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BACCO LTD: TECHOLOGICAL INNOVATIONS FOR ENERGY RECOVERY IN THE BRONTE PISTACHIO CHAIN*

Rosaria Raciti[1], Elisa Terranova[1], Giovanna Tuccio[1], Antonio Zerbo[1], Ilary Rey[2]**

[1]*Department of Economics and Business, University of Catania, Corso Italia 55, 95129 Catania, Italy*
[2]*Bacco S.r.l., 98033, C. da Fontana sn – Zona Artigionale, Cesarò (ME), Italy*

Abstract

The Circular economy has as its main center of interest the efficiency in the use of resources and the reduction of waste production, which constitute a considerable potential, as useful resources to achieve energy. The present study is based on Bacco LTD, a leader company of Made in Sicily in the field of production and the artisan transformation of pistachio. According to European Law, the company operates in implementing a new thermovalorization plant to manage Pistachio Shell (PS) recovery, resulting in the production cycle from the beginning to, its disposal of solid PS wastes. With a complete processing plant for the thermovalorization, it is possible to reuse the recyclable PSs giving to this food waste an alternative destination for indoor use. Within the Green Economy perspectives in preserving the environment, the present research may possible energy savings making ambitious commitments to reduce emissions.

Keywords: biomass wastes, energy recovery, innovation techonlogies, pistachio shell, thermovalorization

1. Introduction

Traditional economic theory depicts the economic system as a closed linear system without any interaction with the surrounding environment, which is contrasted with the circular economic system whose main centre of interest is the efficiency in the use of resources and the reduction of waste production (Giorgi et al., 2017; Toni, 2015). It focuses,

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**Corresponding author: e-mail: sara.raciti26@gmail.com

in fact, on a virtuous use of disused goods, now at the end of their life - through their reuse/recycling - in order to extend the life cycle of products, contributing to the reintroduction in a new production cycle as a second raw material. In September 2014, the European Commission (EC Directive 98, 2008) drew up a package of measures to recycle 70% of municipal waste and 80% of packaging waste by 2030, and to ban the landfilling of recyclable waste from 2025. In 2015, the new circular economy package aims to recycle at least 55% of municipal waste by 2025 (60% by 2030 and 65% by 2035) and, in parallel, to bind landfilling (up to a maximum of 10% by 2035). 65% of packaging (EC Directive 19, 2012; EC Directive 31, 1999) will have to be recycled by 2025 and 70% by 2030. Textile waste and hazardous household waste (such as paints, pesticides, oils and solvents) will have to be collected separately by 2025; biodegradable or recycled at home through composting. The long term strategy is to involve companies in making products with new materials that are fully reusable and therefore do not generate waste, while the short/medium term strategy is to manage the waste produced in a more responsible and virtuous way (www.economiacircolare.confindustria.it).

The legal concept of waste, as set out in art. 2, 1st paragraph, of Presidential Decree 915/82 (Presidential Decree, 1982), included “any substance or object deriving from human activities or natural cycles, abandoned or destined for abandonment”. In Italy, the first measure was taken by Legislative Decree no. 22 of February 5, 1997 - the so-called “D. Lgs. Ronchi Decree” (Legislative Decree 22, 1997) with the aim of reducing the production of waste at source by promoting the recovery of material and energy. The priority is to think of products in such a way as to simplify their management at the end of their life; to reuse and recycle them as far as possible and economically sensible; to recover by-products, starting with energy and compost and ending with poor materials to be used as filling. Only “ultimate waste”, i.e. waste that cannot be further valorised, should end up in landfills (Massarutto, 2008). The decree identifies tools to reduce the quantity, volume and hazardousness of waste, through an approach that considers the life cycle of products at 360°: from design to post-consumption. The implementation of strategies to give priority to the recovery, reuse and recycling of waste is reflected in two priority actions: the optimisation of separate waste collection systems for technical, economic and environmental effectiveness and the development of the market for the recovery, reuse and recycling of waste. Finally, the recovery of energy intended as the production of heat and/or electricity from waste "as is" subject to more or less complex treatment processes by allocating to landfill the residual phase of management related to the recovery of material and energy, through permanent storage in the ground (Massarutto, 2008). Waste can be thermally treated through three basic processes, each with a different amount of oxygen present: Incineration (or waste-to-energy), in which the full combustion of the organic fraction is carried out, in the presence of an adequate excess of air and with the result of obtaining completely oxidized products; Gasification, in which partial combustion of the waste is carried out in the presence of an oxygen defect. Only a part of the treated material burns, producing sufficient heat for the thermal decomposition of the remaining material (Munda and Matarazzo, 2020). The final products are not completely oxidized and therefore have their own calorific value; Pyrolysis, in which no combustion or oxidation takes place but rather a thermal degradation of the material in the absence of oxygen, through direct or indirect heat input (Giunta et al., 2019).

Over the years the cultivation of pistachio has gained considerable importance leading to the establishment of the Consortium for the protection of the same, with various voluntary and binding regulations to guarantee the origin and protection of the product, leading several entrepreneurs to enter into a consortium contract: several entrepreneurs set up a common organization for the discipline or for the conduct of certain phases of their respective businesses (Royal Decree 262, 1942). The Brontese producers have chosen to entrust the

control of D.O.P. Pistacchio Verde di Bronte (www.qualigeo.eu), which is a mark of legal protection conferred by the EU to foods whose distinctive quality characteristics depend essentially or exclusively on the territory where they were produced. The case study presented is based on the implementation, within the company Bacco ltd located in Cesarò (ME), of a new waste-to-energy plant able to manage the treatment of waste, in compliance with regulations, in particular the shell derived from the processing cycle of pistachio from the initial phase, until its disposal. In this way, the fraction of food waste is recovered in order to make it a renewable energy source for internal use.

2. Case study: Bacco ltd

Bacco ltd was born on November 4th 2006 from the entrepreneurial initiative of Claudio Luca in response to a market increasingly attentive to the quality and naturalness of food products combined with an aesthetic and visual presentation that is appealing and stimulating the final purchase (www.fasda.it; Caruso et al., 1999; Putrino, 2007; Spataro, 2015; Spina, 1982).

The Bronte pistachio tree, renowned throughout the world for its uniqueness, grows exclusively on the lava soil of Etna and thanks to its origin has an emerald green color, an intense perfume and a particular tasty taste. The company's mission is to plan an internationalization and marketing of pistachio, offering a “handmade product” to a target that prefers the taste, authenticity and certainty of origin, typically Sicilian, proven by PDO certification. Bacco ltd that in its productions uses the best qualities of pistachio, starting from traditional preparations (from processed pistachio to semi-finished pistachio, from pistachio cakes to liqueur, from nougat to pistachio flour, from crunchy to pistachio grains) and then expanding to other productions, which arise from a careful study of compatibility between the characteristics of pistachio and the eating habits of consumers. The company prepares sweet and savory products using dried fruit (pistachio, almonds, hazelnuts). The processing cycles are:

a) Receipt of raw materials and semi-finished products: The Company Manager (RA) receives raw materials and secondary raw materials (semi-finished products) from qualified suppliers.

b) Order compliance order transport conditions/product specific control: RA on receipt of raw materials checks that the order complies with the order placed, verifies that the raw materials have been transported in suitable hygienic and sanitary conditions.

c) Storage: RA or appointed, transports the raw materials to the storage rooms. The various raw materials are sorted in the storage/cold room and organized according to the type of goods.

Bacco ltd produces: dried fruit pesto; creamy, sweet or savory products; dried fruit pesto. Also it produces crème with: dried fruit, coffee, natural flavors, citrus fruits, berries, dark chocolate; creams based on ingredients other than dried fruit; semi-finished dried fruit products; dried flour and dried fruit packaging; dried confectionery; baked confectionery products with dried fruit; dried fruit nougat; spakkimi; cocoa butter products; other products. Bacco ltd has obtained the international certifications UNI EN ISO 9001 (ISO 9001, 2014) in 2014 with the accreditation body European Certification Institute and BRC (British Retail Consortium, Great Britain), in 2016 with the body Bureau Varitas Certification on its Quality System. In addition, in 2019 Bacco ltd was awarded by the accreditation body RINA Services S.p.A. (Italian Naval and Aeronautical Register) the HALAL/16/6 certification (Halal International Authority (HIA)). Bacco ltd has decided to adopt a BRC Standard (with the intent to define food safety and quality requirements) - IFS (International Food Standard) - HACCP and has defined and implemented a company policy that takes into account

customer care, environmental and personnel responsibility, focusing on product characteristics (safety, quality, legal requirements, processes and specifications). In 2019 the company, again with the certification body RINA Services S.p.a., acquired HALAL/19/6 certification. The term Halal, derived from Arabic, means "lawful" or whatever is permitted under Islam and reflects a quality, supply chain and product certification that includes all quality control systems, and measures affecting all stages of primary production at the preparation, processing, manufacturing, packaging, storage, transport, distribution, handling, sale or supply, including delivery to the consumer. In addition, methods and systems for the provision of financial resources and social responsibility are also involved. Like all agri-food companies, Bacco ltd is also certified on the HACCP (Hazard Analysis Critical Control Point), which involves the adoption, by all links in the production chain, of a series of measures for prevention and control, in compliance with the rules of good hygiene practice contained in the guidebooks of the individual trade associations.

The HACCP system is developed on the principles of the Codex Alimentarius, concerning physical, chemical and microbiological contamination, with the aim of complying with all legal requirements of the countries of production and destination. In compliance with the Initial Environmental Analysis (AAI) we aim at the implementation of an EMS in compliance with UNI EN ISO 14001 (2015) at BACCO ltd The environmental impacts, risks and opportunities identified will constitute the input for the planning and implementation of environmental management, in implementation of the Company's Environmental Policy and in accordance with the EMS reference procedures (Table 1). Environmental impacts and significant risks related to the Company's activities and products:

Table 1. Direct and indirect impacts

Direct Impacts	***Impacts***	***Risks for the Organization***
1 Modification of visual areas and landscape (for plant construction only)	1. On the suppliers of products and/or services	1. Asset Integrity (plants and technologies)
2. Soil modification/contamination	2. Exploitation of resources	2. Business Continuity
3. Exploitation of resources		3. Legal Responsibility (Sanctions)
		4. Image (Reputation)
		5. Market Response
		6. Income Statement (Turnover)

Source: Bacco ltd

3. Material and methods

We do not have specific information to learn more about the origin of pistachio in the Sicilian landscape.

Nowadays, the Pistachio Industry is not consolidated: indeed, the pistachio farmers are not ready to make a better system, which provides lower production costs, and remunerative sales prices.

Then, it is possible to confer an instrumental function to the pistachio farmer's union. Thanks to its agreement several farming entrepreneurs establish a common organization to regulate and/or to conduct specific phases of respective entities (Ingrao et al., 2015).

The circumscribed pistachio area of Catania covers the 80% of the regional soil-especially in the areas of Bronte and Adrano, but also in Agrigento, Caltanissetta and Palermo – represents 2,560 hectares of pistachio threes: 2,400 hectares that are the most representative cultivation and the remaining 250 hectares used as secondary cultivation.

The Pistachio grows in Sicily on lava lands in the Southwest slope of Etna, which are calcareous soils that are rich of pebble skeleton and just fissured lithophones where the species P. terebinths (stonebreaker) forms some "spots" as a result, it can be possible to find a conform plant structure, even if normally is not possible to realize a symmetrical dislocation. The cultivation of pistachio in Sicily offers three different varieties such as the *Napoletana*, the Femminalla (known as Rossa or Cerasuola) and the Agostara.

There is a vast range to the pistachio use: from the traditional one – the consumption of in-shell pistachios – to the industrial one – the confectionery, the cured meats, the culinary arts to the most recent cosmetics industries and such as side dishes to taste aperitifs and liqueurs.

This is the reason why the pistachio becomes an avenue for increased cultivation at a global level (Table 2).

The Sicilian's sale and export of pistachio are made in shell (tignosella), unshelled (ntrita), and seeded.

Table 2. Italian pistachio import export

IMPORT EXPORT ITALIAN PISTACHIO (also shelled or peeled)						
Age	***Import***			***Export***		
	Amount	***Value***	***Euro/kg***	***Amount***	***Value***	***Euro/kg***
2008	103,192	512,273	4.96	9,372	85,190	9.09
2009	104,723	620,764	5.93	7,597	75,725	9.97
2010	60,064	42,496	7.53	4,129	52,624	12.74

Source: processing of Ismea data

Most of Bronte's Pistachio production is exported (80%), so only 343 tons (per year) would be consumed in Italy. The reduction of yields is due to the presence of a maculation that caused a less intense colour of cotyledons emerald green. These features, in combination whit higher prices of the Sicilian product, determinates a competitive disadvantage in terms of imported pistachios.

The 77.5% of the peeled product (1,868 q) is absorbed by the cured meats industry, which almost exclusively processes the superior quality product for the aroma, size, integrity, and colour of the cotyledons. The confectionery industry, which is more interested in the green colour of cotyledons, absorbs 79.8% of the shelled product (1,383 q) and all the grain flour and grain (227 q) but also use peeled (342 q) and 25.2% of the scrap (28 q). The industry for the basic preparations of ice creams absorbs smaller quantities (347 q) and uses peeled (200 q) and shelled (114 q), but also absorbs a large part of the scrap (33 q). On average, the artisan workshops absorb 108 q of shelled (6.2%) and almost half of the scrap. Within the pistachio industry, there are three production steps:

1- Removal of shell à removing the soft nut which is inside a hard-shell. Then, separating it from shells, are removed the external husks to divide the chaff from the nuts themselves. In this case, shells represent a "waste" that does not affect the environment, because it can be classified as secondary raw material to re-use as a new energy source (e.g. turn on a wood stove or oven too)

2- Rasping process à removing the shell to reveal the seed (or separating the split seed from shells).

3- Production of semi-finished goods à the treatment of pistachio to semi-finished good production. Then the output of last pistachio production's stage is semi-finished products.

During this step, the pistachio is manipulated to raise no more scraps and wastes too.

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For what concerns the environmental impact of pistachio industry to production and transformation until its end-user, it is important to highlight that its production contributes to a "zero waste" achievement and to have positive environmental effects.

The achievement of the D.O.P. (Declaration of Performance) according to the European Union provides information on the performance of the different production and transformation phases, which take place in the same area in respecting the production policy of earlier and later processes (Fig. 1). The attribution of the mark, in addition to the commercial benefits, is the main weapon to fight the fake products diffusions (www.qualigeo.eu).

Fig. 1. Logo D.O.P Green Pistachio of Bronte (www.qualigeo.eu)

4. Result and discussion

The process realized by the material derived from plant organisms - biomass - can be used as fuels or transformed into other substances (solid, liquid, or gaseous) easier to use in conversion plants. The heating value of pistachio shells is about 4.40 Kwh/kg (a positive value), while the bulk density does not reach 400 kg per cu. m. This represents a crucial factor in transport costs considering, for example pellets and pomace kernels, which have an apparent density of between 600 kg and 750 kg per cu. m.

Pistachio shells have a humidity percentage always below at the value of 10 (a low-moisture level) (Table 3).

Table 3. Average value per biofuels analysed

Biofuel	*Water content (% t.q.)*	*Ash (% s.s.)*	*PCI (MJ/kg t.q.)*	*Azote (% s.s.)*
Olive pruning	26.76	4.25	12.93	0.93
Grape pruning	36.27	3.42	10.38	0.74
Peanut oil	14.81	1.24	15.80	0.32
Hazelnut shells	13.58	1.22	16.39	0.28
Almond shells	10.98	1.63	16.05	0.36
Walnut shells	10.18	1.25	17.29	0.45
Pistachio shells	11.34	0.66	19.26	0.27
Pine nutshell	12.87	1.60	16.55	0.26
Woodchip A1	25.00	1.00	13.27	-
Pellet A1	10.00	0.70	16.5	0.30

Source: Rossi (2018)

In the Circular Economy perspective - particularly within the agri-food industry - the present case study proposes an experimental use of the pistachio shell - biomass that is mainly made up of substances with a high concentration of hydrocarbons (e.g. cellulose,

hemicellulose, and lignin) or rather. An agricultural waste generated by the production of the fruit during the different transformation's phases of the material.

Pistachio shells represent on average between 35% and 45% of the total weight of the fruit: this means that there is a worldwide potential for pistachio shells that can be able to be used as energy biomass of about 250,000 tons.

The innovative element is the use of pistachios not only to produce confectionery products but also to plan the organic wastes use as an alternative source of energy.

In the examined case, the recyclable energy of the treatment of pistachio shells can be obtained either by direct combustion of the biomass itself or through its gasification obtaining the synthesis gas. In the first case, the heat produced by the combustion of biomass may be used to produce hot water for direct use in building heating systems or for use in production cycles, etc. In the second case, an internal combustion engine in cogeneration for the simultaneous production of electricity consumes the synthesis gas.

The process of creating biogas is the traditional one: once harvested the pistachio nuts are placed in a biomass-fired power station, where they can be used immediately for energy production. Then, the biomass is closed in a digester where begins a biochemical conversion process called anaerobic digestion in the absence of oxygen. Bacco has 55 tonnes of shell waste every year. Therefore, the heating value of the pistachio shell is about 4.40 kWh/kg, applying a proportion it is possible to trace the total heating value given by 55 tons.

The digestion process consists in the demolition, by bacteria, of complex organic substances contained in plants and animal by-products, which produces biogas which, after being collected and dried it could be used as fuel to power gas boilers to produce heat, or combined cycle power plants, or internal combustion engines (Fig. 2).

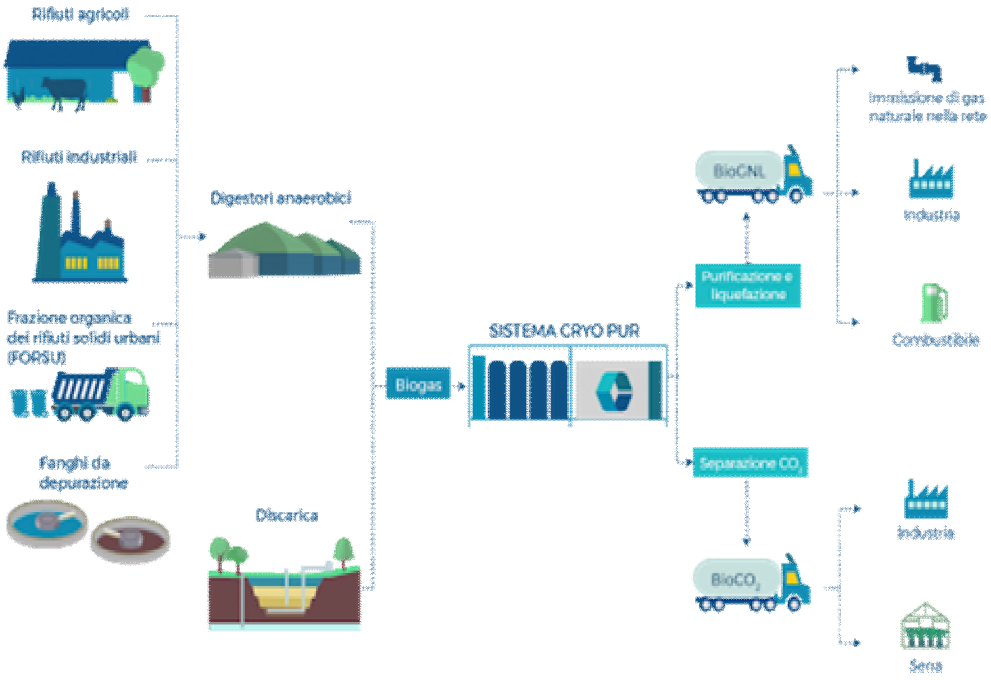

Fig. 2. Eco-efficient management of construction and demolition waste (www.cryopur.com)

55 tonnes → 55,000 kg
1kg : 4.40kwh/kg = 55,000 : x
X= 242,000 kwh/kg (Heating value for one year)
242,000 kwh/kg : 12 = 20,166.67 kwh/kg (Heating value for a month)
20,166.67 : 30 = 672.22 kwh/kg (Heating value for one day)

5. Concluding remarks

The Circular economy paradigm can offer new growth opportunities through an efficient resources' implementation, involving different actors within its supply chain.

The placement of an energy creation plant - through wastes caused by the same company - in Bacco could be a technological innovation, which involves several economic and environmental advantages.

The exploitation of biomass - easily available in nature and low energy expenditure - implies different and advantageous points. In view of this, saving energy is possible to reduce the problem of CO_2 emissions and pollution too, thanks the support to the environment to avoid the use of fossil fuels. The economic feedback can be crucial when it is related to plants that are installed in companies where biomass is generated as a waste of various types of productions, from the other.

A financial/economic analysis and efficiency evaluation of the investment project provided by Bacco ltd, initially estimates high costs caused by the installation of the digester plant, which however should amortize over the years, and the costs of the ordinary maintenance of the plant.

The above-mentioned costs would be supported by using the various reserves accumulated over the years, through two methods self-financing or equity. Over the years, the Company - since the installation of this plant – has obtained a real advantage determined by saving energy costs provided at this time by the agreement that Bacco ltd has signed with electricity service.

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