Bulletin of the *Transilvania* University of Braşov
Series II: Forestry • Wood Industry • Agricultural Food Engineering • Vol. 9 (58) No.1 - 2016

APPLICATION OF MULTIPLE CRITERIA DECISION MAKING (MCDM) IN BAKERY INDUSTRY. STUDY CASE: WASTES AND BY-PRODUCTS

Oana B. OPREA[1] Liviu GACEU[1]

Abstract: *Food waste and food loss is a global issue that became the focus point at many FAO Conferences. Increasing the use of food by- products and wastes is the key for improving the economy, increasing the consumers' incomes and improving food security.*
The article aim is to use the MCDM method for the case of bakery industry, taking in consideration 6 criteria (1 - Availability, 2 - Market price, 3 - Valuable substances, 4 – Resistance, 5 – Organoleptic characteristics, 6 – Shelf life) applied for 3 possible by-products (winemaking, apple, hemp).
Results indicate that the most appropriate waste and by-products suitable to be used in the bakery industry are those from the wine industry (39.6), followed by apple processing industry (36.91p), respectively hemp industry (27.04p).

Key words: *MCDM method, market price, shelf-life, bakery industry, waste.*

1. Introduction

Humanity faces an important resource material and energy crisis, the food crisis context is in the foreground.

Nowadays food waste became a sensitive issue because of the discrepancy between different areas in the world [1].

While in some countries people suffer for hunger, in others consumers produce a massive food waste [6].

One third of food is wasted annually at a global scale which means 1.3 billion tons per year. This aspect was on the agenda at the 29th regional FAO Conference for Europe and central Asia from April 2014 [5].

In this situation, it requires the greatest possible recovery of useful substances from scrap and wastes from the food industry.

At European level, given the importance of this particular research topic H2020 funds programs that aim to reduce waste by 30% by 2025.

This objective can be achieved by using waste and by-products from a food industry branch as raw materials or

[1] Transilvania University of Brasov, Faculty of Food and Tourism, Department of Engineering and Management in Food and Tourism, Castelului Street, no. 148, Braşov 500014;
Correspondence: Oana B. Oprea; email: oprea.oana.bianca@unitbv.ro.

auxiliary materials in another branch of the food industry. For example, bakery industry has a great potential on using waste and by-products as raw materials, because of the specificity of the operations flow.

2. Material and Methods

2.1. MCDM Method

Since the problem of using wastes and by-products from food industry is depending on many criterions, the MCDM (*multiple-criteria decision-making)* method was used.

As possible raw materials was considered: the waste and by-products from the wine industry, the apple pulp as food waste obtained after juice extraction, the defatted hemp seeds after oil extraction.

As main criterions can for MCDM method was considered the following:

- **Criterion 1.** Availability of waste and by-products in the studied region;
- **Criterion 2.** The market price of products and waste taken into consideration;
- **Criterion 3.** The content of valuable substances for human health;
- **Criterion 4.** Resistance of valuable bioactive compounds from wastes at all stages of a specific technological bakery industry (mixing, fermentation, baking etc.);
- **Criterion 5.** Taste and flavor compatible with the organoleptic characteristics of products from the bakery industry;
- **Criterion 6.** Neutral or positive influence on the shelf life of bakery products.

2.2. Aspects regarding the Use of Waste and By-Products from the Wine Industry

By-product means what remains of a material during processing and cannot be used in that processing.

In wine industry the share of secondary products exceed 18-20% from the quantity of grapes processed for obtaining wine.

In our country from the about 1 million tons of grapes used in the wine industry, beside wine, there are obtained 120.000 tones of grape marc, without bunches and 400.000 hectoliters of yeast.

From 1 ton of grapes, through a rational capitalization of the resulted by-products from the primary winemaking process, beside wine, are obtained: 1,2kg of tartaric acid, 180 kg marc and 4.5 kg of yeast. Grape marc represents a complex of solid parts resulted from the wine making process, containing different proportions of bunches, skins and pips, depending from the grape variety.

Through marc are understood solid wastes, separated by the stum , or by wine (fermented pomace) and made of skins (55 – 65%), seeds (18 –25%) and liquid rests (stum, wine); marc sometimes also includes bunches.

Because of the valuable components: carbohydrates, alcohol, tartaric salts and seed oil, marc can be harnessed obtaining protein feed, tartaric acid, alcohol, alimentary oil, technical oil, tannin and dyes in case of red wine [4].

Among the positive properties of the wine industry waste intake, are included the following:

- reduction of dangerous blood sediments;
- reduced cholesterol level;
- strokes prevention;

- good blood pressure;
- prevention of atherosclerosis.

2.3. Aspects regarding the Use of Apple Pulp as Food Waste Obtained after Juice Extraction

Waste derived from apple processing in the juice industry, have an important role in the human body through the quantities of minerals they contain, influencing the secretion of various glands, while serving as a buffer in internal metabolism, especially that of gastric juice.

Along with mineral salts, acids (mainly malic acid) play an important role in the secretion of various glands and also have the advantage of not increase the acidity of gastric juice, in generally weak acids, easily metabolized and broken down into other simpler substances.

Vitamins, in their role as biocatalysts of life processes are indispensable for life, their lack of body metabolism causing serious functional disorders.

Among vitamins absolutely necessary for the proper functioning and development of the human body (A1, B1 C, D, E, F, K, PP), most are found in apples, in varying amounts, depending on the genotype species and varieties of apples taken into account.

In our country now, the fruit consumption structure is 77% as fresh and 23% as processed (of which 21% preserved, 0.5% frozen and 1.5% dry).

Among the countries of the world, the largest producer of apples turned out to be China, which produced 20.5 million tons, representing 34.5% of total world production and EU countries (EU - 15), which produced 13.6 million tons, accounting for 16.6% of the world of 2000 [7].

Average production in Romania during 1985-1989 was 718 900 tons in 1998, Romania producing only 365 000 tons of apples to 1,000 thousand tons in 1989.

Apple cultivated area in 2004 was 71,000 ha (FAO 2004), followed by the plum, fruit tree species located on the first place in the hierarchy of fruit crops in Romania.

2.4. Aspects regarding the Use of Defatted Hemp Seeds after Oil Extraction

In the last decade the hemp was rediscovered as a technical plant with great potential both in organic materials and technology in the food industry by hemp seeds and oil extracted from it.

Hemp seeds contain 36% oil, 28% protein, 17.8 to 26.3% cellulose and 2.5 to 6.8% ash.

Due to this composition, hemp is used in the extractive oil industry, or directly in the diet and fabrication of margarine.

Oilcake resulting from oil extraction still contains numerous active ingredients and fibers useful for human health.

Many researchers have studied the implications of usage of hemp seed partially skimmed from oil extraction in various industries such as bakery industry, margarine or other food complex.

Analyzing samples of bread with added hemp seed partially defatted, it was found that samples of bread made from mixtures of wheat flour with 5%, 10% and 15% flour hemp seed partially defatted, had characteristics very good and good (15% sample with added hemp seed), in terms of quality parameters.

The sample with 20% hemp seed had weak sensory attributes because of intrusive altered flavor.

From a nutritional standpoint all experimental tests of bread fulfil the concept of *"source of fibre", "source of zinc"* and for samples with the addition of more than 10% seeds of hemp can be issued with the term *"source of magnesium"*.

2.5. Generating non-dominated Solutions

Given the previously established analysis criteria, was drawn up in Table 1.

Analyzing the results of multi-criteria analysis (Table 2, Table 3), the most appropriate waste and by-products suitable to be used in the bakery industry are those from: wine industry (39.61p); apple processing industry (36.91p) and hemp industry (27.04p).

3. Results and Discussion

After obtaining the analysis, results that the use of waste and by-products of wine industry has great potential because of the following justification:

- in terms of biochemical antioxidants present in the wine industry waste (resveratrol and anthocyanins) outperforms sanogenous potential of pectin from apples (very useful in dough proofing) and complex minerals and fiber present in the hemp waste processing industry [9], [3].
- in terms of availability of food waste mentioned, it appears that those from the wine industry are present in much larger quantities than those of hemp and comparable to the apple processing industry.

Applying the MCDM method for 6 criteria Table 1

	Crt. 1	Crt. 2	Crt. 3	Crt. 4	Crt. 5	Crt. 6	Points	Level	Share
Crt. 1	0.5	0	0	1	0	1	2.5	2.5	0.9
Crt. 2	1	0.5	1	0.5	0	1	4	2	2.42
Crt. 3	1	0	0.5	1	0	0	2.5	2.5	0.9
Crt. 4	0	0.5	0	0.5	1	0	2	4	0.45
Crt. 5	1	1	1	0	0.5	1	4.5	1	3.5
Crt. 6	0	0	1	1	0	0.5	2.5	2.5	0.9

Note: 1 - Availability; 2 - Market price; 3 - Valuable substances; 4 – Resistance; 5 – Organoleptic characteristics; 6 - Shelf life.

Points distribution on the main criterions used in MCDM method Table 2

Criterion	1	2	3	4	5	6
Points	2,5	4	2,5	2	4,5	2,5
	m=1	m=2	m=1	m=0	m=3	m=1

Final ranking of MCDM analysis Table 3

Criterion		Share	Winemaking		Apple		Hemp	
			Ni	Ni x crit	Ni	Ni x crit	Ni	Ni x crit
Crt. 5	– **Organol. characteristics**	3.5	5	17.5	5	17.5	3	10.5
Crt. 2	– **Market price**	2.42	3	7.26	3	7.26	2	4.84
Crt. 3	– **Valuable substances**	0.9	5	4.5	4	3.6	5	4.5
Crt. 6	– **Shelf life**	0.9	4	3.6	4	3.6	4	3.6
Crt. 1	– **Availability**	0.9	5	4.5	4	3.6	2	1.8
Crt. 4	– **Resistance**	0.45	5	2.25	3	1.35	4	1.8
Final ranking				**39.61**		**36.91**		**27.04**

But winemaking industry waste presents the advantage of self-preservation capabilities in the longer term than those of the apple processing industry, because of the presence of antioxidant compounds. This translates into greater efficiency in transport and processing, requiring no special storage measures.

- in terms of the technological compatibility of the bakery industry, it appears that the wine industry waste are close both biochemical compounds as such and organoleptic alcohol resulting from the fermentation of bakery yeast Saccharomyces cerevisiae.

Studies made by researchers around the world (including Canada where there are numerous patents on this theme) show that antioxidants present in the wastes contribute to increasing the validity of bakery products [3], [9].

3. Conclusions

Use of waste and by-products from the food industry as raw material in the bakery industry is an important measure to reduce losses from food industry.

MCDM method application shows that wastes from the wine industry present a great potential considering: Availability, Market price, Valuable substances, Resistance, Organoleptic characteristics, Shelf life.

FAO has estimated that every year, about one-third of all food produced for human consumption in the world is lost or wasted. Food wastage represents a missed opportunity to improve global food security, but also to reduce the environmental impacts and resources from food chains

References

1. Charles J.H., Godfray J., Beddington R. et al., 2010. Food Security: The Challenge of Feeding 9 Billion People. In: Science, vol. 327(5967), pp. 812-818.
2. Coe S., Ryan L., 2015. White bread enriched with polyphenol extracts shows no effect on glycemic response or satiety, yet may increase postprandial insulin economy in healthy participants. In: Nutrition Research, vol. 36(2), pp. 193-200.
3. Dong Z., 2003. Molecular mechanism of the chemo preventive effect of resveratrol. In: Mutation Research / Fundamental and Molecular Mechanisms of Mutagenesis, vol. 523-524, pp. 145-150.
4. Gavrilă L., 2007. Management, Recovery and Minimization of Food Waste. Lecture notes (in Romanian). PhD Thesis, University of Bacău, Engineering Faculty, 84 pages.
5. Gustavsson J., Cederberg C., Sonesson U. et al., 2011. Global Food Losses and Food Waste - Extent, causes and prevention, FAO, Rome, Italy 3.
6. Ilea M., Chiciudean G., Chiciudean D., 2014. Analysis Regarding Food Waste and Consumption in Romania. Analele Universităţii din Oradea, Fascicula: Ecotoxicologie, Zootehnie şi Tehnologii de Industrie Alimentară, Vol. XIII/A.
7. Koester U.J., Holm E.T., 2013. Food Losses and Waste in Europe and Central Asia, FAO.
8. Parfitt J., Barthel M., Macnaughton S., 2010. Food waste within food supply chains: quantification and potential for change to 2050, Royal Society.
9. Peng X., Jinyu M., Ka-Wing Ch. et al., 2010. The effects of grape seed extract

fortification on the antioxidant activity and quality attributes of bread. In: Food Chemistry, vol. 119(1), pp.49-53.
10. Serazetdinova L., Oldach K.H., Lorz H., 2005. Expression of transgenic stilbene syntheses in wheat causes the accumulation of unknown stilbene derivatives with antifungal activity. In: Journal of Plant Physiology, vol. 162(9), pp. 985-1002.
11. *** National Institute of Statistics, 2013, https://statistici.insse.ro/shop/index.jsp?page=tempo3&lang=ro&ind=BUF110I. Last accessed on 9 May 2016;