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Economic assessment based on scenario analysis for the production of a new functional pasta

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ABSTRACT

Nowadays functional foods are becoming more popular due to their capacity to prevent and/or reduce the risk of certain diseases. Functional foods improve health and give physiological benefits providing nutrients beyond the simple nutritional value. The market for functional foods is growing rapidly and the consumers are willing to pay a premium price for these products. In this context, the production of pasta comprising *Opuntia* may represent an opportunity to combine the widespread consumption of pasta in the traditional Mediterranean Diet and the beneficial characteristics of the *Opuntia*, including anti-inflammatory, antioxidant, hypoglycemic, antimicrobial and neuroprotective properties. The aim of this paper is to evaluate the economic feasibility of the production of dried pasta functionalized with an extract of cladodes from *Opuntia Ficus Indica* in an existing medium-size pasta factory. For this purpose, an economic evaluation based on scenarios analysis was conducted. In particular, in each scenario different percentages of *Opuntia* solution were considered and two different economic aspects were varied: the price of the functionalized pasta and the cost of the *Opuntia* solution that satisfies a fixed price for the final product. The economic evaluation was carried out on the basis of the Net Present Value and of the Investment Payback Time.

1. Introduction

Functional foods consist of selected foods or food components that provide physiological benefits and/or the reduction of disease risk beyond their basic nutritional value (Ross, 2000). These foods can be classified into different categories: (a) conventional food with high quantities of functional ingredients (e.g. β-glucan in oat bran); (b) foods modified through the enrichment with or the removal of functional ingredients (e.g. margarine that contains added phytosterol); and (c) food in which the nature of functional ingredients is changed (Kahl et al., 2012). Several researchers (Troszynska et al., 2002; Yasuda et al., 2017; Ilic et al., 2017) have discovered and studied the functional components of many conventional foods and have developed new food products (Laino et al., 2013; La Scalia et al., 2017) that may be enriched with functional components.

Consumers' acceptance of functional foods depends on several factors, the most important one is the perception of a correlation between diet and health. Consumers are more aware that some foods may prevent chronic diseases and improve physical and mental wellbeing (Hasler et al., 2009). For these reasons, they are willing to pay a premium price for these products (Segovia and Palme, 2016; Markosyan et al., 2009; Marette et al., 2010). The public interest in these foods, coupled with the increase in life expectancy, has eventually led to a considerable growth in the market of functional foods in Europe over the past decade (Bech-Larsen and Scholderer, 2007; Kahl et al., 2012). Finally, the increasingly high proportion of elderly people, along with the dramatic nutritional transition occurred in the last 60 years and the progressive adoption of a sedentary lifestyle, represent major responsible for the rising health care costs in all countries where healthcare systems are publicly funded. In this context, the role of research, government policies and industrial development in healthy Agro-food productions is of paramount importance in order to implement systemic strategies for the reduction of disease risk and the maintenance and/or improvement of consumers' health (Hasler et al., 2009). Hence, functional foods represent an opportunity for firms in the food industry (Menrad, 2003; Arias-Aranda and Romerosa-Martìnez, 2010). The introduction of new healthy products favours exploring new market opportunities in order to increase the profitability of the firms and to satisfy the consumers' needs.

In this context the Opuntia Ficus Indica is a good source of natural compounds with functional properties; its fruits and cladodes are used for obesity, arteriosclerosis, diabetes, hepatitis, kidney stones, gastritis,

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hypercholesterolemia and cardiovascular disorders (Galati et al., 2003; Décordé et al., 2008). They also have anti-inflammatory, antioxidant, hypoglycemic, antimicrobial and neuroprotective properties (El-Mostafa et al., 2014). Furthermore, they can be used to decrease the circulating levels of triglycerides, cholesterol and serum glucose and to treat burns, asthma and indigestion (Kaur et al., 2012). Fruits and cladodes have been used to prepare value-added products, such as juice, jam, pickle, cookies, baking bread, nachos, tortillas, as well as cosmetic products such as body lotions, shampoos, creams and pharmaceuticals capsules (Lòpez et al., 2009). Given the widespread use of pasta in the Mediterranean diet (MeDiet) and the health benefits related to the Opuntia, the production of a new functional pasta may represent an interesting opportunity in the food market. There is in fact evidence in the literature that MeDiet, based on a high consumption of whole grains and their derivatives (including pasta), vegetables, fruit, fish, and extra virgin olive oil, reduces cardiovascular events to a degree greater than low-fat diets and equal to or greater than the benefit observed in statin trials (Dalen and Devires, 2014). Furthermore, Carruba et al. (2006) reported that a traditional Mediterranean dietary model reduces the risk of developing breast cancer in healthy postmenopausal women.

Finally, the study conducted by Dean et al. (2007) shows that the Italian consumer prefers to have functionalized base products (i.e. staple foods such as bread and pasta) and their enrichment with traditional production methods rather than genetic modification. The production of pasta comprising Opuntia is reported in several international patents (Cornelli, 2009; Garza-Lopez et al., 2006). Moreover, in the study of Micale et al. (2017), samples of dried pasta, obtained with different percentages of Opuntia solution and process parameters, have been evaluated in order to achieve a final product with healthy properties without altering its organoleptic characteristics. The aim of this paper is to assess the economic sustainability of industrial large-scale production of dried pasta functionalized with Opuntia. In particular, the economic assessment of the production process will be carried out by means of a scenario analysis.

The remainder of this paper is organized as follows: Section 2 describes the materials and methods implemented in this study, Section 3 shows the results obtained in terms of economic assessment and finally, Section 4 concludes the paper with a short discussion and an outlook into on-going research work.

2. Materials and methods

2.1. Case study

In this study, we assumed to produce the new functional pasta in an existing pasta factory of medium-size located in Sicily (Italy). The pasta factory considered has three automatic lines for dry pasta production:

- two short cut pasta lines, each producing 3200 kg/h of dry product with a flow time of 3 h;
- one long cut pasta line, producing 3500 kg/h of dry product with a flow time of 7 h.

The entire plant's (pasta factory and mill) production cycle is continuous (from Monday to Friday, 24 h per day, stopping only for national holidays and maintenance work).

In this paper, three different scenarios (S_i, $i = 1, 2, 3$) based on the different amount of pasta produced are considered. In particular, the annual amount of the new functional pasta was set equal to 0.1%, 0.3% and 0.5% of the maximum annual production capacity considering a production line utilization coefficient of 85%. The annual amount of pasta produced by the pasta factory is around 52,510 tons then for each scenario considered the annual quantities of functional pasta are respectively 52,510, 157,530 and 262,550 kg/year.

In order to achieve the optimal process efficiency, the Minimum Production Lot Size (MPLS) is calculated as the product of the hourly production rate of each line and the corresponding flow time. In particular, the MPLS for short pasta is 9600 kg while for long pasta is 24,500 kg.

Based on these data, for each scenario, the number of annual production lots was determined by dividing the annual amount of functional pasta by the sum of the two MPLSs in order to consider the contemporary production of short and long pasta. The values obtained, rounded off to the nearest integer, are 2, 5 and 8 respectively for scenario S_1, S_2 and S_3. Considering that for the scenario S_1 the annual production would be obtained with only two production lots this could lead to a storage time nearby its shelf life. For this reason, only the production of the short pasta was considered obtaining 6 production lots. Based on these considerations the new quantities of annual production for each kind of pasta have been calculated by multiplying the MPLS by the number of annual production lots. These quantities are reported in Table 1:

Moreover, considering that the *Opuntia* solution is available in concentrations up to 30% w/w, in this research the following two sub-scenarios were considered:

- S_{ia}: *Opuntia* solution used at a concentration of 10% w/w; and
- S_{ib}: *Opuntia* solution used at a concentration of 30% w/w.

2.2. Economic analysis

In this paper the economic assessment has been carried out on the basis of the following incremental values: the Total Capital Investment (TCI, €), the Total Operating Cost (TOC, €/year) and the Revenues (R, €/year) from the sale of the new functional pasta instead of the traditional one.

In particular, the new functional pasta has been produced by the same process as the traditional dried pasta using two different *Opuntia* concentrations. The *Opuntia* solution is a perishable substance and it should be stored in a refrigerated cell at 4 °C for a maximum of 2 days. Moreover, the viscosity of the liquid requires a special hydraulic system, different from the one normally used for water. For these reasons, the costs of the refrigerated cell and the hydraulic system have to be considered. The capacity of the refrigerated cell depends on the quantity of *Opuntia* solution which is a function of the lot size, relative humidity of the final product and semolina, and the enrichment percentage of *Opuntia* used. In particular, we have considered a relative humidity of the dry pasta to be not greater than 12.5% according to Italian legislation (DPR 187/01, art.6) and a relative humidity of the semolina to be about 15%. The percentage of *Opuntia* solution used with 1 kg of durum wheat semolina was set at about 32% which results in around 2 g of *Opuntia* fibre, per daily food portion (Micale et al., 2017).

For each scenario, the quantity of *Opuntia* solution used was calculated, and two different refrigerators were selected, with capacities of 2500 L and 7000 L at a cost of 18,000 € and 30,000 €, respectively. The power of each refrigerator is 1.5 kW and the installing cost is 1500 €. In Table 2 the litres of *Opuntia* solution (considering its density to be 0.95 kg/L) required to produce each MPLS, the number and the capacity of the refrigerated cells are reported.

The cost of the hydraulic system used to inject the *Opuntia* solution was 5000 €. Finally, the cost of a new packaging system was considered. The printing used was flexography, which is a direct rotary

Table 1
Annual production quantities of functional pasta.

	S_1	S_2	S_3
Short pasta (kg/year)	57,600	48,000	76,800
Long pasta (kg/year)	0	122,500	196,000
Total (kg/year)	57,600	170,500	272,800