits in profits from sales of crop agriculture in 2013, %				15,5

Source: [6].

Despite the use of modern technology and a large number of fertilizers in some cases, we cannot ignore the soil fertility. Depletion and irrational use of soil resources has a negative impact on the productivity of economic activity even in the rich soils of countries. Growth of the areas subject to an erosion leads to washing and weathering of soil, which affects the reduction of humus and subsequently prevents the growth of productivity, which ultimately affects the farmers' income [5].

Expert assessment of economic losses (data of 2013) from spreading soil degradation in Ukraine approximately on area of 10 million hectares has showed (Table 1) that the total economic loss (loss of income (revenue) from sales) due to

harvest shortfall is 14 billion UAH, the total amount of lost profits due to shortage of harvest (in actual profitability in 2013) is 1.4 billion UAH or 15.5% of the profits from sales of crop agriculture in 2013.

Solving the problem of rational use and restoration of soil fertility should be in the following areas: legislative and regulatory support; normative and methodological support; information security; technological support; scientific and human resources; financial support; use of international experience soil protective activities.

2. Strategic priorities of sustainable use of soil resources in agriculture

To achieve the strategic objectives of agricultural sector- development in terms of sustainable use of Ukrainian soil resources, while preventing their degradation along with soil fertility recovery, a whole package of measures has to be implemented; said measures are prompted as strategic governmental priorities in view of the present-day status of soil cover and dynamics of its positive renovation [7]:

– suspending the humus- content decrease and regaining its deficit- free balance sheet. Calculations show that humus recovery needs application of zoogenic mull in amount of 8-9 t/ha of crop- rotation area; or about 250 mio tons for the whole country, whereas in reality, its actual output now shows 20-25 mio tons. Key measures that promise to enable suspension of soil dehumification and optimizing the organic matter contents- recovery in soil, are: rearrangement of crop- rotations towards increasing the share of total sown crops and perennial grasses; utilization of post- harvest residues and stubbly straw of cereal crops as organic fertilizers; application of organic and mineral fertilizers; utilization of peat, sapropel, green manure, pond sludge and other carbon-containing materials; improving conditions for plant residues and fertilizers humification by optimizing the soil tillage technologies; soil upturning depth- adjustment;
– enriching the soils with nutrient substances. Among measures aimed at enriching the soil with nutrients, the major one is a returning to annual fertilizers' application- amount (up to the level of 150-160 kg of dry matter per ha). In order to increase payback from mineral fertilizing, technologies of their usage need changing, so as either to distribute minerals into rows while sowing, or to apply them locally at pre- sawing cultivation and, moreover, at periodical plant- food fertilization during plants' growing season. Thus, payback return from harvest- yield increments due to applied fertilizers shall increase by 2-3 times. Mandatory application of micro-nutrients into soil is also an important measure;
– soils protection from erosion. To maintain operational availability of anti-erosion facilities, their repair and restoration are necessary. To increase effectiveness of anti-erosion measures, the strategy „to combat soil erosion" must be changed by „control on erosion-accumulative processes" strategy achievable by anti- erosion land- management through innovative program activities. In this regard, a prime action is to reduce arable land area to 40-50%. Provided if

about 8.6 mio hectares of unproductive and degraded lands are withdrawn from cultivation, ratio of arable lands and enviro- sustainable areas will be optimized, whilst intensity of erosions shall dramatically go down. An equally important action is employment of minimal and, specifically, zero-tillage methods. In Ukraine, they can be implemented over millions of hectares. Along with these radical anti- degradation actions, we need to use traditional anti- erosion and land treatment approaches, such as: soil slotting, planting of crop cultures on landstrips, -greatly improving forage grassland pastures;

– rehabilitating acidic and solonets soils. In modern- time economical conditions, comeback to traditional continuous chemical restoration technology is impractical, due to its over- costly nature and high losses. Now we need fundamentally novel approaches to solve problems of acidic and solonets soils amelioration, with inevitable transition to resource- saving technologies. In early steps of chemical melioration revival in Ukraine, the most appropriate actions shall include „back-up" liming to hinder soil acidification processes. Due to this technology, only 1-1.5 tons of lime per ha are applied instead of 5-6 tons. A separate and very important link of resource- saving technologies on acidic soils is phyto- restoration that involves selection and placement, in crop rotation, of cultures tolerant to acid reaction of soil environment. Employment of thus proposed resource- saving technologies across the Ukraine would help saving energetic and material resources by 50-60%, while improving the yield-capability of acidic and solonets soils by 35-40%. The deep plowing plantage approach must be returned to, with its significant efficiency and aftereffect duration.

2.1. Reproduction of organic matter in the soil based on the cattle development

The perspective direction of balanced development of agro-ecosystems is cattle revival and development in the context of reproduction of soil fertility, especially improving the humus soil conditions.

The organic component of soil is always at the center of special attention of scientists and practitioners. This is due to the fact that it is one of the most important factors that determines the agronomic potential of the soil. Organic fertilizers usually determine the formation of humus reserve, the composition of newly formed humic substances, the energy potential of soils, and carry out the comprehensive impact on soil fertility. But because of the decline of the livestock sector, now the level of organic fertilizers` usage in Ukraine is decreased to 0.5 tons per hectare of arable land, which resultes to deficit balance of humic substances and threatens reduction of effective soil fertility of agricultural land. There is every reason to offer farmers plowing crop by-products and increasing rates of application of different types of organic fertilizers, including local raw waste. It is clear that increased rate of application of organic fertilizers needs a regeneration and intensive development of the livestock sector, especially cattle in agricultural enterprises.

The comparative analysis of experimental data obtained by different levels of long-term anthropogenic load has clearly demonstrated the importance of adhering appointed agronomic crop rotation requirements for assembly rotation, which will allow to save the state of soil humus, and by the implementation of optimal fertilization will contribute effectively expanded reproduction of soil fertility. Using of crop rotation with high saturation level with cultivated crops (75%) inevitably leads to reduction of total humus content in the soil with a simultaneous deterioration of its quality parameters. Preventing these degradation phenomena can be possible only through the use of science-based organic-mineral fertilizer system [8, p. 224].

Hence, we had conducted the potential aspects of the soil organic matter due to the reconstruction of farms based on innovative technologies the loose cattle (Table 2) using a methodical approach to assessing the economic efficiency of modernization of farms with an emphasis on the need to consider both the costs and proceeds from the sale of all products of livestock with a phased increase in the productivity of cows and definition of land capacity of production and efficiency of feed area [9, p. 51].

According to the calculations for the milk production and growing of replacement young animals on a farm with 800 cows it should be 1312 hectares of arable land for grain crops and forage crops for supply their productivity of 5000 kg per cow. In order to increase productivity to 6000 kg (the second phase) the acreage of crops should be increased to 1504 hectares (on 14.6%) by the growth of productivity of cows to 7000 kg crop area should be increased to 1670 ha (on 27.3%). The farm with 1200 cows must have 1817 hectares of feed area with productivity of 5000 kg per cow, with cow productivity 7000 kg land capacity increased by almost a third.

The transformation of crop area is going with the increasing of productivity of cows in the direction of saturation of crops in rotation by reducing the share of forage crops, due to greater demand in concentrated feed cows.

At the same time the proportion of perennial grasses in the structure of feed area in all versions become greater than 25.5%, which is enough even by 30% of cultivated crops to provide a deficit-free humus balance with application 1 t/ha of manure a year and plow on the field 50 % straw winter wheat.

On the other side, the required output of organic fertilizers on 1 hectare of fodder area of the farm with 800 cows plume is 10,4-13,3 t, and a farm with 1200 cows plume – 8,3-10,8 t, it is enough to ensure a deficit-free humus balance.

Thus, given the cumulative positive effects of perennial grasses and organic fertilizers on potential soil fertility, it is possible through the development of livestock sector to provide not only simple, but also expanded reproduction of organic matter in the soil.

Table 2. Calculation of need for fodder area (land capacity) for the production of livestock, organic fertilizer output and efficiency of land use of pastoral enterprises of different sizes

Indexes	Milk yield per cow, kg		
	5000	6000	7000
Farm on 800 cows			
The feed area required for the farm (land capacity), ha	1312	1504	1670
The share of perennial grasses in the structure of the feed area, %	28.7	26.7	25.7
Normative output of organic fertilizers per 1 ha of fodder area, t	13.3	11.6	10.4
Normative formed humus for 1 ha of fodder area, t	678	592	530
Per 100 hectares of fodder area, centner: milk production	3049	3191	3353
live weight gain of cattle	85.7	74.7	67.3
Per 100 hectares of fodder area, thousand UAH: the cost of livestock	2250.5	2135.8	2167.0
proceeds (revenue) from sales	3105.5	3212.2	3365.5
income from sales	855.0	1076.5	1198.5
Cost recovery ratio	1.380	1.504	1.553
Farm on 1200 cows			
The feed area required for the farm (land capacity) ha	1817	2103	2353
The share of perennial grasses in the structure of the feed area, %	29.0	26.7	25.5
Normative output of organic fertilizers per 1 ha of fodder area, t	14.4	12.4	11.1
Normative formed humus for 1 ha of fodder area, t	734	632	566
Per 100 hectares of fodder area, centner: milk production	3302	3424	3570
live weight gain of cattle	10.8	9.3	8.3
Per 100 hectares of fodder area, thousand UAH: the cost of livestock	1925.0	1847.3	1905.5
proceeds (revenue) from sales	2975.0	3102.0	3223.8
income from sales	1050.0	1254.8	1318.3
Cost recovery ratio	1.545	1.679	1.692

**Note. Based on an average humification coefficient of 0.051, ie application 1 ton of litter manure provides 51 kg of humus formation.*

Source: authors' calculations.

The analysis of efficiency of feed area use indicates that the increase in the average milk yield per cow affected increase economic efficiency of cattle industry and land use.

For example, the profit from sales on the farm with 1200 cows and productivity at 5000 kg per cow is 1050.0 thousand UAH/100 hectares, for it's raising to 6000 kg income increased on 19.5%, and up to 7000 kg on 25.5%.

Thus, with increasing average milk yield per cow increased and the rate of cost recovery in the field of livestock sector and land use efficiency by simultaneously expanded reproduction of soil fertility.

The result of the study shows the possibility to increase not only the economic efficiency of production of animal husbandry, but efficiency of land use (primarily those areas that reserved for forage and grain crops) and provide enhanced playback organic matter in the soil by developing industry cattle through the reconstruction of existing and construction of new farms.

2.2. Potential economic effect from removing of arable land from intensive cultivation

In order to determine the potential economic effect of converting arable land to adverse physical, physico-chemical and technological to the meadows and afforestation on the first stage, we examined the relationship of economic efficiency intensity crop production (Table 3).

Table 3. Parameters of econometric models of dependence of the economic efficiency of arable land (У) using on the magnitude of the costs per hectare of arable land (x) in agricultural enterprises of Ukraine, 2014

Indicator	Linear regression model	Pair correlation coefficient (*r*)	Coefficient of determination (R^2)	Student's t-criterion		Fisher's F-criterion	
				T_{fact}	T_{table}	F_{fact}	F_{table}
Gross output ($У_1$)	$У_1 = 1608,4 + 0,653\ x$	0,898	0,806	21,9	2,06	91,3	4,26
Trading output ($У_2$)	$У_2 = 883,1 + 1,037\ x$	0,898	0,807	21,9	2,06	92,0	4,26
Pure output ($У_3$)	$У_3 = 282,2 + 0,480\ x$	0,876	0,768	33,7	2,06	72,8	4,26
Profit ($У_4$)	$У_4 = -211,6 + 0,246\ x$	0,732	0,536	12,8	2,06	25,4	4,26

Source: author's calculations.

The parameters of the developed models show that in 2014 an increase in the cost of 1 UAH/ha expected increase in gross production in constant prices of 2010 to 0.65 UAH/ha, trading output – up to 1.04 UAH/ha, pure output – 0.48 UAH/ha and profit – 0.25 UAH/ha. The coefficients of determination obtained equations indicate high closer approximation of normal distribution using the selected function type. Comparison of Student's t-test and F-test Fisher with tabular values demonstrates the accuracy and adequacy developed models. On the basis of an econometric model, we tried to estimate the probable economic effect of the withdrawal of degraded and marginal arable land with intensive cultivation (Table 4).

The expected economic effect from increasing production intensity is formed by rational redistribution of production costs (the same amount of resources will be applied to a smaller area, which will ensure the elimination of shortages of working capital and a higher concentration of advanced capital per hectare of land, besides better quality) and increasing their efficiency.

The calculation is made by three options which can display three scenarios or stages removing of arable land from cultivation. Thus, in the short term (to 2025) potentially it could be derived from the cultivation 5 mln ha of arable land, in the medium term (to 2030) can be derived from intensive cultivation 2 mln ha and, finally, in the long term (by 2040) we can predict the reduction of arable land for 3 mln ha and transfer it in the grasslands and under afforestation.

Table 4. Calculation of potential economic effects from removing of arable land from intensive cultivation in Ukraine, 2014

Indicator	Actual indicators in the 2014	Projected effects of removing of arable land from cultivation in the area, mln ha:			Projected effect in % to actual data of 2014		
		5	7	10	5	7	10
The area of arable land, mln ha	32,5	27,5	25,5	22,5	84,6	78,5	69,2
At the rate per 1 ha, UAH							
Production costs	8994	10629	11463	12991	118,2	127,5	144,4
Gross output	7300	8549	9094	10092	117,1	124,6	138,2
Trading output	9900	12288	13183	14822	124,1	133,2	149,7
Pure output	4598	5384	5784	6518	117,1	125,8	141,8
Profit	1940	2826	3031	3407	145,7	156,2	175,6
At the rate of the whole area of arable land, mln UAH							
Gross output	237250	235101	231890	227059	99,1	98,6	97,9
Trading output	321750	337920	336164	333505	105,0	99,5	99,2
Pure output	149435	148063	147503	146652	99,1	99,6	99,4
Profit	63050	77724	77303	76666	123,3	99,5	99,2

Source: author's calculations.

Thus, by reducing the area of agricultural land will be: 1) concentrating financial and material resources on soils more fertile; 2) increase the area under forage for livestock sector development; 3) ensure environmental sustainability in agricultural by restoring the relationship between natural systems (meadows, forests, agricultural land); 4) reducing the risk of degradation of agricultural land due to erosion of surface soil.

3. The effectiveness of sustainable soil management based on program-oriented approach at the macro level

Given the current state of the soil cover of Ukraine, to rectify any negative situation, a change of land use strategies is necessary, including through the adoption and implementation of the National Program of Soil Protection of Ukraine. Considering this in the NSC „Institute for Soil Sciences and Agrochemistry Research named after O. N. Sokolovsky" with the author of this publication it was prepared a draft of the revised and improved National Program of Soil Protection of Ukraine (hereinafter – the Program) as attempt to harmonize the strategy of using soil cover of Ukraine with the European Soil Policy [10]. It considers the basic positions of the Program, proves its scope, estimated costs and funding sources, organizational, technological and legal measures and mechanisms and stages of implementation and state control and the expected results of its implementation. Financial and economic aspects of the Program, certainly, are among the most urgent, so we consider them in detail.

The total cost of total work complex for 10 years on prices of 2015 is 603.128 bln UAH, of which 11.099 bln UAH – the state budget and local budgets, the average total funding of 60.313 bln UAH. Without the cost of mineral

fertilizers the total amount of financing of the Program for 10 years equals 53.128 bln UAH (average – 5.313 bln UAH), including funds (Table 5): state and local budgets – 11.099 bln UAH, representing 20.9 % (average – 1109.9 million UAH); at the expense of landowners and land users – 42.029 bln UAH, accounting for 79.1% (average – 4202.9 million UAH).

Table 5. Projected amount of expenditures by Program according to funding sources

Funding sources	Projected amount of expenditures, mln UAH					
	2016-2020		2021-2025		2016-2025	
	Total	Average per year	Total	Average per year	Total	Average per year
Budget funds (State and local budgets)	5570.6	1114.1	5528.6	1105.7	11099.2	1109.9
Costs of land users and landowners and other sources	240701.9	48140.4	351326.9	70265.4	592028.8	59202.9
including without mineral fertilizers	20701.9	4140.4	21326.9	4265.4	42028.8	4202.9
Total	246272.5	49254.5	356855.5	71371.1	603128.0	60312.8
including without mineral fertilizers	26272.5	5254.5	26855.5	5371.1	53128.0	5312.8

Source: author's calculations.

Expenditures for the implementation of Programme's activities are determined by the Cabinet of Ministers of Ukraine and local authorities during the drafting of state and local budgets for the year. Potential funding sources of soil-protective activities under the Programme could be [11]:

- channeling funds (30%) of the single tax that replaces the fixed agricultural tax, the estimated amount of annual revenues – 813.9 million UAH;
- the introduction of tax on soil protection in the amount of 0.5% of the normative monetary value of agricultural land, the approximate amount of annual revenues – 2474.8 million UAH;
- channeling of funds (30 %) of the land tax, provided the increase of its stake to 1% of regulatory monetary value of arable land, estimated amount of annual revenues – 703.5 million UAH.
- it is possible simultaneous use of several versions. Depending on which version of the budget funding for reproduction of soil fertility will be selected, it will be formed appropriate relationship between different sources of funding priorities soil-protective measures.

Additional potential sources of funding priorities soil-protective measures in agriculture of Ukraine could be:

- fines on violations of soil-protective law and the funds received as compensation for losses of agricultural and forestry production.
- funds of international currency investments of the World Bank, International Monetary Fund, European Bank for Reconstruction and Development and other international financial organizations; funds of private equity funds,

international grants; funds allocated under the sector budget support from the European Union and international technical assistance; other sources that are not prohibited by law.

Calculation of economic efficiency of Programme was conducted taking into account ecological and socio-economic results of its implementation. According to preliminary calculations, the projected annual total economic effect of increasing crop yields by 40-50%, which can be reached in case of implementing the anticipated measures for rational use of soil resources in agricultural enterprises of Ukraine equals 110.3 bln UAH of additional income for 2016-2020 and about 137.8 bln UAH per year for the 2021-2025 (Table 6).

Table 6. Projected calculation of economic benefits from the use of agricultural enterprises in Ukraine measures for rational use and protection of soil resources, projected by the Program

Indicators	Actual data by 2014		Price realization in the 2015 UAH/t	Calculated data on average per year					
				Increase of productivity, c/ha		Additional gross yield, ths. tons		Additional income, million UAH	
	Gathering area, ths. hectares	Yield, c/ha		2016-2020	2021-2025	2016-2020	2021-2025	2016-2020	2021-2025
Cereals and legumes	10507.2	47.5	2905.1	19.0	23.8	19963.7	24954.6	57996.5	72495.6
Sugar beets	297.8	490.2	633.7	196.1	245.1	5839.3	7299.1	3700.3	4625.4
Sunflower	4226.0	20.5	7633.3	8.2	10.3	3465.3	4331.7	26451.8	33064.8
Flax	1.3	6.3	7256	2.5	3.2	0.3	0.4	2.4	3.0
Soybean	1677.8	21.9	7626.9	8.8	11.0	1469.8	1837.2	11209.7	14012.1
Raps	839.5	25.6	7303	10.2	12.8	859.6	1074.6	6278.0	7847.5
Potato	29.6	256.4	2095.6	102.6	128.2	303.6	379.5	636.2	795.2
Vegetables	38.7	346.4	4622.6	138.6	173.2	536.2	670.3	2478.8	3098.5
Food melons	6.8	65.4	1081.5	26.2	32.7	17.8	22.2	19.2	24.0
Fruits and berries	61.7	53.7	7396.7	21.5	26.9	132.5	165.7	980.3	1225.4
Grapes	31.6	76.4	5157.6	30.6	38.2	96.6	120.7	498.1	622.6
Total								110251.2	137814.1
Projected annual additional profit by achieved in 2014 profitability of crop production (29.2 %), million UAH								24917.5	31146.8

Source: author's calculations.

By achieved in 2014 profitability of crop production (29.2%) annual additional profit in 2016-2020 can reach 24.9 bln UAH, during the 2021-2025 – 31.1 bln UAH, ie profitability program activities is about 51%. Ratio payback of 1 UAH costs of Programme activities by cost growth yield (income) depending on the crops is 1.9-2.2 UAH.

But perhaps the most important environmental and economic impact is suspension of the main types of soil degradation and achieving simple reproduction

of soil fertility, prevent (minimize) the ecological and economic losses each year worth about 40 bln UAH, including: a) by providing a balance of humus and nutrients – 23 bln UAH; b) reducing the environmental and economic impact of production shortfall and loss of soil through erosion – 17 bln UAH [8, p. 31].

Social efficiency will be achieved through guaranteeing the food security of the population, maintaining complete living environment and the preservation of existing and creation of new jobs. In addition, social efficiency will lie in the fact that the formation of additional payroll will serve as an additional source of filling the state social funds.

Budget efficiency is in that fact the formation of additional income and profit will allow providing additional income taxes and duties to the state and local budgets.

Thus, it is necessary to adopt a National Program of Soil Protection of Ukraine to attract specialized scientific institutions to its implementation and to find appropriate sources of funding (through the land of taxes and the expense of land users).

We need to restore funding from the state and local budget for land protection programs (national, regional, district), give them priority status. Considering the basic provisions of the Concept of reforming local self-government and territorial organization in Ukraine should develop and translate into practice of Regional programs of land protection and reproduction of soil fertility. Kharkiv region could be interesting to introduce appropriate pilot project for the protection and reproduction of soil fertility.

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RENEWABLE ENERGY FOR FOOD PREPARATION PROCESSES: LIFE CYCLE ASSESSMENT CASE STUDY

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1. Introduction

Economic development results in increased human impact on the environment. Modern companies are forced to face more and more demanding: legal, economic and social requirements which are taken under consideration for environmental aspects. Entrepreneurs are looking for a way to establish such a management system where both production and environmental targets are achieved. To systematize these tasks and ease their implementation, guidelines for environmental management systems (EMS) were developed, which should be closely linked to the overall management system. Examples of such guidelines are a series of ISO 14000 [1, 2] as well as EMAS Regulation [3].

Food preparation processes consume relatively considerable amount of energy compared to other activities in commercial and residential buildings. High energy demand contributes to environmental impact connected with fossil fuels depletion and harmful emission of pollution. The use of renewable energy sources is a very popular way to reduce environmental impact of energy generation.

The main aim of this study is to discuss issues associated with food preparation processes from energy consumption perspective. The discussion will be illustrated by case study concerning product life cycle assessment for food preparation appliances and renewable energy application.

2. Energy consumption in food preparation processes

Economic development and life quality improvement cause gradually increase of energy demand. Power generation traditional techniques, based on burning of fossil fuels, entail various environmental issues, i.e. public health effects due to pollution, corrosion intensification, agricultural crops reduction, greenhouse effect, etc [4]. That is the reason to search for alternative methods of energy production, including renewable energy sources, that do not depend on fossil fuels accessibility and have lesser environmental impact. However, despite intensive development of renewable sources technologies, which has been observed for last decades, the amount of energy produced from them is insufficient. According to global data, only 9% of energy is produced using renewable energy sources, and only 6% – excluding hydropower plants (see Figure 1).

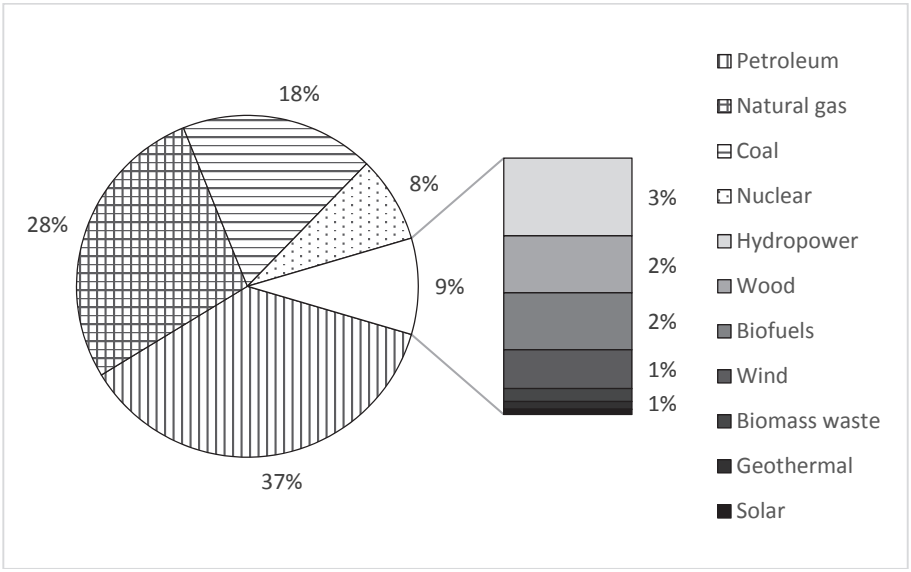

Figure 1. World energy consumption ratio by energy sources
Source: U.S. Energy Information Administration, 2012.

There are three main energy consumers in the economy, namely: industry, transportation and buildings. Buildings have the greatest share in energy use reaching almost 40% [5]. This percentage distributes approximately evenly on commercial and residential buildings, representing 18% and 21% of energy consumption, respectively (see Figure 2).

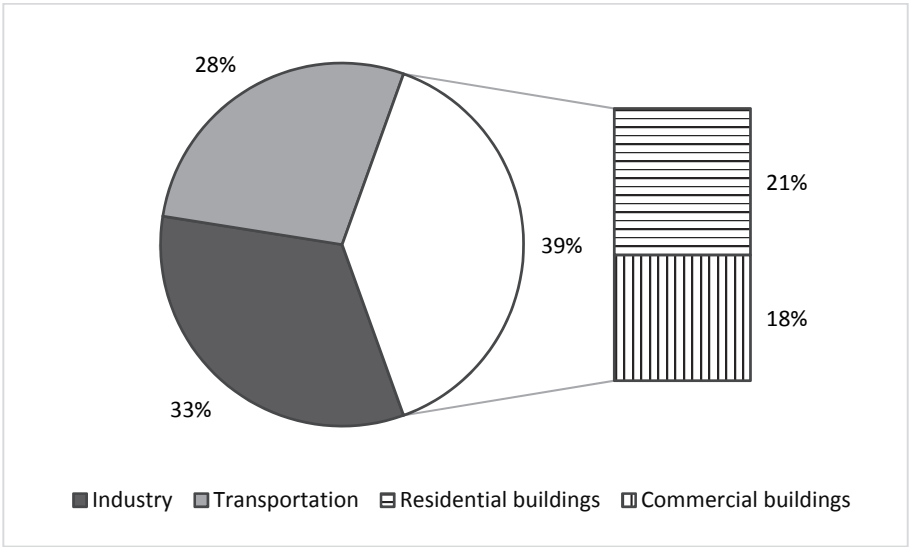

Figure 2. Buildings share of energy consumption
Source: Building Overview Climate TechBook, PEW Center on Global Climate Change, 2009.

Among different types of commercial buildings, the most intensive energy consumers are buildings used by food service companies [6] (see Figure 3). In case of residential buildings, food preparation, may also be one of the main activities contributing to energy consumption, depending on country. According to UK residential data, 12% of electricity is used for cooking, and 13% is used for refrigeration. Thus, a quarter of electricity is consumed for food preparation purposes, that is comparable amount with energy consumption for heating, lighting and entertainment [7].

One of traditional ways to reduce environmental impact connected with energy demand is use of renewable energy sources. Despite large amount of energy consumed by food preparation processes, that is quite difficult to replace it with renewable energy. Usually the cooking uses electricity or gas. Electricity comes from national grid where the percentage of renewable energy sources for most countries is rather low and majority of power is generated basing on fossil fuels. One may consider photovoltaic panels or wind turbines application and produce green electricity for household/commercial building's needs, but the aim of the change like this would be more universal than perspective of food preparation only. That is also difficult to replace gas used for cooking/baking (no matter natural or liquid) with renewable fuel. Biogas production needs steady organic raw material supply, as well as complex equipment which is not available for most buildings.

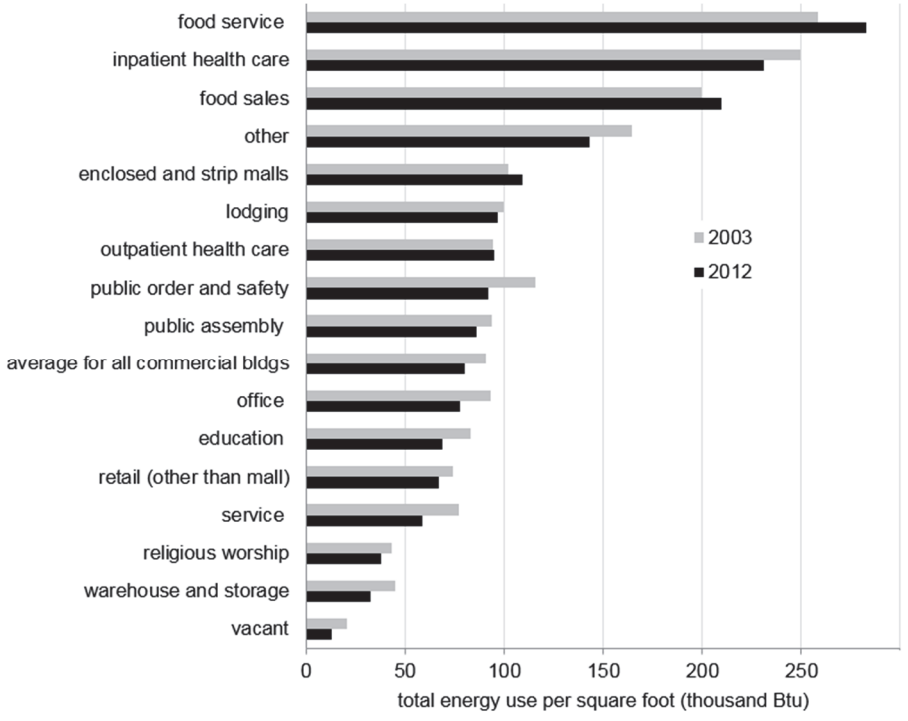

Figure 3. Energy consumption by commercial buildings
Source: U.S. Energy Information Administration, Commercial Buildings Energy Consumption Survey.

Wood and charcoal are biofuels that are directly used as energy carriers in traditional processes of food preparation such as baking or grilling. An undoubted advantage of the processes is renewable energy use, but there are also significant disadvantages:

- relatively low efficiency,
- emission close to in densely populated area.

Solid fuel burning entail lower efficiency compared to different energy carriers use such as electricity or gas. Low efficiency results in increased fuel consumption. This is a disadvantage not only from economic but also from environmental point of view. The more fuel is burned, the more pollution is emitted.

Central power plants that produce most electricity, are usually located far from big towns. Harmful emissions occur in low populated area. Moreover, professional emission reduction devices are often applied, as more beneficial in big power generation scale. An environmental impact associated with human health problems is therefore reduced. However, in case the fuel is being burned within food preparation process, emission has a direct impact on people.

It is very difficult to predict whether or not the above discussed disadvantages outweighed the advantages

It is very difficult to predict whether or not the advantages resulting from renewable energy sources application are able to outweigh the disadvantages discussed above. To answer this question, life cycle assessment could be an invaluable help.

3. Life cycle assessment

Environmental protection should be seen both in the manufacturing process and production phases as well as in whole life cycle of products manufacturing – „from cradle to grave" approach. Environmental impacts of all phases of the life cycle should be taken into account:

- acquisition of resources (metal ores, crude oil, coal extraction processes, etc.),
- raw materials production, from which the final product will be made (metals, alloys smelting processes),
- materials and semi-products transport (influence of transport ways on the environment),
- final product production processes (impact of operations on the environment),
- packaging production,
- supplying products to customers (distribution influence on the environment),
- phase of product usage (used materials, energy consumption),
- waste disposal – getting rid of product, packaging and materials after being used up (environment impact of disposal methods such as re-use, recycling, landfill operations, incineration, etc.).

The environmental impact of the above-mentioned stages of the product life cycle usually depends mostly on the designer, who by his decisions determines: raw materials usage, energy consumption, etc. Design phase grows to the most

important from the point of view of the product influence on the environment. To help the designer to take account of environmental considerations in his decisions so-called eco-design guidelines were created. They are determined by the ISO 14040:2006 [8] and ISO 14044:2006 [9].

Environmental life cycle assessment is very useful tool for companies applying modern approach to production activities. The environmental management system consistent with ISO 14001 standard has often been implemented in the organizations like these. After the years of continual improvement, running environmental programmes and achieving goals, a very high level of environmental performance has been obtained. In such cases, significant environmental aspects may result less from direct industrial activities (as the field which has been successfully improved), and more from indirect environmental aspects. The latter are related to the supply chain (the actions of external companies which provide raw materials and media), products distribution, phase of products usage and disposal. Life cycle assessment of a given product can reveal that most important environmental impacts result not from industrial activity of producer but from the other stage of the product life cycle. An example of the environmental impacts for company producing domestic appliances is shown in Figure 4.

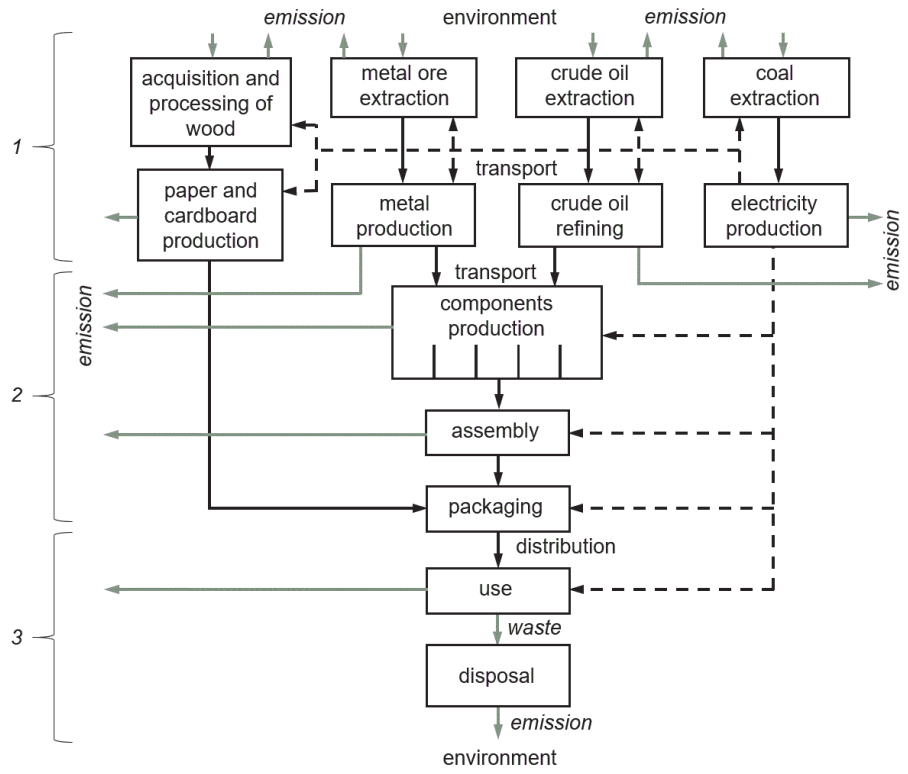

Figure 4. Simplified diagram of impacts on the environment of life cycle of an electric appliance for food preparation
Source: own research.

Different types of material and energy flows are marked with different colours of the arrows:

- grey colour – environmental impact (natural resources, emission, waste),
- black colour – raw materials, half-finished products, products,
- black colour, dashed line – energy.

Diagram has been divided into three main parts with different specificities. The central part (2) represents direct environmental aspects, associated with activities of the organizations under their direct management control. Indirect aspects are represented by the other parts of the diagram, symbolizing the preparation phase for the production (1), phase of the operation by users and waste phase, when the used product becomes a waste (III).

1. The extraction of raw materials from the environment and their processing – indirect environmental aspects are associated with the use of given raw materials and energy by the organization. Impact on the environment results from consumption/depletion of non-renewable resources (e.g. coal, crude oil, metal ores) and renewable resources (e.g. wood) and emissions associated with the extraction, processing and transport. Reduction of environmental impacts can be done by optimizing the selection of raw materials, having an effect on the activities of suppliers and subcontractors or amending them.
2. The activities of the organization which produces analysed product – in this field, the organization has full management control over its environmental aspects, which include emissions, efficiency of production, raw material and energy consumption (per unit of product produced), the quantity of waste generated, fuel consumption for transport fleet, maintenance of equipment, the occurrence of emergency situations, etc. Their impact on the environment depends strongly on the organization.
3. The use of domestic appliances and disposal of waste products –environmental aspects related to this phase result from the product features, such as energy consumption, the demand for additional materials, the properties of materials that were applied for production (from waste scenario perspective – recyclability, decomposition harmfulness, etc.), but may also result from incorrect operation by users. In this phase the most important source of information about environmental aspects may be opinions of customers and information about their behaviour. Reducing the environmental impact can mainly be obtained at the design stage of the product, taking into account comments of users on the utility, energy consumption, product durability, etc.

Life cycle assessment allows the comparison of environmental impacts of different products. In case of similar products (the same function, capacity scale, similar life cycle scheme), the analysis like this can be carried out by direct comparison of products' life cycles. However, in case of more important differences between compared products, environmental impact can be assessed relating to their function. This is a very useful approach, which enables comparison of products that have various capacity, scale and even totally different way that they are used, but there is a very important condition: products should

fulfil the same function. The comparison is carried out by means of functional unit as the essential figure to which the environmental impact is referred.

4. Grill comparison – LCA case study

4.1. Input data and model assumption

As it has been mentioned before, renewable energy sources applied for food preparation besides undeniable advantages entails also serious disadvantages compared to grid electricity. The main aim of this chapter is to investigate and compare environmental impact of traditional charcoal grill and its equivalent – electric grill. For this purpose, life cycle assessment has been used. Apart from material and structure differences between two analyzed appliances, traditional grill represents renewable energy use, whereas electric one – electricity consumption.

In order to avoid problems concerning functional unit determination, similar dimensions appliances have been chosen for this comparison. Both the devices enable to grill similar amount of food each time. The inventory of materials used for both products are presented in table 1.

Table 1. Inventory of materials used for traditional and electric grill production

electric grill

Part name	Mass, g	Material
glass cover	1114	glass
handles	183	PF
screws, etc.	26	stainless steel
heater	1547	steel
	309	nickel
	77	chromium
plate for fat	395	tin plate
base	757	PP
cable	112	PVC
	63	copper
termostate	33	PF
	28	non-ferro metals
	33	stainless steel
legs	20	PF
packaging box	439	cardboard
styrofoam	73	styrofoam

traditional grill

Part name	Mass, g	Material
stand	3912	steel
grill frame	576	stainless steel
handles	18	wood
wheels	156	PP
axle	65	steel
screws, etc.	7	stainless steel
packaging box	545	cardboard

Source: own survey.

Apart from materials necessary to manufacture the appliances, the other life cycle phases should be also described. In case of charcoal burning process, majority of heat energy is dissipated in vicinity, whereas in case of electricity use, most of energy is used for food preparation purpose. As the result of this, far lower energy efficiency was assumed in case of traditional grilling compared to electric one. For whole life cycle of the products, the following amounts of fuel/energy was determined: 59.6 kg of charcoal and 266.7 kWh of electricity. Similar

assumption concerning waste scenario was made for both cases: particular materials will be partly recycled and partly landfilled. The share of recycling depends of material type. In case of metals and metal alloys the proportion reaches 75% and for glass, plastics, cardboard and wood, as less valuable materials – 50%.

SimaPro software has been applied to support life cycle assessment. Eco-indicator 99 methodology has been chosen for subsequent LCA stages. The results obtained for single grill are presented in form of process network separately for assembly and whole life cycle of the products. As the analysis is very detailed, in order to avoid information chaos, only the most significant blocks are shown each time. The products comparison is presented by means of bar charts.

4.2. LCA results

Figure 5 shows process network for traditional grill production phase (assembly). The most important environmental impact results from steel parts production (77%). This is no surprise, as steel predominates among various materials. It would not be too easy to find another material to replace steel successfully in this case, as it stands high temperature and is quite popular. The influence of packaging is, by contrast, negligible (less than 8%), as it is made of cardboard that is renewable and biodegradable material.

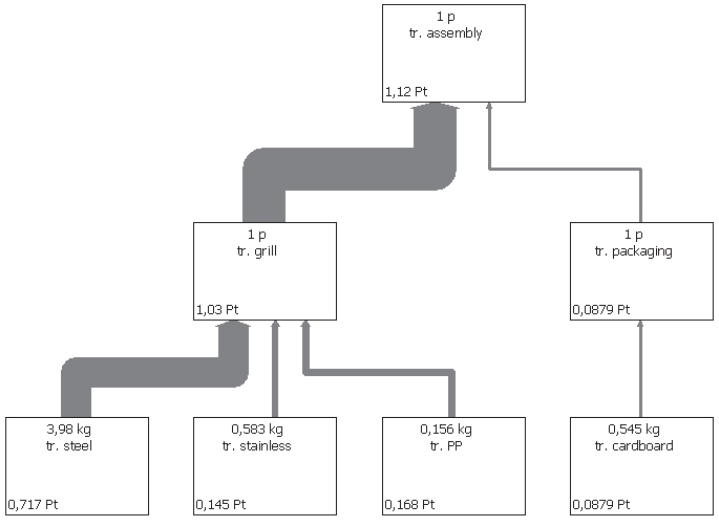

Figure 5. Process network for production phase of traditional grill
Source: own research.

Figure 6 shows process network for production phase of electric grill. Metals are again the most significant factor, but non-ferrous metals this time. Nickel production environmental impact predominates as it is the main component of electric heaters of the grill. Packaging share is again negligible (less than 2%) although it consists of styrofoam besides cardboard.

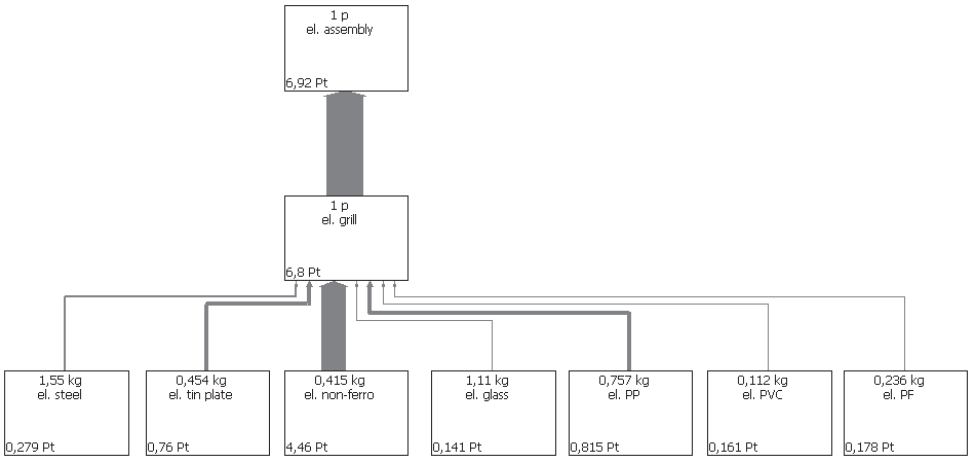

Figure 6. Process network for production phase of electric grill
Source: own research.

Figures 7 and 8 present process network for whole life cycle of both analyzed products. A common feature can be observed: environmental impact of production phases is overwhelmed by charcoal and electricity consumption during product usage phase. Energy demand for food preparation dominates over other life cycle elements reaching 81% and 74% respectively. Waste scenario contribution to total life cycle environmental impact in both cases is negligible (ca. 0.3%).

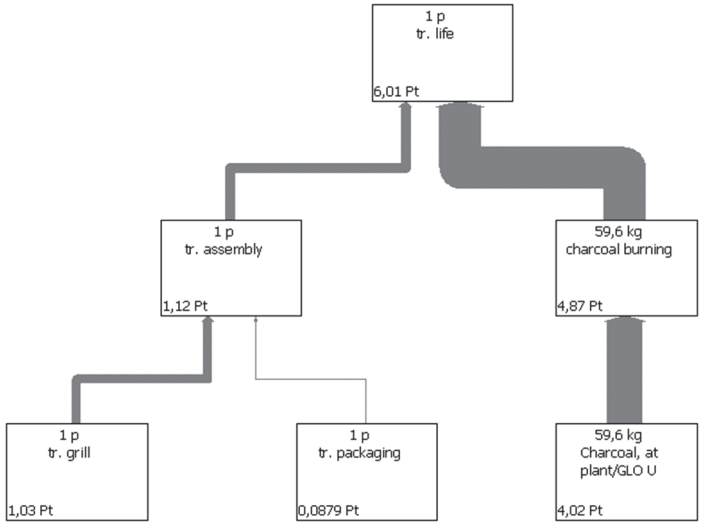

Figure 7. Process network for life cycle environmental impact of traditional grill
Source: own research.

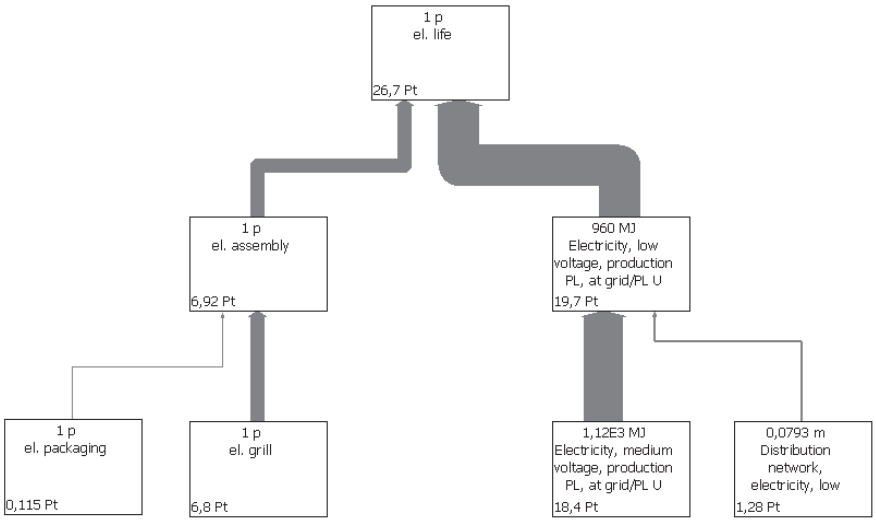

Figure 8. Process network for life cycle environmental impact of electric grill
Source: own research.

On the basis of results discussed above, a conclusion may be drown that searching for energy carrier replacement has been well-founded idea as it concerns dominating environmental impacts in analyzed cases. Thus, the most important question concerns environmental performance of two different types of energy carrier: charcoal and electricity.

4.3. Product comparison

Figure 9 presents comparison between environmental impact of full life cycle of traditional grill (white bars) and electric grill (grey bars). The impact is expressed by normalization indicators separately for three groups of impact categories: human health, ecosystem quality and resources. An environmental impact of electric grill is much higher for human health and resources use compared to adequate impact of charcoal grill. However, traditional grill is a bit more harmful for ecosystems. Normalization results clearly indicate that electric grill has greater environmental impact compared traditional one. The same conclusion can be drawn on basis of single score results (including weighting) – see Figure 10. The indicators reach totally different values: 26.7 Pt (where 19.7 Pt results from electricity consumption) for electric grill and 6.0 Pt (where 4.9 Pt results from charcoal use).

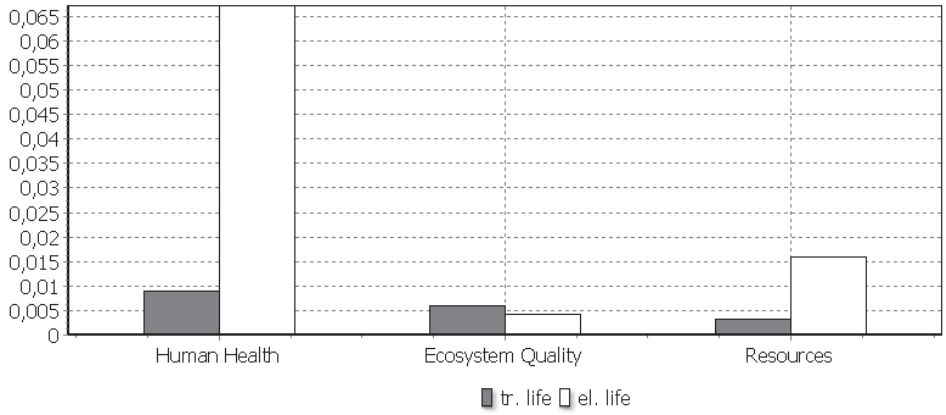

Figure 9. Environmental impact comparison for life cycle of traditional and electric grill: normalization procedure
Source: own research.

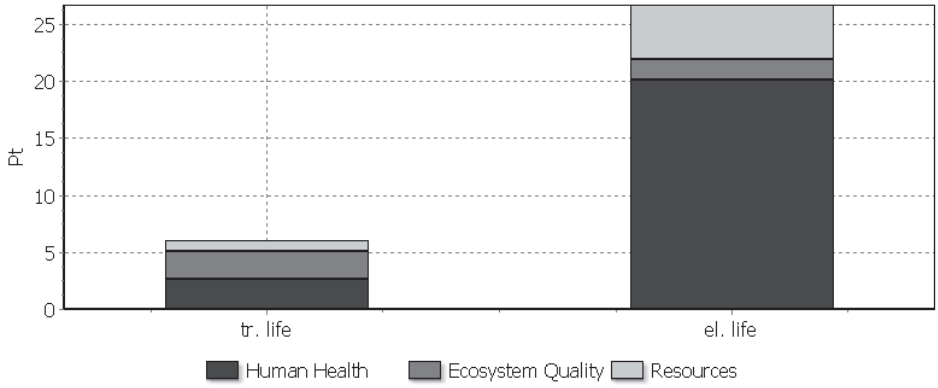

Figure 10. Environmental impact comparison for life cycle of traditional and electric grill: single score procedure
Source: own research.

4.4. Uncertainty and sensitivity analyses

Amounts of various materials presented in table 1 were determined at different accuracy. Most of them were weighted to within 1 gram although in some cases in was difficult to determine so accurately, as analysed parts of electric grill consisted of materials that were inseparably connected, e.g. alloys. Mass of particular materials was estimated with some error in cases like that. However, obtained LCA results revealed the most significant environmental impact was associated with energy needed for food preparation, thus the mentioned inaccuracies did not affect general conclusion.

Energy demand in case of domestic appliances depends on users/householders personal manners and habits. Both for electricity and charcoal amount determination some assumptions were necessary. As quite optimistic scenarios

were assumed, the energy demand was determined moderately. If amount of electricity and charcoal were greater, the general conclusion would be pretty much the same. Stronger domination of energy impact over remaining life cycle elements would be observed.

5. Conclusions

On basis of the analysis of the experimental results the following conclusions can be drawn.

1. The most significant share of environmental impact results from energy demand for food preparation. This factor dominates over other life cycle elements reaching 81% in case of traditional grill and 74% in case of electric grill.
2. If it comes to production phase (from-cradle-to-gate approach) the most important impact is connected with metals used in appliances (77% in case of traditional grill and 81% in case of electric one). It is quite difficult to reduce the impact, as the devices need materials resistant to high temperatures of food preparation processes, as well as resistive materials for heaters construction in case of electric grill.
3. Waste scenario contribution to total life cycle environmental impact in both cases is negligible (ca. 0.3%).
4. Contribution of packaging production to total environmental impact was very low in both cases reaching less than 1.5% for traditional grill and 0.4% for electric one.
5. The reduction of environmental impact of analyzed appliances' life cycles should be based first of all on increase of energy efficiency of food preparation process, as the impact is associated mostly with charcoal and electricity consumption. The products should be designed taking into account proper heat dissipation and prevention of energy loss. Apart from construction geometry, the efficiency depends on personal habits and manners of users who operate grill. Manufacturers can provide a manual including tips aiming to reduce charcoal or electricity consumption.

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ACTIVE AND INTELLIGENT PACKAGING IN TERMS OF FOOD SAFETY

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1. Introduction

Packaging intended to come into contact with food shall meet certain requirements. The most important fact is whether the packaging itself, and more specifically the material of which it has been produced, is inert in relation to food which comes into contact with it. The intensity of transferring, and thus the substance released from the packaging material that comes in contact with food, depend mainly on the type of food that comes into contact with the packaging, heat treatment, ambient temperature of the surrounding in which the commodity is stored, time of storage as well as exposure to UV radiation. Inert interaction of the material, which the food packaging has been made of, is a key criterion of usefulness of a given material. The lack of interaction between the material and food causes that certain packaging may be classified as the group of „safe" packaging. Micromolecular substances, used during production, being released from the packaging during contact with food, will enter to a human body via oral route with high probability, and may pose risk to health and even life [2].

The main objective of food packaging is ensuring quality and reducing losses of the nutrition value of the product. Regardless packaging is made of glass or cardboard, the packaging itself should prevent getting microbiological and biochemical contamination from the outside to the product. Appropriate airtightness of the packaging affects the amount of additives, which prolong the shelf-life, to food and prevent penetration of contaminants. The airtightness of the packaging is also responsible for maintaining proper form of the product, its shape and structure; it prevents loss of smell, extends the shelf-life and maintains proper humidity. In many cases, the appropriate choice of material of which the packaging has been made, might directly affect the nutrition properties of the product. Wrongly selected packaging, its transparency, is able in case of such products as dairy products, cause reduction in B2 vitamin content that is sensitive to sunlight.

Technological development, assistance of a number of scientific units, extension of research of new materials, cause that the packaging market is one of the most innovative and fastest growing industries. Applying innovation in packaging increases the attractiveness of the product, which directly translates into demand [1]. In addition to traditional packaging, e.g. made of glass, the use of modern materials combined with plastics increases. Dynamic technological development of its production causes that today's packaging is composed of multiple layers. This composite structure combines a variety of materials, such as previously mentioned plastics based on PP, PE as well as paper, cardboard or

aluminum foil. The outer part of the package should have good functional and marketing properties whilst inner part of the packaging should be „safe". Applying vacuum packaging revolutionized storage of such products as coffee or tea. Vacuum packaging reduces contact of the product with air and prolongs its freshness. Another way to increase food safety is modified atmosphere packing – MAP. It is based on the change of the composition of gas remaining in contact with food by replacing air with single gas or specially formulated gas mixture [1]. The MAP vacuum packaging is useful in case of products with high content of fats. Furthermore, special adsorptive materials are used, which change gas composition inside the packaging during storage. Adsorption of oxygen reduces development of aerobic bacteria and reduces severity of rancidity of fats [1, 2].

Another innovation in terms of packaging is functionality of use, e.g. the „sous-vide" technique. It enables packaging of a food product in vacuum and then, after pasteurization, its storage while maintaining nutrition values, taste and structure. Products stored in this packaging are ready to be cooked in microwave without opening, as polyethylene and crystalline polyethylene materials, which are resistant to high temperatures, are used to produce the packaging.

2. Contemporary definition of „packaging", packaging market

In the light of the above-stated tendency of packaging development, packaging may by understood as an article intended for storage, protection, transportation, delivery and presentation of any products, starting at raw materials and going up to processed commodities. The packaging should have a practical and marketing function in order to attract a consumer to purchase the item. Environmental requirements [3] force manufacturers to produce eco-friendly and recyclable packaging. In accordance with the Act [4], Art. 3.1. packaging is an article, also an article that is non-refundable, made of any kind of material, intended for storage, protection, transportation, delivery and presentation of goods, from raw materials to processed commodities.

The packaging is considered to be [4]:

a) An article that functions as packaging referred to in paragraph 1, without prejudice to its other functions, excluding an article whose all elements are intended to common use, consumption or removal, constituting an integral part of an article and required for storage, maintaining or protection of the product throughout the cycle and period of its functioning,
b) An article that functions as packaging referred to in paragraph 1:
   - made of, and intended to be filled in the point of sale,
   - non-reusable – sold, filled in, manufactured or intended to by filled in in the point of sale,
c) A component of packaging and an auxiliary element joined to the package, functioning as packaging referred to in paragraph 1, provided that the auxiliary element joined directly or attached to the product is deemed to be packaging, with the exception of an element which constitutes an integral part of the product intended to common use or removal.

The following categories of packaging have been distinguished in the Act [4]:

a) Unite packaging – used for handing over a product to a user in the place of purchase,
b) Collective packaging – containing multiple unit packaging, regardless of whether it is handed over to a user or used to supply to points of sale that can be removed from the product without spoiling the characteristics of the product,
c) Transport packaging – used to transport products in a unit or collective packaging in order to prevent damage to products, excluding containers used in road, rail, water or air transport.

In case of food products, it is impossible to launch them into trade without packaging and this refers to liquid and dry products. In the process of sale, food products constitute, as it is called, an integrated product where combination of independent articles, i.e. a product and packaging, makes the packed product the object of trading as well as a market offer [5]. The world market of plastic packaging has reached the value of USD 259.6 billion in 2013 according to Transparency Market Research (TMR) [6-7]. It is predicted that its value will rise to USD 370.2 billion at the end of the year 2010. Dynamic development of pharmaceutical and food industry has increased demand for plastic packaging. The global market of plastic packaging has been generally divided into several regions such as Asian, European, Pacific, North American and other countries of the world. Among them, Asian and Pacific regions showed the highest demand and amounted to 35% of the world plastic packaging market in 2013 [6-8]. This region is likely to be an undisputable market leader due to increasing use of plastic packaging in medical industry and growing demand for food packaging.

The packaging market in Poland is measured according to the value of packaging sold. It is developing together with the Polish economic growth and the level of affluence within society. According to the analysis of the Polish Chamber of Packaging, the value of the packaging market in 2014 amounted to approximately EUR 8.0 billion (PLN 35 billion), which amounts to approximately EUR 212 (PLN 890) per capita.

The biggest development of packaging market in Poland took place in 2000-2008 (approx. 8-10% per year). In the years 2009-2013, there was a decline in the rate of development of the packaging market to 3.5-6% per year, which resulted from a slowdown in economic growth both in the USA and Western and Central European countries [9].

3. Materials to come into contact with food

3.1. Legal status

In trading, the food comes into contact with lots of materials during storage, preparation and serving, which are referred to as Eurofins Product Testing (FCM). Such materials should be sufficiently inert so as to their components would not have negative impact on the consumers' health and would not interact with the quality of the food. In order to ensure safety and free flow of commodities,

the European Union (EU) has launched a series of legal requirements and controls [11]. The EU law introduces mandatory standards that have to be obeyed by the entities operating on the market. The standards may have a general range, i.e. apply to all (FCM), or a specific one, which refers to certain materials only. The regulation (EC) No. 1935/2004 introduces a harmonised legal framework at EU level. It provides general safety and inertness standards for all (FCM).

In accordance with the provisions of the Regulation (EC) No. 1935/2004 the material should not [12]:

- Preclude substance from being transferred to food in quantities that are harmful to human health,
- Cause unacceptable changes in the composition of the food, its taste and smell.

Furthermore, the Regulation [12] introduces as follows:

- Special rules regarding active and intelligent materials (which, by virtue of their structure, are not inert),
- Authorization to introduce additional legislative measures at EU level in the scope of specific materials (e.g. plastics),
- Procedure for carrying out assessment of safety of substances used in manufacturing (FCM) with the participation of the European Food Safety Authority,
- Labelling rules, including information on using (e.g. coffee machine, wine bottle or soup spoon) or providing a symbol,
- Compliance and traceability documentation.

3.2. Good manufacturing practice

Regulation (EC) No. 2023/2006 [13] provides constant compliance with the requirements in the field of manufacturing (FCM) through:

- Appropriate organisation of the premises and knowledge of staff on critical stages of production,
- Implementation of documented quality assurance system and quality control system in the plant and the selection of appropriate starting materials for production, with a view to safety and inertness of final articles.

In addition to general provisions, some of them (FCM) – such as ceramic materials, regenerated cellulose film, plastics (including recycled) and active and intelligent materials, are covered by specific EU legal measures. There are also specific rules applied in relation to starting substances used for manufacturing (FCM).

3.3. Information policy

The producers (FCM) also have to provide appropriate information regarding safe use of its products. The information should be directed to further users in the supply chain to ensure proper use of indirect materials, and include instructions

for consumers indicating, where necessary, on safe and proper use of the articles [11].

There are principles of compliance of plastic materials and specifications, and limitations regarding the use of these substances in Regulation No. 10/2011 [10, 14]. The latter ones include migration limits that specify the maximum quantity of substance that is allowed to migrate to food. Total migration of substance from plastic to food cannot exceed 60mg/kg of food.

Efforts aiming at the best possible use of resources mean that recycled materials are more and more popular in the manufacturing sector. For this reason, Regulation (EC) No. 282/2008 provides the principles for recycled plastics that might be contaminated with unknown substances. Active and intelligent materials prolong the shelf-life by preserving or improving the condition of packed food, releasing substances to food or its surrounding, or by absorbing them. Therefore, they have been included to general principles of inertness of materials referred to in Regulation (EC) No. 1935/2004 [12]. Detailed rules referred to in Regulation (EC) No. 450/2009 on active and intelligent materials and articles intended to come into contact with food [17] are applied here, and take into account their specific purpose, e.g.:

- Absorption of substances from the inside of packaging, such as liquid or oxygen,
- Releasing substances to food, such as preservatives,
- Indicating food that pasted its sell-by date through releasing substances causing the change of colour depending on the time and temperature of storage,
- Substances responsible for active and intelligent feature of a given material or article should be reviewed in order to guarantee their safety and compliance with the requirements of Resolution (EC) No. 1935/2004 [12],
- In some cases, it may be necessary to assess and provide authorisation to use a combination of substances, when an active or an intelligent feature entails interactions among different substances [17],
- Food additives and enzymes may be located in a material or be immobilized in it, and interact technologically on food; such use is covered with legislation on food additives and enzymes,
- For active and intelligent materials and articles, at trading stages other than a point of sale to a final customer; a written declaration whether they come into contact with food or not is attached.

Labelling is the main communication tool with retailers and consumers. The retailers and the consumers should follow appropriate instructions for use to avoid contamination of the product.

In the absence of specific provisions at the EU level, the member states may introduce internal legal measures. There are no, for instance, detailed legal measures at the level of EU in the scope of paper or cardboard, metal, glass and printing inks. Some member states have therefore introduced their own rules.

4. Active and intelligent packaging

Active packaging is packaging that actively changes packed food in order to extend its shelf-life, provide microbiological safety of products. Active packaging is called interactive packaging in case of which the product, the packaging and the surrounding interact with each other.

Due to their function, the group of active packaging can be divided into two main groups. The first of them is a group of absorbers (Table 1).

Table 1. Examples of application of various absorbers [17-19]

Type of absorber	Examples of compounds	Use
Oxygen scavengers	Compounds of iron, ascorbic acid, metal salts, glucose oxidases	Cheese, bread, candy, nuts, milk powder, coffee, tea, beans, cereal, meat
Water absorbers	Silicone gel, glycerol	read, meat, fish, poultry, fruit and vegetables
CO2 absorbers	Calcium, sodium or potassium hydroxide	Roasted coffee
Ethylene absorbers	Aluminium oxide, active carbon, potassium permanganate	Fruit (apples, apricots, bananas, avocado) and vegetables (carrots, potatoes, tomatoes, cucumbers)
Fragrance absorbers	Citric acid, esters of cellulose, polyamide	Products subject to easy oxidation such as fats in fish products, fruit juices

Source: [17-19].

In case of active packaging the following are distinguished: oxygen scavengers, fragrance absorbers (amines and aldehydes), which protect the colour of the product, packaging with antimicrobial properties, fragrance absorbing packaging and ethylene absorbers (Figure 1), water content regulators, carbon dioxide absorbers, light absorbers and substances protecting the colour of a packed product [19]. Gradual removal of oxygen from the atmosphere of the packaging causes vacuum, resulting in deformation of packaging or a dent. In order to eliminate this adverse action, the substances, which produce equivalent amount of carbon dioxide during oxygen reduction, are used in the packaging [19].

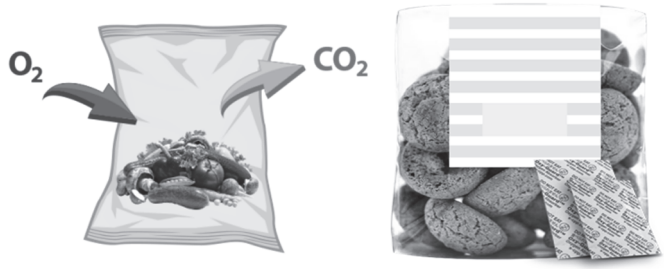

Figure 1. An example of active packaging, in the form of a sachet, which absorbs oxygen
Source: [23-24].

The application of ethylene absorbers is used for storage of fruit and vegetables, some of which emit ethylene spontaneously (such as apples), and other ripen quicker if it is present, and hence are subject to putrefactive decomposition quicker (such as bananas) [19].

Another group of active packaging are, as it is called, emitters. The principle of action of emitters is based on migration of substances inside the packaging and delaying unfavourable processes. They may also migrate on the surface of a food product. The emitters are responsible for regulating water content in the atmosphere of the packaging, i.e. relative humidity (packaging of vegetables), they protect the product against development of microorganisms that cause bacterial spoilage) [20]. An example of the emitter in ethanol. During storage of dried food and bakery products, ethanol is one of well-known and commonly used antibacterial measures that prevents mould growth and reproduction of pathogenic microorganisms. Inside the packaging, there are sachets with alcohol absorbed on an appropriate medium placed. The medium absorbs water from the product, releasing ethanol. Carbon dioxide or sulphur dioxide may also serve as emitters. Packaging containing ethanol, due to particular considerations of some consumers (religious believes or alcohol abuse), have to be appropriately marked [19, 20]. Active packaging can have various forms. Most often the following are used:

- Sachets or sub-sachets containing compounds with antibacterial properties, usually placed inside packaging,
- Polymers, due to its molecular structure, have GRAS (Generally Recognized as Safe) anti-microbial properties [21],
- Anti-microbial layers on the surface of the polymer,
- Substances included in the polymer structure which limit the growth of microflora.

The active packaging is often equipped in various types of sensor for monitoring concentration of gases such as CO_2 – Figure 2. Such sensors are quire universal. The factors that limit their use include price, large volume and need for power. CO_2 sensor are usually mounted with RFID sensors. This type of sensors are mostly placed inside the packaging and used in the assessment of tightness of packaging in MAP e-technology.

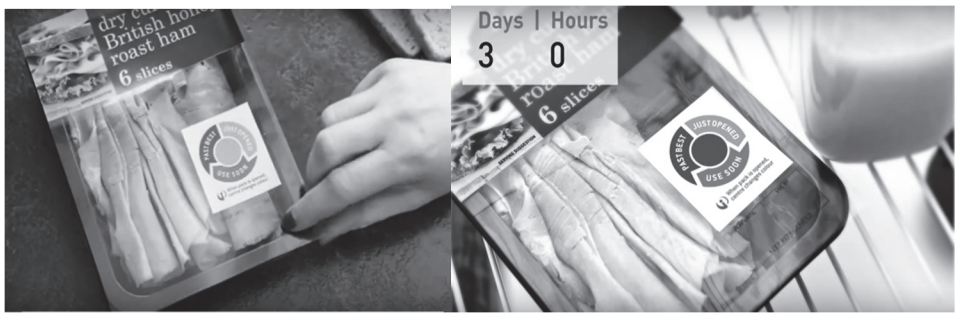

Figure 2. Packaging with an indicator of presence of gases and spoiled integrity of the packaging
Source: [22].

Cheaper sensor, using the change of colour of chemical indicators, do not directly measure CO_2 concentration in the gas phase but change pH of the solution due to the presence of dissociated form. Cheaper and more versatile way is the use of freshness indicators based on detection of amines and their derivatives. An example might be Isignia Embedded Colour Canging Labels with an indicator of the presents of gases and spoiled integrity of the packaging. The change of colour on the indicator informs a consumer about the shelf-life upon opening the packaging. This type of indicators act on the basis of reaction caused by the change in the composition of atmosphere, for example when a new component appears. Thanks to this it is possible to determine whether the packaging has been fractured and how long it has been opened. The action of active packaging should be inert in relation to the product. Their action is based on interaction that occurs in food during storage. The way of reaction and action cannot be coincidental but carefully planned, and most often adapted to individual characteristics of the product.

In case of packaging which absorbs or emits CO^2 – Figure 3, the following are the most commonly used as the absorbers: physical absorbent called Zeolite or powdered active carbon, while chemical absorbent can be sodium carbonate, magnesium hydroxide.

Figure 3. An example of an oxygen scavenger active packaging
Source: [23-24].

In case of products that are sensitive to moisture, packaging with bags are used, in which a moisture absorbent in the form of gel, e.g. silica gel, sodium chloride or cellulose fibres, is placed – Figure 4. Excessive moisture in packaging may cause changes in temperature, leakage of tissue fluid in case of meat from poultry, while in case of dry articles – coffee, tea, its spoiling. Figure 4. presents a moisture absorber with a moisture indicator inside the packaging.

Figure 4. A moisture absorber with a moisture indicator
Source: [25].

Intelligent packaging is „materials and articles which monitor the condition of packed food or its surrounding". Active and intelligent packaging appeared on the Japanese market in mid-seventies of the past century for the first time. They appeared only in the 90s of the last century on the European market. The first intelligent and active packaging interacted with the product and informed the customer about its condition. They contained moisture absorbers and oxygen scavengers. Innovation in packaging related also to materials engineering, new polymers and multilayer materials. Today, intelligent packaging with new innovative structure solutions appear on the Polish market. Innovative solutions in the field of packaging may include:

- Packaging with sensors, biosensors and gas sensors to identify the condition of the product thanks to moisture indicators, temperature indicators – including optimal temperature for consumption, freshness indicators or fractured packaging indicators,
- Packaging with Radio Frequency Identification,
- Products protection measures containing oxygen scavengers, oxygen indicators, laminates containing silicones as drying agents, metallized PP containers,
- Safe locks in packaging (protecting against unwanted opening by children), adapted to be used by the elderly, indicatory locks, „Dri-Top" locks equipped with a filter, which is transported to the inside of the container while opening, that prevents form escaping gases from the inside,
- Metal packaging with improved corrosion resistance,
- Bottles (glass bottles made of cullet, thin-walled, bottles made of PET, multilayer, 5-layer with high barrier capacity and resistance to high temperature).

With regard to the way of placement of indicators on the packaging, the indicators can be divided into:

- External (temperature and time indicator),
- Internal (oxygen indicator, microbiological and pathogen condition indicator, carbon dioxide indicator),
- Indicators for effective communication with the consumer, which causes an increase in effectiveness of information about the product.

The intelligent packaging may have a number of functions, mostly an informative one.

Providing information serves as identification, sale, appropriate use or warning. Information about the packaging and its content provide persons involved in storage, transportation and sale necessary data, such as name of the product, name of the manufacturer, the country of origin. The intelligent packaging provides also other information, for example on storage conditions, integrity, changes appearing inside at any stage of a food supply chain and at a consumer's home [26].

The intelligent packaging, depending on the role it is supposed to meet, is divided into [27]:

- Monitoring changes of quality of the product, changes of atmosphere inside the packaging,
- Improving a consumer's convenience,
- Protecting against damage, theft.

The intelligent packaging indicating opening is based on the principle of change in the composition of atmosphere – Figure 5 and Figure 6. An example of such packaging may be packaging with an oxygen absorbing system called Ageleee-Eye by Mitsubishi Gas Chemical Co. An oxidation-reduction reaction takes place and an appropriate indicator indicates the result.

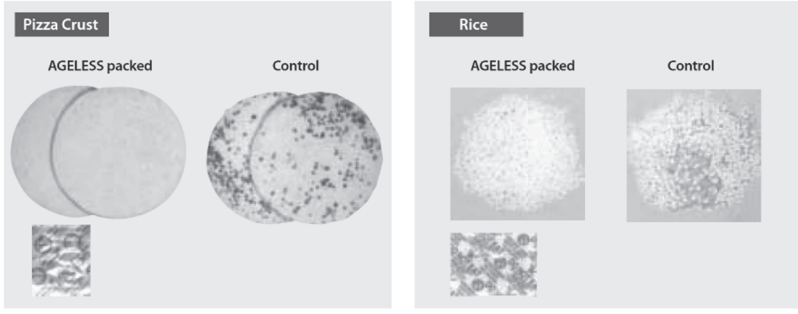

Figure 5. Intelligent packaging with oxygen absorbing function
Source: [28].

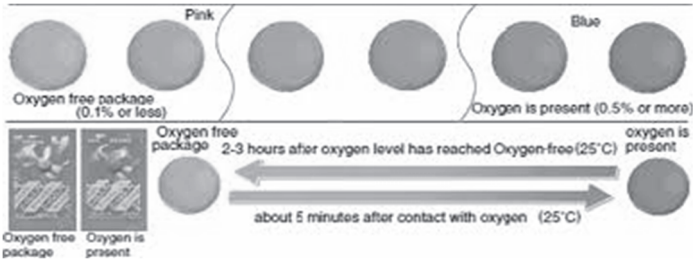

Figure 6. Packaging with an indicator of lack or presence of oxygen
Source: [29].

High content of oxygen may inform a customer about the lack of tightness of the packaging, or indicate the possibility of bacterial contamination. It acts on the basis of the change of colour in line with the change of oxygen concentration in the packaging. The packaging with a temperature indicator is equipped in simple and cheap solutions. It allows to assess at what temperature and for how long a given product has been stored – Figures 7 and 8. TTI indicators are based on the principle of assessment of irreversible changes of colour under the influence of too high temperature.

Figure 7. ColdMark temperature indicator
Source: [30].

A mechanism of colour changes based on chemical or microbiological reaction. In case of products sensitive to too low temperature, the ColdMark or Freeze-Watch indicators are applied. At present, the TTI indicators can be divided into three main groups [31]:

- Defrost indicators which inform whether a given product has been stored in a temperature higher than required,
- Temperature and time integrators which inform on total temperature and time of influence on the product in the packaging,
- Temperature and time indicators/integrators whose action is similar to functioning of integrators of temperature and time but starts only after the established initial temperature has been exceeded.

A temperature indicator presented in Figure 8 has a special vial of liquid which is sensitive to temperature changes. Too low temperature causes an irreversible change in the colour of liquid. The advantage of such a solution is the fact that this type of indicator can be used in any kind of packaging.

Figure 8. FreezeWatch temperature indicator
Source: [31].

There is packaging with temperature indicators present on the Polish market. Żywiec beer manufacturer poured its product into packaging with a label that contained information for the client about properly chilled product. Figure 9.

OnVu indicator of the condition of food monitoring [32-33] whose shelf-life does not exceed 14 days, is shown in Figure 10. The basis of this system is printing ink used for printing on packaging that can be exposed to ultraviolet light, and as a result by means of chemical reaction, its colour changes – it turns from colourless into blue.

Figure 9. A temperature indicator indicating appropriate temperature for consumption
Source: [32].

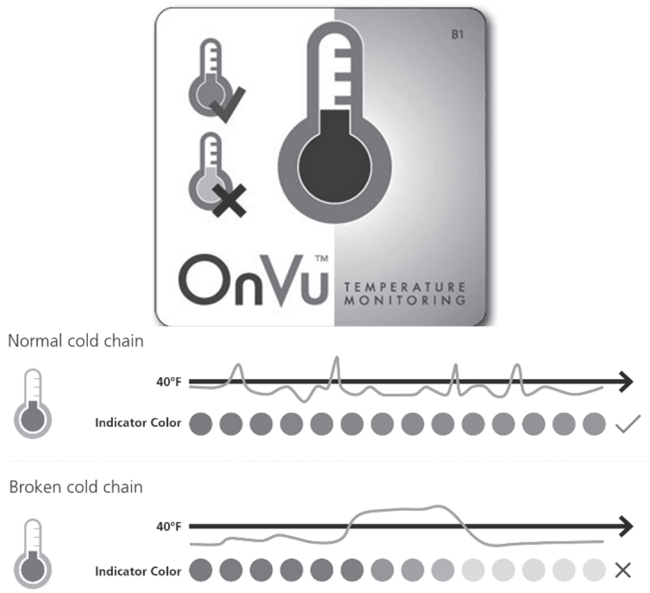

Figure 10. OnVu food monitoring indicator
Source: [32-33].

Over time, the above-stated reaction is automatically reversed. This discolouration – from blue to colourless condition, is as faster as higher the ambient temperature. Depending on how much UV light has been previously directed on the label, the intensity of blue colour may be changed, which allows to extend, or reduce, the period of discoloration of the label. Thus, using this type of label will make it possible to reproduce the curves of spoiling of all sorts of products. The TTI indicator should be activated in a way that after the expiry of the shelf-life, it will indicate that a given product is not suitable for consumption, even if it has been properly stored. If the required storage temperature will not be provided even for a short period of time, discoloration of a label will occur sufficiently in advance [33].

Another interesting solution of intelligent packaging is the use of freshness indicator. The action of such indicators is based on the reaction of their ingredients and substances emitted during decomposition, which result from changes appearing in the product. Chemical compounds released to the atmosphere of the packaging such as carbon dioxide, volatile amines, hydrogen sulphide, acetic acid, ethylene, react with the indicator. As a result, there is a change of its colour, which gives the consumer the opportunity to assess the condition of a packed product [34-38]. The solutions suggested currently, are based primarily on carbon dioxide and volatile amines. In order to detect volatile products, indicators based on chemical reactions are used, and to detect non-volatile products – enzymatic reactions. An example of freshness indicator based on amines and their derivatives detection is a label to monitor freshness of fish and fish preparations

called Fresh Tag (Cox Recorders, USA) that changes the colour in contact with volatile amines even at –20°C temperature.

The intelligent packaging for active people that enables heating food without the use of stoves, in case of which the principle of action is based on an exothermic process. Ready meals in cans are available on the market. The principle of action of this product is as follows: you remove a rubber lid, make a few holes with the attached hammer. You open a can after twelve minutes and eat a ready meal.

Figure 11 shows a self-heating meal.

Figure 11. A self-heating dish
Source: [39-40].

5. Conclusions

Packaging should provide maximum safety of food – this should be a primary function; the other functions may be informative or marketing. Active and intelligent packaging causes extending the period of food storage.

Appropriate functions of packaging allow for better control of storage conditions, and hence, better brand image for a consumer.

The active and intelligent packaging is used with high quality products. The price of materials used for manufacturing of active and intelligent packaging is too high at the moment to use them widely.

In case of intelligent packaging chemical substances, which should safely react with the product, are often used. Thanks to a simple principle of action their price, in relation to other solutions based on RFID microsystems, is cheaper.

The intelligent packaging is used in products for active people who do not have time for preparing warm meal.

By analysing the literature of the subject matter and available data, it can be concluded that, in general, an interest in such type of packaging will grow.

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IMPACT OF ISSUES IN FOOD VALUE CHAIN ON FOOD SECURITY OF COLOMBO CITY REGION

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1. Introduction

Food and nutrition security in the context of rapid urbanization has brought attention to the consequent rural impacts and the importance of sustainable food systems. Today, it is increasingly realized that city region food systems can play an important part in helping to provide for many people's food security and nutrition. The agricultural and food value chain is composed of farmer input supply, production, post-harvest handling, traders, food manufacturing companies, retailers and consumers. Identifying issues along the Agri-food value chain could help its members (e.g. Farmers, food producers, food retailers, and consumers) mitigate these issues, and help improve the chain's effectiveness and impact on local and regional economies(Bloom and Hinrichs 2011). Problems in the food value chain hinder the potential gains that could have been attained from existing opportunities (Fernando S. 2016). In this regard, food value chain and its impact on food security analysis is an interesting process that has not been investigated much in the Sri Lankan context.

A global concept of food security is a challenge for Sri Lanka as well. Food security has a great relation with agriculture. Most of the city regions in Sri Lanka link with agriculture based economies. Therefore, the food system in Sri Lanka links agriculture and urban centers of various sizes, including cities and secondary towns. The term' city region' refers not only to megacities and the immediate, proximate rural and agricultural areas surrounding them, but also to small and medium-sized towns that can serve to link the more remote small-scale producers and their agricultural value chains to urban centers and markets. For instance, Colombo city region has directly link with other cities and rural producers such as Nuwaraeliya, Dambulla…etc. As population gravitates towards urban centers like Colombo, there are increasing difficulties in meeting the needs and realizing the rights of growing urban population. There is a need to better understand the appropriate scales and entry points for food system development to achieve sustainable food system. Therefore, understand, characterized and map city region food system, while analyzing critical issues, weakness, gaps and bottleneck with local priorities will

help to achieve better economic, social and environmental conditions in both urban and nearby rural areas (FAO 2014).

The purpose of this research is to identify the issue and problems in food value chain in Colombo city region and its impact on urban city region food security while recognizing the main indicators to show problem related to vegetable and fruits value chain in Sri Lanka. With this main purpose, this study indented to answer the following research questions:

- What are the main foods value chains exist in the Colombo city region?
- What are the main issues in vegetable & fruits value chain in Sri Lanka?
- How the issues and problems in vegetable & fruits value chain affecting on urban food security?
- What are the main indicators that show problems related to vegetable & fruits value chain in Sri Lanka?
- What are the policies and strategies applicable to overcoming issues in vegetable & fruits value chain?

Daily food patterns of Sri Lankans depend on socio-demographic diversities, even though rice and rice related food had been main meal in Sri Lankan agrarian society. The major food groups of Sri Lankan dietary pattern consists with cereals, prepared food , pulses, vegetables, yams and other, meat, fish, dried fish, eggs, coconuts, condiments, milk and milk food, fat & oil, sugar Juggery & treacle, fruits, confectionery & short eats, beverages (non-alcoholic) and other food (HIES 2015). Therefore, among large different food groups of food value chain, Fruits and Vegetable (F&V) groups are selected for the further analysis with this study. (HIES 2015) Illustrated that highest expenditure on consumption of vegetables are described from Brinjals and Beans and highest expenditure on consumption of fruits are reported from Banana and Papaw. Therefore, the scope of this study further narrow down to the two representative vegetables (Brinjals and Beans) and two representative fruits (Banana and Papaw).

1.1. Problem identification

The agricultural and food value chain is composed of farmer, input supply, production, post-harvest handling, traders, food manufacturing companies, retailers and consumers. The value chain is defined by vertical and horizontal linkage (Spencer and Kneebone 2012) with a range of players. As per pointed by (Sobal, Khan, and Bisogni 1998) the different types of food and nutrition system revealed different characteristics. Food chains, food cycles, food webs and food contexts are existing models which are not comprehensive and focused on placing a specific issue into a larger context. Food chain models focused on the flow of material or objects through a sequence of steps, emphasizing movement and transformation through a series of stages that are often ordered and linear (Sobal, Khan, and Bisogni 1998). In recent years, international organization and donor agencies have increasing use of value chain analysis in policy and project work in developing countries. However, a conceptual framework that logically combines

global value chain theory with practice to guide such activities in agro-food chains is lacking. (Reardon et al. 2012) emphasized future agenda for developing a transdisciplinary, multidimensional conceptual framework to study food value chain in order to establish best practice to benefit the poor, protect the environment, and help smallholder farmers meet growing consumer demand for sustainability attributes.

Fruits & Vegetable constitutes a major part of the world economy and is the raw material for many industries. The Supply Chain Management of perishable food produce founds the processes from production to delivery of the Agri-fresh produce. i.e. from the farmer to the customer. SCM of perishable food produce is complex as compared to other SCMs due to the perishable nature of the produce, high fluctuation in demand and prices, increasing consumer concerns for food safety & quality, and dependence on climate conditions. Perishable food produced in the farmer's field reaches the end consumer through a chain of intermediaries (Halder and Pati 2011). These intermediaries carry out various functions, such as transfer of ownership of commodities, its movement, maintenance and preservation of quantity & quality, payment to the seller and commodity delivery to the buyer.

Cities can build more sustainable food systems to prevent and reduce food wastes, provide decent livelihood opportunities for rural, peri-urban and urban producers, promote sustainable ways of food production, processing and marketing, and ensure food and nutrition security for all consumers and value chain actors (FAO 2014). Improved city region food systems will help achieve better economic, social and environmental conditions in both urban and nearby rural areas (RUAF 2015).

The world needs to produce at least 50% more food to feed 9 billion people by 2050 (FAO 2015). However climate change could cut crop yields by more than 25%. The land, biodiversity, oceans, forests, and other forms of natural capital are being depleted at extraordinary rates. Unless we change how we grow our food and manage our natural capital, food security-especially for the world's poorest-will be at risk. Addressing the urban dimension of food insecurity also important to reduce urban food insecurity. Most of the time cities and peri-urban areas have problems that are very different from those of rural areas in terms of availability and access to food, market development, management of natural resources, access to basic services (FAO 2015). Food security is a situation that exists when all people, at all times, have physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preference for an active and healthy life (FAO 2005). Food availability, food price and nutrient security are the dimensions that address the issue of food security. It is also interesting to note that there is a hierarchical interdependency among those dimensions (Barrett 2010): availability is a necessary, yet insufficient, condition for access, which in turn is necessary, to reach adequate nutritional outcomes.

Food security can be ensured only if two conditions are met: food must be available and households must have the ability to acquire it (The World Bank 1990). Therefore, availability of sufficient quantities of food of appropriate qualities, supplied through domestic production or imports is vital. Food access

refers to the ability of households to obtain food, whether its source be home production, commercial purchases, or transfers. It may be considered as roughly equivalent to „real household income" or „effective demand", with respect to the cost of some prescribed food basket. Together, incomes and price are important determinant of food access. Security of food access, however, implies that we consider both current and future sources of production and income (Diskin 1994). Food accessibility is defined as utilization of food by individuals through direct consumption (UNDP 1998). One factor that directly affects food consumption is food price. Low-food price equates to easier access to food and higher levels of consumption. The role of food prices may be important for producers and consumers. Food prices have a strong influence on real incomes for poor consumers because a larger share of their income is spent on food (Diskin 1994). People with equal access to food, but different food preferences, could show different levels of food security. As long as the term, "preferences "are interpreted to mean foods that are socially & culturally acceptable and consistent with religious and ethical values(Molnar 1999). Additional gains to food production and food security will come from newer techniques and processes developed recently due to information technology, biotechnology and nanotechnology. Deployment of these technologies can be facilitated by using policies that promote inventions, innovations and diffusion, dissemination of information, improvements in market access, and minimizing risks to health of humans and livestock (Kasturi 2009).

Food value chain play a crucial role in productivity growth and food security through direct and indirect effects. However, greater food security will be achieved through a combination of different indicators (Campbell et al. 2009) and in many cases ,assumptions of strong and straightforward linkages along the pathway from food production to nutritional outcomes are not well-founded. A major problem in the consideration over the nature and extent of the relationship between issues in food value chain and food security has been a lack of empirical data for measuring the linkages.

2. Methods

This study is based on a qualitative, exploratory research design and used focus group discussions, personal observations, open ended questionnaire and face to face interview as its primary data collection techniques. Focus group discussions that included representative sample of vegetable and fruits value chain actors who are direclty and indireclty linked with Colombo city region food value chain and few in-depth interviews with farmers (who grow banana, papaya, brinjals and beans), intermediaries,wholesalers (Colombo Manning Market), retailers (Colombo Manning market) and consumers were conducted to explore the issues in food value chain and its impact urban food security. The discusion and inteviews were facilitated by guides focusing on food value chain issues under food production, food transport/storage/process, Food procesing and price. The data resulting from the discussion and interviews were transcribed and investigated

using a qualitative thematic analysis to identify, analyze and reporting patterns (themes) within data.The thematic analysis coding are used to categories food value chain issues under diffenrent themes.

Finally outcome of primary data ,are further validated with expert survey. Identified food value chain issues and problems are classified based on the food security dimensions and upon the completion of the classification process, panel of experts were asked to priorities the food value chain issues or problems from the collapsed category list within each food security dimensions.Apart from that, secondary data were gathered from annual reports, journals, government publications, central bank report, FAO (Food & Agriculture Organization) reports.

Identified issues have been further analyzed with secondary data and indicators are derived to measure problem areas in food value chain and food security impact.

3. Findings and argument

Food items consumed in Colombo food system are broadly categorized into three categories as agriculture products, animal products and imported products. Consistent with the secondary data analysis, the highest expenditure on consumption of vegetables are described from **Brinjals and Beans** and highest expenditure on consumption of fruits are reported from **Banana and Papaw (HIES 2015)**.

According to the findings Colombo Manning market is the center for wholesale marketing and there are different types of distribution flows associated from farmer to consumer through this main exchange point. Vegetable/Fruits price fluctuations, excess supply and wastage are the most common and recent issues that are famous in vegetable and fruit supply chains. However, due to the traditional supply chain, F&V supply chain is not the demand driven and the price of the F&V are determined by the daily supply and demand. Quality of the harvest is another important factor, which influence the F&V price fluctuation. Transportation and food waste are another major issue for F&V value chain. Finally, Colombo city region issues and problems are categorized under main value chain processes identified in city region food system & further analysis carried out with primary and secondary date to support derived (Table 1) indicators (FAO 2014); (Fernando S. 2016); (RUAF 2015) to measure issues and gaps in F&V value chain.

Table 1. F&V value chain process and related indicators

Value chain Process areas	Indicators
Production	**I1**: Availability of local products labels **I2**: Number of urban agriculture producers **I3**: Number of farms in the city region for different food products **I4**: Share of food coming from the city region versus imported

Transport/storage/process	**I5:** Number, type and geographic spread distribution points in the city region **I6**: Number of food wholesale and distribution business
Processing	**I7:** Carbon foot prints city region food processing and manufacturing **I8**: Diversity in food retail and catering in the city region **I9:** Type of food categories/volumes of city region produced/ processed food procured
Price	**I10:** Consumer food price for different food products across different types of outlets in the city **I11**: Source of food products that are sold wholesale or distributed in the city **I12**: Price difference between farm gate and the retailer

Bibliography: (FAO 2014); (Fernando S. 2016); (RUAF 2015).

4. Conclusion and recommendations

Result driven from this study contributed towards the theoretical and practical implications. This paper introduces a conceptual framework (Figure 1) to guide the food value chain issues and its impact on food security. The conceptual framework specifically focuses on developing food security and food value chain related indicators for the future decision making process. However, food availability, access, utilization, vulnerability and resilience linked with best practice in food value chain.

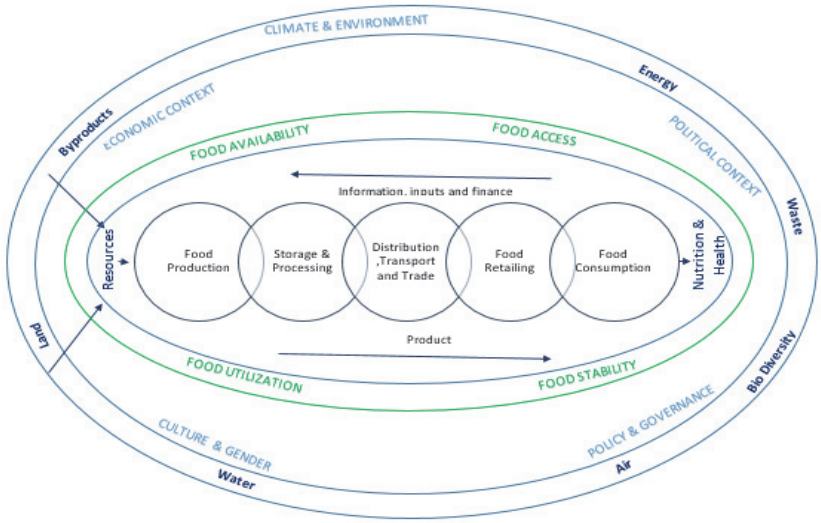

Figure 1. Conceptual Framework: Linking food value chain and Food security
Source: author compile.

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ANNEX TO THE ARTICLE – pp. 17-26

SUPPLY CHAIN ENTITIES' AWARENESS OF CORRECT FOOD LABELING AS AN ELEMENT CONTRIBUTING TO THE SAFETY OF THE PACKAGED PRODUCT

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