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ASSESSMENT OF THE ENERGETIC VALUE OF ANCIENT SICILIAN WHEAT IN THE INDUSTRIAL SYMBIOSIS PERSPECTIVE*

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Abstract

In recent years, the European Union has promoted several strategies to support the transition from a linear economy to a circular economy without waste. In this context, industrial symbiosis plays a fundamental role, that is, by the process of company interaction aimed at obtaining competitive advantages from the transfer of resources between dissimilar industries. In this regard, Sicilian farmers and agronomists have recently rediscovered ancient Sicilian wheat, re-evaluating the local agricultural sector. It has been long time since the latter was outclassed by modern wheat substantially accountable for food allergies. Due to hot, dry weather conditions and to a low gluten index, this wheat keeps its special healthy benefits that makes it ideal for combating digestive disorders. The project studies the Company "F.lli Vescera S.r.l. – bakers and pasta makers", situated in Carlentini (Sicily). The aim of this research is the analysis of agri-food companies' potentialities to produce energy from biomass which comes from ancient Sicilian wheat.

Keywords: industrial symbiosis, circular economy, biomass, energy efficiency, ancient Sicilian wheat

1. Introduction

The transition to a circular economy mainly involves the agricultural sector, which must be up to this challenge through a sustainable management of natural resources. For this reason, in many agri-food companies, the production and the use of biomass as a new source of renewable energy in the manufacturing process has emerged. The circular economy,

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according to the definition given by the Ellen MacArthur Foundation, is a generic term widely used to define an economy designed to regenerate itself. It is, therefore, a system that organizes all the activities - from the extraction to the production. In the linear economy, however, once consumption has taken place, the cycle of the product ends too and it becomes waste, forcing the economic chain to continuously follow the same extraction, production, consumption, and disposal scheme. The circular economy provides for a massive use of renewable energy sources (central element of sustainability), a large transfer of information among economic actors, a strong capacity for technological innovation and products that are totally or partially recyclable or reusable. This phenomenon could bring with it the end of one of the mechanisms that underlies the linear economy: the programmed obsolescence of products. The incentives to produce on the model of a circular economy would be essentially a saving on production costs and the acquisition of a competitive advantage, as a consumer prefers to buy a circular consumer product rather than a linear one. This new approach also entails a significant decrease in the company's environmental impact. It is therefore advantageous to apply the concept of circular economy to all the activities linked to the primary sector, in particular to livestock farming. The improper waste disposal risks negative effects being produced both from an economic and environmental point of view: diffusion in the environment of pathogens; production of harmful elements for soil, plants and man himself; eutrophication of water (Chen et al., 1994).

In July 2018 the EU outlined some fundamental strategic guidelines in which industrial symbiosis is identified as a particularly useful policy tool for achieving this innovation. This new field of interdisciplinary research, aiming at sharing resources between companies in traditionally separate sectors, wants to avoid that a company’s by-products, potentially used for production purposes by other companies, can become waste. The transition to a circular economy model is a relevant matter, especially for the agricultural sector. In fact, even if traditional agriculture already incorporates cyclic reuse of its products, industrial agriculture that has developed recently, has become much more linear, consuming materials and disposing of more waste. In fact, it is necessary to highlight how this new approach can contribute to a more efficient use of natural resources and, at the same time, to encourage an increase in the competitiveness of agricultural enterprises. The way agri-food companies implement circular economy processes to make sustainable activities has been widely discussed. What is significant is certainly the re-use of resources available to create something new to reduce waste through biomass production. For a part of the planet, a high level of satisfying food needs has been reached (food security), but the industrialization of the food production processes has led to a flattening of the features of production. In short, a lowering of safety (food safety), has been demonstrated by the large numbers of emergencies caused by contamination and food quality. In very recent times, various Sicilian agronomists have rediscovered ancient wheat for its extraordinary beneficial properties. The scientific definition of the Mediterranean diet is owed to the American scholar Ancel Keys, who studied the eating habits of people when heart disease or strokes were still unknown. Durum wheat is certainly the most important of southern Mediterranean cereals and bread and pasta are the main foods derived from processing. These constitute the essential elements of the Mediterranean diet which, as well as a beneficial health food system, defines a model of endogenous, integrated and sustainable development (Saia et al., 2015; Scheer, 2006).

The objective of this research is to analyse agri-food companies to understand how they can achieve energy efficiency while maintaining a proactive behaviour towards the environment. This can happen, in fact, in different ways depending on the resources that the company makes available. So, this includes investments in plants aimed at using renewable energy, or recovering waste materials, especially with the creation and use of biomass energy.

The industrial symbiosis, in this perspective, plays a fundamental role because it could represent an opportunity for those companies that do not have the proper resources to adapt to the new environmental necessities that nowadays are increasingly urgent.

2. Materials and methods

The food industry and food farming sectors in Italy are mainly composed by small-average firms. To innovate means to equip the company with the basic tools that allow the Italian enterprises to reduce their own energy requirements. The production of renewable energy from agricultural sources is an articulated challenge. Zootechnical are organized for origin (agricultural enterprise, agroindustry, forest, biomasses of the management of the public green or the wooded areas) and for typology (grassy crops, woody biomasses, by-products, outflowing zootechnic). Besides, the techniques of transformation of these raw materials are constituted by a multitude of physical, chemical and biological processes. An agricultural enterprise, to exploit the opportunities offered by the sector of the renewable sour-energies, must proceed in different ways: first, the agricultural enterprise can produce different raw materials (like biomass) that can be converted in energy through different technologies of transformation. The agricultural enterprise can produce biomass from annual vegetable species (sorghum, corn, kenaf), from long-time ones (thistle, Miscanthus, reeds, poplars) or from pruning waste. These raw materials can be transformed through a thermochemical conversion, in fuel (bio-oil, coal, gas, combustible gas) or heat, which in turn produce electric energy. A second possibility is that the agricultural enterprise can produce ethanol or combustible gas through fermentation and digestion of the biomass. Otherwise, it produces an oleaginous oil (as that of the sunflower) and, through a process of physical-chemistry conversion - called pressing - and get combustible oil or biodiesel, turned into electric energy or heat (Bartolazzi, 2006).

The biomass in the form of plants, trees, grass, leaves, manure and animal waste can be a valid source to produce alternative fuels that can replace combustible fossils. Recently, the ancient wheats have been rediscovered: they contribute to the production of biomass through the recycling of some inedible components, as the stem. One of the most innovative approaches, undertaken by a food-farming firm, could be the investment in new equipment in order to transform biomass to produce biogas. Systems and machinery available in agriculture, such as combine harvesters, with models of various power and dimension, carry out the processes of harvest and transformation.

Biomass energy is, perhaps, one of the most controversial typologies of alternative energy used today. The advantages of energy coming from biomasses are different. First, biomass energy is a renewable resource. Secondly, it reduces the dependence from the fossil fuels, and it is a carbon neutral resource: that is to say, it does not produce carbonic anhydride in excess during its transformation. Besides, the organic waste in the form of leaves, grass and trees, but also carcasses of animals and their excrements are available in abundance and they can be used to produce energy. This is a possible way to use waste because if it was not used to produce electricity, it would increase the quantity of waste in dumps. It helps therefore to reduce waste and the management of the waste. Continually enormous quantities of solid waste are created which can be classified as biodegradable, recyclable refusals, but also dangerous toxic ones. Finally, the biomass can be useful to create different products coming from different forms of organic material: it can be used for producing gas methane, biodiesel and other biofuel or directly in the form of heat or electricity (Scheer, 2006). The interest in renewable energies emerged in 70’s, following the first great world oil crisis of the 1973. In 1974 the report "A Time to Choose" by David

Freeman was published, commissioned by the Ford Foundation, which addressed the opportunities given from the use of the renewable energies and on the possible energetic savings thanks to the new productive technologies. It was not about climatic changes, the main issue concerned atmospheric pollution and the overcoming of economic and political risks determined by the dependence toward the importations of energy. The American government stimulated the production and the use of the so-called "green energies" (Raj and Antil, 2011).

Table 1. Renewable resources in European countries (QualEnergia.it) – primary production by energy type, 2013

Country	***Total primary production (Mtoe)***	***of which (shares):***					
		Solid fuels %	***Oil %***	***Gas %***	***Nuclear %***	***Renewable sources %***	***Wastes (nonrenewable) %***
EU	**789.7**	**19.7**	**9.1**	**16.7**	**28.7**	**24.3**	**1.5**
Belgium	14.6	0.0	0.0	0.0	75.2	20.0	4.8
Bulgaria	10.5	45.4	0.3	2.1	34.8	17.3	0.1
Czech Republic	29.9	59.0	0.9	0.7	26.6	12.2	0.7
Denmark	16.6	0.0	52.3	25.8	0.0	19.5	2.4
Germany	120.6	37.4	3.1	7.4	20.8	27.9	3.4
Estonia	5.7	78.3	0.0	0.0	0.0	19.9	1.9
Ireland	2.3	56.9	0.0	6.8	0.0	33.7	2.5
Greece	9.3	72.3	0.8	0.1	0.0	26.7	0.2
Spain	34.2	5.1	1.1	0.1	42.7	50.5	0.4
France	135.1	0.0	0.9	0.2	80.9	17.1	0.9
Croatia	3.6	0.0	16.8	41.6	0.0	41.4	0.2
Italy	36.9	0.1	15.9	17.2	0.0	63.7	3.1
Cyprus	0.1	0.0	0.0	0.0	0.0	100	0.0
Latvia	2.1	0.1	0.0	0.0	0.0	97.1	0.2
Lithuania	1.4	1.7	6.2	0.0	0.0	91.1	0.1
Luxembourg	0.1	0.0	0.0	0.0	0.0	76.4	23.6
Hungary	10.1	15.9	8.5	15.3	39.3	20.5	0.5
Malta	0.0	0.0	0.0	0.0	0.0	100	0.0
Netherlands	69.7	0.0	3.1	88.7	1.1	6.2	0.9
Austria	12.1	0.0	7.2	9.3	0.0	78.2	5.3
Poland	70.5	80.5	1.4	5.4	0.0	12.1	0.6
Portugal	5.8	0.0	0.0	0.0	0.0	97.5	2.5
Romania	26.1	17.8	16.3	32.9	11.5	21.3	0.3
Slovenia	3.6	30.3	0.0	0.1	38.5	30.2	1.0
Slovakia	6.4	9.1	0.2	1.6	64.1	22.9	2.1
Finland	18.0	9.4	0.4	0.0	33.8	55.2	1.2
Sweden	34.7	0.5	0.0	0.0	49.4	48.4	1.7
United Kingdom	109.5	6.7	38.3	30.0	16.6	7.7	0.7
Norway	**193.9**	**0.6**	**43.5**	**49.3**	**0.0**	**6.4**	**0.1**
Montenegro	0.8	48.9	0.0	0.0	0.0	51.1	0.0
FYR of Macedonia	1.4	77.9	0.0	0.0	0.0	22.1	0.0
Albania	2.0	0.0	57.9	0.7	0.0	41.4	0.0
Serbia	11.4	67.4	10.8	3.7	0.0	18.1	0.0

3. Case study: F.lli Vescera S.r.l.

Ancient wheats, after being rediscovered by local farmers, are considered fundamental for the realization of the circular economy within the agri-food companies. Thanks to their different physiognomy and their longer stem, as compared to the modern grains, the production of greater biomass is possible.

Spelt has a very different bran compared to soft wheat because this fiber is largely made up of non-cellulosic polysaccharides that our intestinal flora can transform into short-chain organic acids. These are the primary sources of energy for the epithelium of the colon and stimulate cell turnover, blood flow and intestinal motility. Spelt has easily digestible, non-allergenic proteins and starches with slow release of sugars. This allow the sick organism to restore the organic functions compromised by incurable diseases such as chronic disease, celiac disease, diabetes mellitus or even cancer. In reality, what has changed recently is not the quantity of gluten of the wheats but the "Gluten Index", which is linked to the rheological properties of gluten. The study focused on 8 modern wheat varieties (Adamello, Simeto, Preco, Iride, Svevo, Claudio, Saragolla, PR22D89) and 7 ancient wheat varieties (from 1900 to 1949 Dauno III, old Saragolla, Rusello, Timilia, Capelli Garigliano, Grifoni 235) to investigate the different composition of gluten. Gluten is deposited in a grid and, with a centrifugation; it is observed how much of the gluten comes out of the grill. The amount of gluten that remains in the centrifuge grid in relation to the total weight of the wet gluten compared to the Gluten Index (De Santis et al., 2017).

Table 2. Ancient and modern grains in comparison

Groups	*Genotypes*	*Pedigree*	*Year of release*
Old	Dauno III	Landraces from south Italy	1900
	old Saragolla	Landraces from south Italy	1900
	Russello	Landraces from Sicily, Italy	1910
	Timilia (R.B.) “reste bianche”	Landraces from Sicily, Italy	1910
	Cappelli	Selection from Tunisian population Jean Retifah	1915
	Garigliano	Tripolino x Cappelli	1927
	Grifoni 235	Cappelli x *Triticum aestivum*	1949
Modern	Adamello	Valforte x turkish line 7116	1985
	Simeto	Capeiti 8 x Valnova	1988
	Preco	(Edmore x WPB881) x Selected line 3	1995
	Iride	Altar 84 x Ionio	1996
	Svevo	Cimmyt line x Zenit	1996
	Claudio	(Cimmyt selection x Durango) x (IS1938 x Grazia)	1998
	Saragolla	Iride x PSB 014 Line	2004
	PR22D89	(Ofanto x Duilio) x Ixos	2005

According to ISTAT, the area sown with durum wheat in Italy in 2017 amounts to 1.28 million hectares following a marketing campaign carried out in 2016. For centuries Sicily was considered a "granary" of Italy. The ancient Greeks and Romans contributed significantly to the cereal cultivation on the island. It was during the period of Greek domination that the trimenaias, quarterly cycle wheat, sown in March (more commonly known as timilia) began to be cultivated. Among the most important centres where the cultivation obtained immediately excellent results were the fields of Lentini, a production that has been carried out over the years up to the present day. From 1890, in Carlentini the Vescera family has carried out their activity as bakers: today, with Franco Vescera, they have reached the eigth generation. The company philosophy is aimed at the recovery of ancient Sicilian grains such as Russello, Tumminia and Margarito Persicane (grains that still follow the traditional grinding techniques) to make the typical bakery products of the territory.

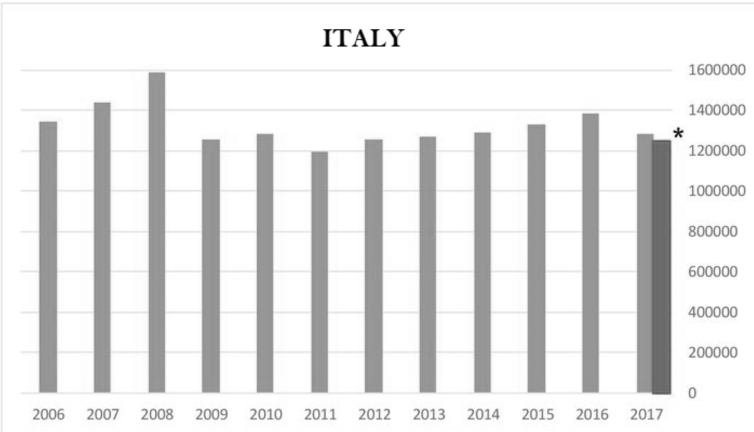

Fig. 1. Chart of durum wheat sowing in Italy (source: ISTAT)

Grinding at low speed prevents the cooking of flour due to overheating: in this way the ground product maintains taste, aromas and beneficial properties that would otherwise be lost by industrial grinding. In fact, the ancient grains favour a better digestive action and are particularly suitable for those who suffer from gluten intolerance. This is combined with the use of sourdough and of course the art of bakers in processing and baking in a wood oven, resulting in a nostalgic reappearance of the ancient Sicilian breads.

The company alternate the grains of Timilia, which occupy 50% of the land (used for sowing cereal for their high versatility), with the grains of Russello to produce bread: both products are varieties available for many years with their fragrance and organoleptic properties are a clear example of the Sicilian tradition handed down over the centuries. Tumminia and Russello bread, obtained from integral re-milled durum wheat semolina, has a higher antioxidant content than that obtained from red grapes. The grinding is done in stone mill at low speed, and cooking is done in a wood oven. This is how the wholemeal semolina bread is made, obtained from the indigenous wheat grains of timilia, rich in fiber, easily digestible and long-lasting.

Recently, other varieties of bread, pizza dough and bronze-drawn pasta in various shapes, including lasagne, linguine and macaroni have been produced. The company obtained the BIO certification, defined at Community level through the EC Regulation 834 (2007) and nationally by the Ministerial Decree 220/95, and, of course, HACCP according to the European Directive 43 (1993) (implemented in Italy with the Legislative Decree n.155 of 1997). Since the Expo in Milan in 2015, remarkable results have been obtained. The company is also the main figure at many trade fairs and markets that take place annually throughout Europe to promote and make them known internationally.

4. Results and discussions

The “F.lli Vescera” company is considered a leader in the circular economy sector, since it reuses everything produced during the production process. Always attentive and respectful of the surrounding environment, it represents a combination of efficiency and quality, tradition and innovation. The company produces biomass from anything that could be considered waste: waste from olive groves, citrus groves and straw. An efficient use of biomasses is their carbonization in stone ovens, from which the ash is obtained that is very popular with farmers to fertilize their plants. Since 2000 the company, in close collaboration with the Experimental Consortium of Granicoltura for Sicily located in Caltagirone, has begun to carry out research to deepen and analyse the sources of provenance of the wheat used.

The company intends to introduce photovoltaic panels on all the roofs of their buildings within the next two years. In this way solar power will be used to produce electricity. This is possible thanks to the fact that Eastern Sicily is the sunniest area in Europe. Another important initiative is to install water facilities throughout the structure to collect rainwater and not waste even a single drop. The water collected can be useful in all stages of processing, from upstream to downstream: for example, it is useful for the irrigation of plants and therefore their photosynthesis, it can be used in the cleaning and rinsing of plants and tools. Once filtered and purified, it could also be used in the processing of products.

The proposal offered to the company is to introduce biomass transformation plants to create energy. Careful analysis allowed the most suitable biomasses for biogas yield in animal escrement, crop residues, organic waste from agri-industry and energy crops through anaerobic digestion. For biomass to become biogas the action of different types of specialised microorganism is required. A first group of bacteria starts the degradation process, transforming the organic substance into intermediate compounds such as hydrogen, acetic acid and carbon dioxide. A second group of bacteria, made up of metanigenic microorganisms, completes the work producing methane. The biogas production process takes place inside specific "digesters", where the introduced biomass (the so-called "substrate") is divided in variable percentages between 40% and 60%. The anaerobic digestion technique can be dry or wet, in mesophilic conditions (about 35 ° C) or thermophilous (55°C). Once the biogas is obtained, before its use, it must be purified by desulphurization and dehumidification. Then, it is ready for the realization of energy. This can be done by:

- direct combustion in the boiler, with the production of only thermal energy
- combustion in engines that drive generating sets to produce electricity
- combustion in co-generators for the combined production of electricity and thermal energy
- for automotive use as 95% methane

Another product obtained from the anaerobic digestion of biomass is the digestate, which can represent an exceptional fertilizer rich in nutrients. The latter can be separated by centrifugation in a liquid and a solid phase. The solid phase is sent to the production of compost, while the liquid phase can be reused as an inoculum in the production cycle or be distributed in the field by special machines or directly by fertigation.

The environmental advantages deriving from an anaerobic digestion plant are certainly significant. First, it is possible to produce energy from a renewable source; secondly, there are less greenhouse gas emissions and, consequently, better management of emissions into the atmosphere; finally, it leads to a marked improvement in the economy of livestock and/or farms that can point to a new revenue from a secondary activity (Cocozza, 2013). Productivity (in terms of the quantity of wheat per hectare) in a company that decides to grow ancient grains in a biological way is reduced by about 50%. Nevertheless, profit margins are not reduced; on the contrary, they increase thanks to two elements:

1) Cost reduction: to produce the local wheat the grower does not have to turn to any supplier: the seed is on the farm; it does not need to be fertilized chemically, not to be defended by herbicides. This results in a significant reduction in costs.

2) Premium Price: given its quality, ancient wheat can be sold at a higher price than modern wheat. The premium price can more than offset the revenue losses generated by lower productivity. The company's revenues are not reduced. Given its characteristics, ancient wheat does not need the many inputs (fertilizers) and the processing that conventional (or modern) grain requires; moreover, it is better able to resist the negative effects of the weeds because it is possible to obtain more biomass (the modern grain is just 90 cm tall, while the local wheat is between 1.5 and 2.2 meters) (Ruggiero, 2014).

Ancient wheat has a capacity to root more than modern grains because it must support a taller stem; which allows it to access micronutrients normally not accessible to modern grains. The straw obtained from the wheat is destined for 40-50% as litter for animal shelter, 10% for animal feed, and the remaining 30% is burned in the field. With the entry into force of the Kyoto Protocol, the research and use of renewable energy sources has become necessary, thus reducing the emissions of greenhouse gases into the atmosphere: biomass represents a concrete and current possibility in this sense.

5. Conclusions

It has been written how the industrial symbiosis in the agri-food sector proposes a new vision of the circular economy, a model which today is increasingly widespread and rooted in the thinking of companies replacing the old linear model. Thanks to this premise, the italics company has decided to embark on this path that will lead to an improvement of effectiveness and efficiency of the input/output ratio, becoming a proactive company using solar-energy.

The creation of new structures aimed at exploiting biomass as a source of biogas represents an important starting point for obtaining other certifications, such as those of the ISO 9000 family. This conclusion considers the increasing needs of the modern consumer who demands technological innovations and respect for the environment. It emerges how the market, in the last 20 years in constant ferment, increasingly seeks "green" companies that are careful about their emissions. The companies, through an intense environmental marketing activity, will have a wide competitive gap that the competitors will necessarily have to fill.

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