UNIVERSITY OF FOGGIA

DEPARTMENT OF ECONOMICS

PHD

"HEALTH FOOD INNOVATION AND MANAGEMENT"

TITLE OF THESIS:

"Sustainability and shelf life extension: the case studies of fresh cut salad, extra virgin olive oil and vegetable derivate"

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Riassunto

Oggigiorno, gli sforzi più significativi nella scienza delle tecnologie alimentari hanno riguardato l'allungamento delle vita commerciale (SLE degli alimenti e delle bevande. In questo contesto, però, è stata prestata una scarsa o nulla attenzione al possibile contributo positivo che la SLE ha sulla sostenibilità globale di un prodotto alimentare lungo tutta la filiera. La SLE può contrastare le perdite di cibo e avere degli impatti positivi sulla distribuzione e sulla logistica. Numerosi studi hanno sottolineato l'importanza di aumentare le conoscenze su questi temi. Il presente progetto mira a colmare questo gap, utilizzando la SLE, ottenuta con un'innovazione di formulazione, di trasformazione o di confezionamento, come un nuovo indicatore di sostenibilità. Le attività si focalizzano su tre diversi tipologie di prodotto alimentare: l'insalata di IV gamma, l'olio extra vergine di oliva e il patè di olive. Sono stati raccolti dati relativi agli alimenti selezionati (consumi, perdita di cibo, canali di distribuzione), al fine di valutare l'impatto della SLE. Questi dati saranno utili per supportare il decision maker nella valutazione e modellizzazione di nuove strategie in grado di tener conto degli effetti di SLE sulla sostenibilità globale degli alimenti selezionati.

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Abstract

Actually, in the recent past the most significant efforts in food science and technology have been addressed to extending the commercial life of foods and beverages. In this context, however, very little or null attention has been paid to the possible positive contribution, coming from a shelf life extension (SLE) to the overall sustainability of a food product along its entire supply chain. Nevertheless, a shelf life extension can contrast food losses and the logistic distribution impacts and several studies stressed the importance of increasing the knowledge about these issues.

The project aims to overcome this gap, using SLE as a new Sustainability Indicator and matching the shelf life extension, due to a formulation, processing or packaging innovation, with the possible increase of global sustainability of food products. The activities faced different food items selected such as fresh cut salad, extra virgin olive oil, and vegetable derivate. Data pertinent to the target foods have been collected (consumptions, food loss, pathways of distribution), in order to assess the impact of shelf life extension through innovations developed or tested. These data will be useful to support the decision maker in the assessing and modelling new strategies able to take into account the effects of SLE on the global sustainability of the target foods selected.

1. INTRODUCTION

1.1- The importance of food waste reduction

The way to produce and consume food has a huge impact on the planet's resources. There is no doubt that to move towards a sustainable future involves a profound transformation of the food sector, because this food style in our society has proved harmful to health and environment. “Sustainable Products” are those able to provide environmental, social and economic benefits over their full commercial cycle, from the extraction of raw materials to final disposition. A huge interest is already on this subject and it increases daily, more and more. A lot of sustainable product standards are now available and it is now quite easy to find life cycle based metrics by which it is possible to identify sustainable products (Baldwin, 2009). In addressing the sustainability issue, researchers and policy-makers have to face economic development and environmental preservation, while also ensuring intergenerational equity balancing the need for development and the concern for the least advantaged generations (Martinet, 2012). Food scraps or losses represent irrational use of resources producing a negative direct impact on the income of entrepreneurs and consumers; a coordinated strategy that improves the efficiency of the entire supply chain is, therefore, required.

In this context, a clarification of terminology between food loss and food waste is needed:

Worldwide, an estimated 1.3 billion tonnes of food is lost or wasted annually in production, manufacture and distribution, and in homes (FAO, 2013); this is approximately one third of food produced for human consumption. This means that a huge amount of resources used in food production is used in vain and the same for the greenhouse gas emissions caused by the production of food (Segrè, 2011; FAO, 2011).

"Food loss" represents the amount of edible food, originally intended for human consumption but is not consumed for any reason; it includes loss and natural shrinkage (e.g., moisture loss), loss from mold, pest or inadequate climate control and plate waste.

"**Food waste"** occurs when an edible item goes unconsumed, such as food discarded by retailers due to undesirable color or blemishes and plate waste discarded by consumers (Wells et al., 2014).

To classify a product as "sustainable", it is also important to take into account the improvement efficiency of the whole supply chain, considering that the largest part of the waste is concentrated in the latter stages: distribution and consumption.

Food is wasted from agricultural phase to final household consumption. In developed countries, food losses are primarily due to the lack of infrastructure (i.e., cold chain developments), as well as lack of knowledge or investment in the means to protect from losses arising from damage and spoilage attributable to rodents, insects, molds, and other microorganisms. Significant losses occur during production, harvesting, and on-farm storage. In contrast, in industrialized countries, food gets lost when production exceeds demand, and losses are more significant at household level and in retail and foodservice establishments. There are three broad stages of the food supply chain (i.e., at the farm, retail, and consumer levels); and although many of the causes are similar across developed countries, such as food that has past its 'use-by' dates, some factors have greater variation, such as the socio-demographic characteristics and cultural traditions manifested through individual behaviour.

According to a study across Europe countries the amount of food waste in 2012 is equal to 88 million tonnes (this amount includes both edible food and inedible parts associated with food) that corresponds to 173 kilograms of food waste per person (Stenmarck et al., 2016). In Fig.1.1.1the percentage of food waste assessed by sector (among 28 European countries) in 2012 were reported: at households level the higher food waste percentage occurs (53%) following by Processing(11%) and Food Service (12%) phases (Stenmarck et al., 2016).

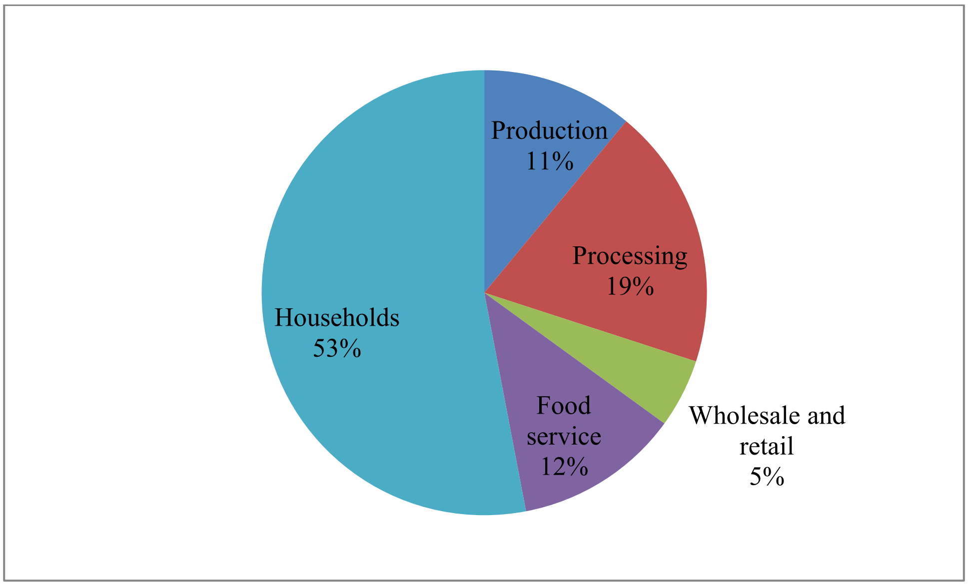

Fig. 1.1.1-Food waste by sector in 2012 (includes food and inedible parts associated with food)
Source: Stenmarck et al., 2016

Food losses and wastes reduction and the optimization of the logistics are for the EU and not only a key challenge. There are several reasons that drive food loss and waste prevention (Buzby and Hyman, 2011).The first reason is due to the growth of world population, thus more food is needed to ensure access to food. The second reason is that food waste represents significant economic resources invested throughout food's entire lifecycle to produce, store, transport, and otherwise handle something that does not ultimately meet its intended purpose of feeding people. The losses on the time of harvest and storage are the cause of lost income for small farmers and higher prices for consumers. The reduction of losses has therefore an immediate and significant socio-economic impact.It becomes difficult to estimate the costs and impacts of these losses. Basing on producers prices only, the direct economic cost of food wastage for agricultural products (excluding fish and seafood), is equal to USD 750 billion, equivalent to the GDP of Switzerland (FAO, 2013).

Stenmarck et al. (2016) assess the costs associated with edible food EU-28 in 2012, and it is equal to 11334 euros per tonne. Particularly the cost at households level is equal to 3529 euros (31.1%), 3148 euros (27,8%) for food service phase, 2790 euros

(24.4%) in wholesale and retail phase, 1490 euros (13.1%) in processing phase, and 399 euros (3.5%) in production phase (Fig.1.1.2).

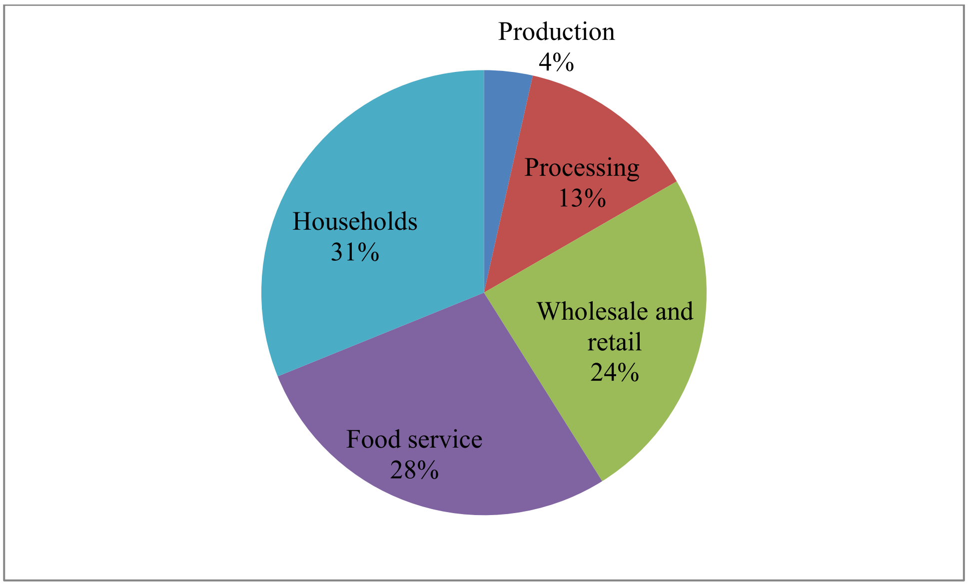

Fig. 1.1.2 -Costs of edible food in 2012 across EU-28
Source: our processing data from Stenmarck et al. (2016)

The third reason is that food production generates negative externalities and adversely impact society and the environment such as (Fiore et al., 2015):

- greenhouse gas emissions;
- water pollution and damage to marine and freshwater fisheries from agricultural chemical run-off during crop production;
- soil erosion, salinization, and nutrient depletion;
- uneaten food vainly occupies almost 1.4 billion hectares of land representing about 30 percent of the world's agricultural land area.
- genetic erosion and biodiversity loss (Graham-Rowe et al., 2014; Pearson et al., 2014).

The social impact of food waste contributes to increase the global food prices, consequently makes the food not accessible for the poorest and allows the increase of malnutrition (Graham-Rowe et al., 2014).

Furthermore the social implications of food waste are related to food security, and the reduction of food waste has been identified as a key component of strategies to feed a future global population of 9 million people (Parizeau et al., 2014).

A food which become a waste, has a negative impact on the Society, the Economy and the Environment that we should learn how to assess. A very recent EUResolution states that if nothing is done, food wastage will grow 40% by 2020 (http://www.europarl.europa.eu, 2011). This is an ethical but also an economic and social problem, with huge implications for the environment. The measuring of food loss is a complicate issue. Several different approaches have been used, based on estimates and real data, using surveys, interviews, indirect statistical measures and even archaeological examination of household, cafeterias and restaurant garbage. In any case, what is definitely clear is that food losses occur throughout the entire food system. It is clear evident, in any case, that a significant improvement in the capacity of estimating the food losses is required and protocols and procedures are needed, as well as an action towards the education of consumers is really urgent (Scott et al. 1997, Schneider 2007).

In a study conducted in UK the authors assess that the percentage of GHG emissions of the whole food chain excluding land use (Garnett, 2008). As shown in Fig.1.1.3 the phase that more contributes to GHG emissions is production, following by processing, households, transport and retail. This classification depends certainly on the type of analyzed product.

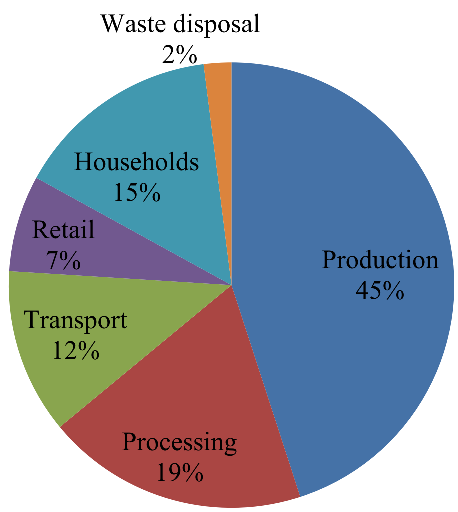

Fig. 1.1.3-Breakdown of food chain GHG emissions in the UK excluding land use change. *Source*: Garnett (2008)

According to FAO (2012) and Griffin *et al*. (2009), consumers are the biggest contributors to the total volume of food waste generated over the world: the carbon footprint of wastage in the consumption phase is equal to 37% of total, whereas consumption only accounts for 22% of total food wastage. The carbon footprint attributed to production and post harvest waste is equal to 34% with an highest percentage of waste (respectively 32% and 23%); the lowest percentage of carbon footprint occurs at the processing (14%) and distribution (15%) phases with a waste percentage equal to 10% and 13% (Fig. 1.1.4). One kilogram of food that is wasted further along the supply chain will have an higher carbon intensity than at earlier stages. These data constitute the basis for planning evaluation and identification of waste prevention measures.

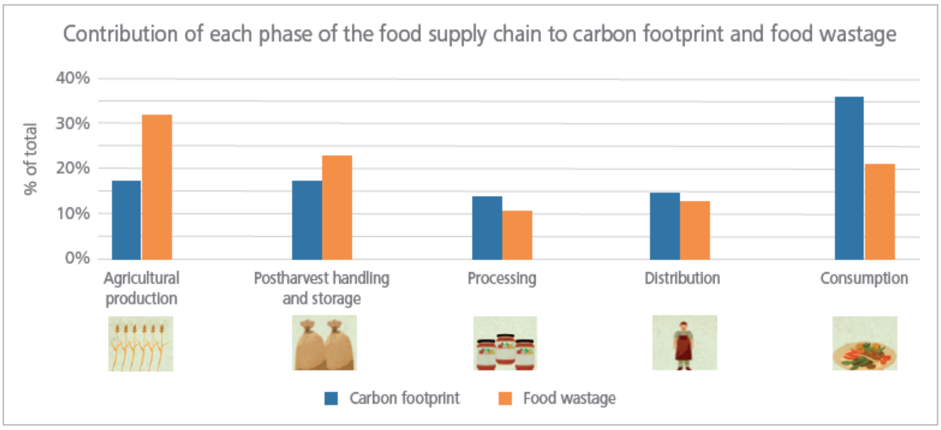

Fig.1.1.4- CF and FW contribution of each phase in food supply chain
Source: FAO 2013

The loss of land, water and biodiversity, as well as the negative impacts of climate change, represents huge costs to society that are yet to be quantified. Fig. 1.1.5 shows the food items that more contribute to CO_2 emissions production such as meat and drink until to arrive to oil and fat.

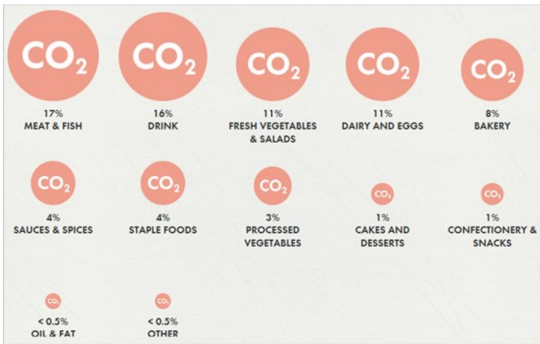

Fig. 1.1.5– Foods contributing increase of CO_2 emissions.
Source: WRAP data (2015)

Fig. 1.1.6 shows the per capita food waste footprint in different region of the world. It is clear that in industrialized countries and areas such as North America and Oceania and Europe. Particularly North America and Oceania per capita footprint (860 kg CO_2)

is four times higher than Sub Saharan Africa (210kg CO_2). In Europe, is equal 680 kg CO_2 (Fig. 6) less than Industrialized Asia with 810 kg $CO_2 \cdot person^{-1}$ (FAO,2013).

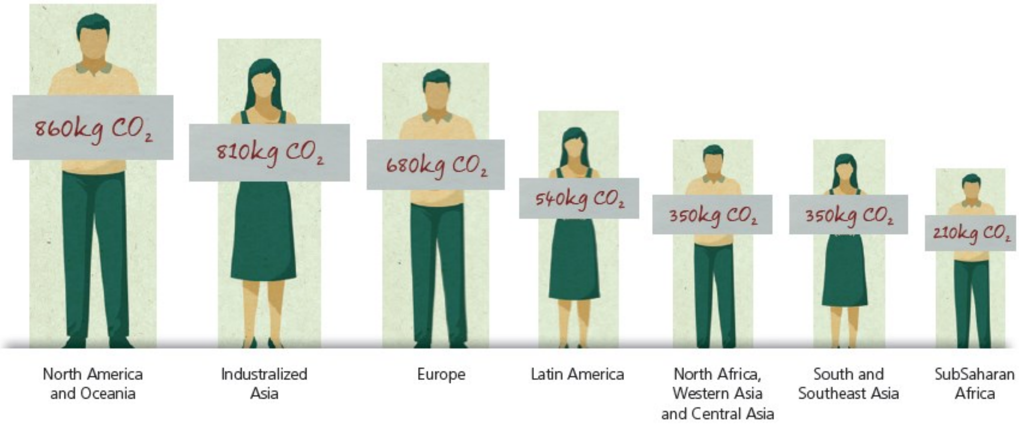

Fig. 1.1.6- Global average, per capita food wastage footprint on climate in different countries
Source: FAO, 2013\

In Europe, in 2014, 122 million people (24,4%) were at risk of poverty or social exclusion and among them 55 million (9,6%) were not able to afford a quality meal every second day (Fiore et al., 2015)

In Fig. 1.1.7 the percentage of around the world from 1990-1992 to 2012-2014 period was reported.

According to FAO's food balance sheets, all high-income countries now have available at retail level, more than 3,000 kcal of food per day per capita, with Europe leading the list (Smil 2010).

	Number of undernourished *(millions)* and prevalence *(%)* of undernourishment									
	1990–92		2000–02		2005–07		2008–10		2012–14*	
	No.	%	No.	%	No.	%	No.	%	No.	%
WORLD	**1 014.5**	**18.7**	**929.9**	**14.9**	**946.2**	**14.3**	**840.5**	**12.1**	**805.3**	**11.3**
DEVELOPED REGIONS	**20.4**	**<5**	**21.1**	**<5**	**15.4**	**<5**	**15.7**	**<5**	**14.6**	**<5**
DEVELOPING REGIONS	**994.1**	**23.4**	**908.7**	**18.2**	**930.8**	**17.3**	**824.9**	**14.5**	**790.7**	**13.5**
Africa	**182.1**	**27.7**	**209.0**	**25.2**	**211.8**	**22.6**	**216.8**	**20.9**	**226.7**	**20.5**
Northern Africa	6.0	<5	6.5	<5	6.4	<5	5.6	<5	12.6	6.0
Sub-Saharan Africa	176.0	33.3	202.5	29.8	205.3	26.5	211.2	24.4	214.1	23.8
Asia	**742.6**	**23.7**	**637.5**	**17.6**	**668.6**	**17.4**	**565.3**	**14.1**	**525.6**	**12.7**
Caucasus and Central Asia	9.6	14.1	10.9	15.3	8.5	11.3	7.4	9.5	6.0	7.4
Eastern Asia	295.2	23.2	222.2	16.0	218.4	15.3	185.8	12.7	161.2	10.8
South-Eastern Asia	138.0	30.7	117.7	22.3	103.3	18.3	79.3	13.4	63.5	10.3
Southern Asia	291.7	24.0	272.9	18.5	321.4	20.2	274.5	16.3	276.4	15.8
Western Asia	8.0	6.3	13.8	8.6	17.0	9.3	18.3	9.1	18.5	8.7
Latin America and the Caribbean	**68.5**	**15.3**	**61.0**	**11.5**	**49.2**	**8.7**	**41.5**	**7.0**	**37.0**	**6.1**
Caribbean	8.1	27.0	8.2	24.4	8.4	23.7	7.6	20.7	7.5	20.1
Latin America	60.3	14.4	52.7	10.7	40.8	7.7	33.9	6.1	29.5	5.1
Oceania	**1.0**	**15.7**	**1.3**	**16.5**	**1.3**	**15.4**	**1.3**	**13.5**	**1.4**	**14.0**

Fig. 1.1.7 - Undernourishment around the world, 1990-1992 to 2012-2014.
Source: FAO, 2014*projection

Significant effort are so to be planned to reduce undernourishment, food waste and CO_2 emissions reduction, conserve the environmental and natural resources, mainly through community participation to ensure that growth is sustainable.

Food losses are principally caused by lack of coordination between the different actors in the chain, by the consumer's behaviour as well as by the presence of the certification rules that reject foods not perfect in form or appearance (BCFN, 2013; Schneider, 2007).

Thus, understanding of factors that contribute to the amount of food waste generated by consumers is a priority and so a crucial driver for providing policies suggestions. According to HLPE (2014), the possible sources of global food waste are:

- lack of adequate infrastructure (market, storage, cold chain, processing infrastructure)
- lack of support for actors for investment (often results from lack of access to finance and credit) and implementation of good practices
- lack of integrated food chain approaches and management
- lack of awareness, lack of shopping planning, confusion about "best before" and" use by" date labels
- lack of knowledge on how to cook with leftovers (households)
- lack of investments
- standard portion sizes, difficulty of anticipating the number of clients (catering)
- stock management inefficiencies, marketing strategies (2 for 1, buy 1 get 1 free), aesthetic issues (retail)
- overproduction, product & packaging damage (farmers and food manufacturing);
- inadequate storage (whole food supply chain);
- inadequate packaging
- impact of policies, laws and regulations (waste disposal)
- the manufacture of safe food is the responsibility of everyone in the food chain and food factory, from the operative on the conveyor belt to higher management
- agricultural investment policies, including training and extension
- animal feed regulations

1.2- Food waste reduction initiatives in Italy

The estimation of food loss and waste is becoming increasingly important as a quantitative baseline for policy makers and to food industry to set targets and develop initiatives, legislation, or policies to minimize food waste, conserve resources, and to improve human health worldwide. According BCFN (2012) every year 9 billion tonne of food go to waste. This amount is able to feed 44 billion of people and is equal to 37 billion of euro that represent 450 € $year^{-1}$ per family. Today there are several types of action for waste reduction and recuperation of food in order to improve the optimization of supply chain:

One of the example of initiative was the *Milan Protocol*: a policy document, promoted by Barilla Center for Food and Nutrition (BCFN) that presents targets and guidelines for improvements of the food system, in order to tackle 3 core issues: promote healthy lifestyles (and so defeating hunger and stop rising of obesity), create sustainable agriculture (rebalancing the percentage of crops for food and fuel) and reduce food waste (reduce waste by 50% within 2020).

The mostly non-profit organizations is *Last Minute Market* , a spin-off of the University of Bologna that is a project where retailers, shops and producers who have unsold food which would otherwise be discarded are linked with people and charities who need food. This project offers services to enterprises and institutions in order to prevent and reduce waste production at its origin. It also develops innovative services for the recovery and reuse of unsold goods.

Fondazione Banco Alimentare is an Onlus organization with 1900 volunteers that collect food from canteens, catering, supermarket and large-scale retail trade to charity organization. Today, about 700 firms provide excess of food to Banco Alimentare.

The same activities are developed by:

- program *SITICIBO*, the first initiative that applied the Buon Samaritano law (155/2003);
- *EQUOEVENTO ONLUS* born in Rome in 2013 that collect food also from events (wedding, conference etc.).

*Carta Spreco Zero*is an academic spin-off which commits public administrators to support initiatives for the reduction of food losses and wastes. The project is connected to the European Resolution against food waste that has dedicated 2014 European Year for combating waste. The Innovative Procedural Protocol for sustainability and global health from farm to fork engages an economic/social virtuous circle involving all stakeholders, defining an innovative orientation (which is inserted into the Task Force

Models for the reduction of food waste of the Ministry of the Environment) and is a priority of action in the framework of social challenges and of new paths of the regional strategy based on smart specialization.

The *Innovative Procedural Protocol* for sustainability and global health from farm to fork engages an economic/social virtuous circle involving all stakeholders, defining an innovative orientation (which is inserted into the Task Force Models for the reduction of food waste of the Ministry of the Environment) and is a priority of action in the framework of social challenges and of new paths of the regional strategy based on smart specialization.

Several procedural/regulatory/management options can be adopted: tax law and corporate responsibility for inclusion of bonuses and rebates for businesses and consumers; regulation of discounted sales (when a product is close to expiring or has a defect, the discounted price to 50% or even less); simplification of the endorsements on food labels for expiration but with only two dates, one of the trade deadline (use by), the other on consumption (best before); modification of rules for public procurement and catering services of hospitality and establishing programs and courses of food education, economy and home ecology. Training on supply chain losses in schools and political initiatives are possible starting points to change people's attitudes towards the current massive food waste (FAO, 2011).

1.3- Food waste reduction initiatives in Europe

Several initiatives to prevent food waste throughout the food chain have already been rolled out in many European countries. There are many organizations and action initiatives in the world aimed at the reduction and/or recuperation of food products that can no longer be sold but are still edible. Few examples are: Banco Alimentare, the Buon Samaritano, Società del Pane Quotidiano, Last Minute Market and Buon Fine Coop in Italy. FareShare, WRAP, This is Rubbish, Love Food Hate Waste and Keep Britain Tidy in Great Britain; United Against Waste and Foodwaste.ch in Switzerland; The Zero Hunger Challenge, City Harvest and Food Schift in the United States; Mesa and del Sesc in Brazil; Plataforma Aprofitem els Aliments in Spain; Satisfeito in Portugal; Stop Wasting Food and United against food waste in Denmark; MTT in Finland; Hungarian Foodbank Association; OzHarvest in Australia; Ademe campaign in France; Agriculture and Consumer Protection and Save Food initiative in Germany.

In 2015, Fedération Européenne des Banques Alimentaires (FEBA) distributed 2,9 million meals every day (equivalent to 531 000 tons of food) to 5,7 million people.

1.4- Shelf-life extension as possible solution to reduce food waste

"Shelf Life" is the period of time during which a food retains acceptable sensory characteristics, nutritional value, and safety. The Shelf Life concept is almost always referred to the commercial life of packaged food products but it is well known that Shelf Life is affected by the food, the package, and the environment (Waletzko & Labuza, 1976, Labuza & Taoukis, 1990; Fu & Labuza 1993 and 1997; Nelson & Labuza 1994; Labuza &Szybist, 2001; Lee et al. 2008) and the rate at which the food quality decay results from the integrated effects of formulation, processing, packaging and storage conditions. When food exceed shelf life become a waste to be disposed, and it increase the environmental, economic and social impacts.

The distances that foods products travel are huge nowadays and, consequently, transport is considered to be no more than a storage on wheels/ships/wings. Recently, an Italian survey by Accenture-SDA Bocconi (May 2011) stated that more than 78% of the logistic costs are due to transports and warehouse management. Transport systems have significant impacts on the environment, accounting for between 20% of world energy consumption (Pagani et al., 2015). Greenhouse gas emissions from transport are increasing at a faster rate than any other energy using sector (Energy Council, 2007). Therefore, extending the commercial life of a food or a beverage might mean an optimization of the supply chain. The SLE is obtained thought:

- product reformulation with the use of natural ingredients that increase its stability;
- the use of packaging innovation;
- the use of mild technologies that preserve sensorial and nutritional food characteristics.

The topics of global sustainability, sustainable development and sustainable packaging are big issues of daily debate, but still represent a big challenge for the developed countries (Verghese et al., 2015). In fact, the definition of smart and green food products and chain delivery systems, definitely fulfils the key objectives of Horizon 2020. Guidelines for the management and reduction of food losses falls within the "smart and green" Horizon 2020 approach and is functional in order to eliminate an information gap that precludes the implementation of the triple bottom line (People-Planet-Profit) social, economic, environmental sustainability.

1.5- The objective of the research

The present PhD project is included in a national project PRIN 2012 “Long Life High Sustainability” in which the Department of Economics of Foggia’s University is involved. This project is aimed to match a Shelf Life Extension (SLE), due to a formulation, processing or packaging innovation (developed by other food technologists from other Research Units), to the possible increase of food product global sustainability along the entire supply chain, from farm to fork. Several studies, demonstrated that a SLE can be real important or even conclusive in contrasting two main issues which can be detrimental for the overall sustainability of a product: “Food Loss” and “Chain Fails” (Amani and Gadde, 2015). Learning how to estimate the SLE in relation to an increase of sustainability, can represent a true improvement in the task of designing new technological solutions, providing real benefits to the food companies, to the consumers and the environment. Secondly the project is aimed to assess the social impact of food waste considering the largest part of it: household’ food waste. In this regard, the activities focused on the analysis of cosumer’s attitude, habits and behaviour that minimize food waste. The SLE could reduce food loss along the entire supply chain, with the possible improvement in logistics. Therefore, the measure of the SLE impact on logistics becomes crucial.; thus this project is aimed also to evaluate the logistic improvement aspects. In particular different scenarios, characterized by some interesting issues, such as the type of transport and distance, transport refrigeration temperature, as well as supermarket refrigeration were taken into account. The present project is arranged as follows: the first part of the research project activities will allow to set up procedures and tools to understand some behaviours of the consumers as far as food losses are concerned. In this session the research activities lead to a useful archive of information concerning the food consumption habits of the selected food items. Furthermore a social implications of food waste related to food security and what it would be happen if food losses were reduced were analyzed. In the second part of the work an environmental impact analysis of new technologies and new solutions in order to reduce energy burdens and food losses was carried out. This part of the study, is aimed to highlight problems and opportunities related to the introduction of innovation through the elaboration of a set of technical-economic indicators connected to the product innovation.

The analysis is based upon the use of the Life Cycle Thinking approach “from cradle to grave" that seeks the energy and environment production process impact improvement (Toepfer, 2000). In the third step, the supply chain was simulated by means of simulation model in order to highlight the impact of product SLE and to assess the energy and food waste potential savings reducing cooling temperature in the supermarkets. The environmental and economic sustainability was assessed considering three product items: olive paste and extra-virgin olive oil. The evaluation of SLE impact on logistics was carried out simulation fresh cut salad supply chain. These products were selected due to the perishability.

References

Pegah Amani and Lars-Erik Gadde (2015). Shelf life extension and food waste reduction Proceedings in System Dynamics and Innovation in Food Networks 2015. ISSN 2194-511X

Baldwin C.J. (2009). Sustainability in the Food Industry, Wiley-Blackwell, ISBN 978-0-8138-0846-8

Barilla Center for Food and Nutrition, (2012) Food Waste: causes impact and proposals. Milano: BCFN.

Buzby, J.C., Hyman, J., Stewart, H., & Wells, H. F. (2011). The value of retail- and consumer-level fruit and vegetable losses in the united states. Journal of Consumer Affairs, 45(3): 492-515

Fao,(2013) Food wastage footprint, Summary Report. ISBN 978-92-5-107752-8

Fao,(2011) The State of Food Insecurity in the World.

Fu, B., Labuza, T.P. (1993). Shelf life prediction: theory and application. Food Control, 4(3): 125-133.

Fu, B., Labuza, T.P. (1997). Shelf life testing: procedures and prediction method. In Quality of Frozen Food ed.in "Fresh Point Magazin", Il sole 24 Ore, Milan, pp. 3-4.

Garnett, T. (2008). Cooking up a Storm: Food, Greenhouse Gas Emissions and our Changing Climate. Food Climate Research Network, Centre for Environmental Strategy, University of Surrey, UK.

Graham-Rowe E., Jessop D.C., Sparks P. (2014) Identify motivations and barriers to minimizing household food waste. Resources, Conservation and Recycling 84: 15-23.

Griffin, M., Sobal, J., & Lyson, T. A. (2009). An analysis of a community food waste stream. Agriculture and Human Values 26(1–2): 67–81.

HLPE (2014). Food losses and waste in the context of sustainable food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome 2014.

Labuza, T.P., Szybist, L.M. (2001). Open dating of foods. Trumbull: Food and Nutrition Press, Inc.ISBN: 0-917678-53-2

Lee D.S., Yam K.L and Piergiovanni L. 2008.Shelf life of packaged food products. In Food Packaging science and technology, D.S. Lee, Ed., 480-506. Boca Raton, FL: Taylor & Francis. Publishers Inc.

Labuza, T.P. and Taoukis, P.S. (1990). The relationship between processing and shelf life. In Foods for the '90s, ed. G.G. Birch, G. Campbell-platt, M.G. Lindley, 73-106. London: Elsevier Applied Science

Martinet, V. (2012). Economic theory and sustainable development: What can we preserve for future generations. Oxford: Taylor and Francis.

Nelson, K.A. Labuza T.P. (1994). Water activity and food polymer science: implications of the state on Arhenius and WLF models in predicting shelf life. Journal of Food Engineering, 22: 271-289.

Parizeau K.,Von Massow M., Martin R.(2014). Household-level dynamics of food waste production and related beliefs, attitudes, and behaviours in Guelph, Ontario. Waste Management 35: 207-217.

Pearson D., Friel S., Lawrence M. (2014). Building environmentally sustainable food systems on informed citizen choices: evidence from Australia. Biological Agriculture & Horticulture 30(3): 183-197.

Schneider F. (2007) Considerations on Food Losses in Life Cycle Approach of Food Supply Chain. In Eidgenössiche Technische Hochschule Zürich: From Analysis to Implementation. 3rd International Conference on Life Cycle Management, 27-29 August 2007, Zurich, Switzerland. Abstract, pp.89-90.

Scott Kantor L., Lipton K., Manchester A., Oliveira V. (1997). Estimating and Addressing America’s Food Losses. Food Review Jenuary-April.

Segrè, A. (2011), What is needed is a more sustainable agro-food system that reduce [sic] waste, in “Fresh Point Magazin”, Il sole 24 Ore, Milan, pp. 3-4.

Stenmarck, Å., Jensen, C., Quested, T., Moates, G., (2016). Estimates of European food waste levels IVL Swedish Environmental Research Institute, Stockholm, Sweden, Report number: C186, ISBN 978-91-88319-01-2. DOI: 10.13140/RG.2.1.4658.4721.

Toepfer K., (2000). Evaluation of Environmental Impacts in Life Cycle Assessment. UNEP “United Nations Environment Programme Division of Technology, Industry and Economics Production and Consumption Branch.

Verghese, K., Lewis, H., Lockrey, S., Williams, H. (2015) Packaging's Role in Minimizing Food Loss and Waste Across the Supply Chain. Packaging Technology and Science, 28 (7), pp. 603-620.

Waletzko, P and Labuza, T.P. (1976). Accelerated shelf life testing of an intermediate moisture food in air and in oxygen free atmosphere. Journal of Food Science, 41(6): 1338-1344

Wells, H. F. Hyman, J. Buzby, J.C.(2014) Estimated Amount, Value, and Calories of Postharvest Food Losses at Retail and Consumer Levels in the United States. Economic Research Service, Washington, DC.

Sitography

http://www.europarl.europa.eu, 2011

2. SOCIAL IMPACT

In this chapter the author firstly will analyze the social impacts of food losses along the food chain: the methodology is based on the elaboration of a dis-opportunity cost taking into account food waste and losses of Kcals and Kcals/required per day (to cope

with the energy expenditure), U.A.A. (Utilized Agricultural Area) cost. Findings are aimed to highlighting how the food losses reduction is crucial for an intra/inter-geninter
rational equity. Secondly belief, attitudes and behaviours releted to food waste at the household level among Italian consumers were analyzed. Furthermore, more insights concernig the possible drivers that influenced consumer behaviour towards food waste were provided.

Some some parts of this research were taken from:

Fiore M., Contò F., Pellegrini G. (2015). Reducing Food Losses: A (Dis)-Opportunity Cost Model. Revue Of Studies On Sustainability 1: 151–166.

2.1- Reducing food losses: a (dis)-opportunity cost model

2.1.1- Introduction

In this session, the authors focus on the social-economic impact of food losses and waste trying to model a possible (dis)-opportunity cost: the starting point of the model starts from the notion of opportunity cost (Buchanan, 1969; Baumol and Blinder, 2007). Basically, the concept expresses the basic relationship between scarcity and choice and the opportunity cost of a choice refers to the value of the next best alternative or opportunity (Buchanan, 1969; Arnold, 2008). In microeconomic theory, the opportunity cost of a choice is the value of the best alternative forgone, in a situation in which a choice needs to be made between several alternatives given limited resources. Indeed, over the centuries scholars and researchers gave insights to deal with the essential problem of scarcity that arises from the impossibility of fitting between the demand of necessary goods and services and the limited resources. In this context of scarcity, it is essential to try to set up a priorities scale between possible alternatives.

Therefore, the opportunity cost is a tool aiming at investigate the real value of the choices in the light of the benefits foregone by the taken decisions and so to measure all the costs of an opportunity foregone, in monetary and non-monetary terms. Other studies define the opportunity cost as an avoided loss or avoided carbon emissions (Damnyag et al., 2011; Golub et al., 2009).

In our study, the (Dis)-opportunity cost model is a theoretical and speculative elaboration taking into account food waste, Kcals/required per day (to cope with the energy expenditure), U.A.A. (Utilized Agricultural Area) cost.

2.1.2- Methodology and Results

The assumptions are as follows:

- 1 g of food losses can be measured with the lost Kcal/capita/day value (FAOSTAT data);
- the actual daily food requirements range mostly between 1,500–2,000 kcal/capita for adult females and 2,000–2,600 kcal/capita for adult males, and weighted means for entire populations are rarely above 2,000 kcal/person (Smil, 2010);
- for each commodity group corresponds a percentage of food waste along the FSC (Gustavsson *et al*., 2011).

Table 2.1.1 shows estimated/assumed waste percentage for each commodity group of the FSC for Europe incl. Russia. In this study, cereals commodities was considered and the consumption level was the starting point for the assessment of dis-opportunity cost.

Table. 2.1.1 – Estimated/assumed waste percentage for each commodity group of the FSC for Europe incl. Russia

	Agricultural production	Postharvest handling and storage	Processing and packaging	Distribution: Supermarket Retail	Consumption
Cereals	2%	4%	0.5%, 10%	2%	25%
Roots & Tubers	20%	9%	15%	7%	17%
Oilseeds & Pulses	10%	1%	5%	1%	4%
Fruit & Vegetables	20%	5%	2%	10%	19%
Meat	3.1%	0.7%	5%	4%	11%
Fish & Seafood	9.4%	0.5%	6%	9%	11%
Milk	3.5%	0.5%	1.2%	0.5%	7%

Source: Gustavsson et al., 2011

The following steps were carried out for the calculation of dis-opportunity cost:

1. Food waste amount = 25% of Production for human consumption (FAOSTAT data) [this value was considered per day].
2. Conversion of the total waste amount from ktonnes to grams.
3. Conversion of the total waste amount (in grams) in Protein kcal/g by using Atwater specific factors for selected foods (Merrill & Watt, 1973): in particular, an average equivalent value related to grain products was considered (FAOSTAT, 2003).
4. The amount obtained according to point 3 was rationed at 2.000 kcal that is average daily food requirements for human need (Smil, 2010).

2.1.3- Discussion

The results highlight the different steps carried out: in particular, the table below shows considered variables and values, calculated amounts and sources of the variables in order to calculate the (Dis)-opportunity cost(Table 2.1.2).

Table. 2.1.2 – Variables, values, amounts and relative sources to calculate the (Dis)-opportunity cost

Variables	Values	Amounts	Source
Production for human consumption	126.734,00 ktonnes	126.734,00 ktonnes	FAOSTAT (2011)
Estimated/assumed waste percentage for cereals	25%	868.041.000,00* g	Gustavsson et al., 2011
Average equivalent in proteins related to grain products	3,23	2.803.772.430,00 kcal	FAOSTAT (2013)
Average daily food requirements for human need	2.000 kcal/capita/day		Slim, 2010
Dis-opportunity cost		**1.401.886,2 n°** 	

Source: our processing on indicated source

*This value was considered per day in grams

The following steps was carried out for the calculation of U.A.A. cost:

1. European total production and total U.A.A. of cereals amount were considered (FAOSTAT, 2011).
2. Average yield obtained by the ratio between total production and total U.A.A was calculated.
3. U.A.A. cost was accounting by considering the ratio between production for human consumption wasted and average yield above-mentioned.

Table2.1.3 – Variables, values and relative sources to calculate the (Dis)-opportunity cost in terms of UAA cost

Variables	Values	Source
Total Production	561.729,00 ktonnes	FAOSTAT (2011)
Production for human consumption	126.734,00 ktonnes	FAOSTAT (2011)

Total U.A.A.	116.270.137,00 ha	FAOSTAT (2011)
U.A.A. cost	6.558,046 ha	

Source: our processing on indicated source

Finally, if reduction of food waste is implemented along the FSC, the society could obtain a decreasing of undernourishment equal to 1.401.886,2 n° persons with a UAA cost equal to 6.558.046 ha. These values are to be considered very carefully and with much caution; they can represent only the huge extent of the issue of food waste and correlatively of the undernourishment. The research highlights the importance of the intangible aspects of the environmental issues too. Academic and policy implications are related to the advantage deriving from the understanding of the multi-sectorial perspective and scenarios (environmental, economic, social, ethics, human aspects and so on).

The final aim of this study is the measurement in terms of not-possibility to gain a best position of the population well-being: when there are food waste and losses, we give up to feed a share of population. But if the undernourishment decreases by means a re-consideration of the system, therefore the opportunity cost of having a minor undernourishment will be the time I could spend searching new solution to cope the hunger issues and the money I could earn not saving the food from waste and losses along the agri-food chain at consumption and pre-consumption stages.

The Fig. 2.1.1 below shows the (Dis)-opportunity cost model in terms of policies. A country can decide to implement either policies to reduce food waste and losses and correlatively the undernourishment (FW&U), or policies to reduce only the undernourishment (U). By devoting all resources to FW&U (A), the country can reduce food waste and undernourishment together not only undernourishment. By devoting all resources to U policy (B), the country can reduce only undernourishment and increases food waste. However, the trade-off, and therefore the opportunity cost, is not here constant. The line that connects the points 'A' and 'B', which respectively represent the maximum decreasing attainable by devoting all our resources to one end or another, is the production possibility frontier (PPF) which shows the combinations of two policies that can be produced by using all the resources at our disposal (Arnold, 2008).

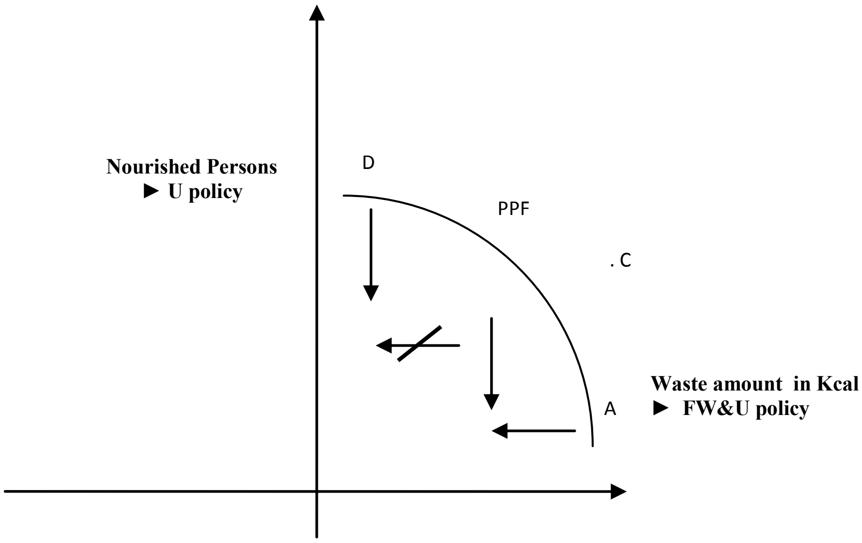

Fig. 2.1.1 – A (Dis)-opportunity cost model in terms of policies.
Source: our processing

At the point ‘A’ we implement FW&U policies and none U policy. As we move from ‘A’ to ‘B’ we implement U policies to reduce undernourishment decreasing the percentage of undernourishment at the opportunity cost of FW&U policies that should have the chance to reduce FW+U. Besides some limitations, above highlighted that are largely typical of explorative researches, this paper has the merit of providing some useful insights on the close relations between food waste and undernourishment, between policy choice and ethics behavior.

Finally, the opportunity cost allows to understand the real cost of our choices according to the best possible alternative we have to sacrifice. Opportunity costs are generally not considered as the choice is concentrated on the benefits and direct costs of our choice, without taking into account what we are giving up. Nevertheless, measuring this (Dis)-opportunity cost is not immediate owing to many different factors such as the ability of identifying which is the best alternative to a choice and evaluating all the potential monetary and non-monetary benefits foregone, are to be taken into account. Besides a certain degree of subjectivity is involved in the measurement, because the evaluation is often oriented towards future events whose outcomes are uncertain and because of the different perspective and perception of the stakeholders involved (Buchanan, 1969).

Developing a dis-opportunity cost taking into account waste Kcal and Kcal/per day required (for balanced nutrition of a person) and UAA cost can increases the efficiency of the entire supply chain in terms of production, logistics and distribution, quality and healthy food, thus representing an element of improvement as regards the intra/inter- generational equity.

2.1.4- Conclusions

Reducing Food Losses and wastes and optimization of the logistics is for the EU and not only, a key challenge to increase competitiveness, sustainability, equity of the agri-food sector. The consumer and business level approach is essential as food losses and waste occur during the entire supply chain and, in quality of recipients of food products, it is important to take into account specific methods to affect their behaviors. The results of this research can be therefore strategic in the current context. The definition of a (dis)-opportunity cost for the management and reduction of food losses falls within the smart and green Horizon 2020 approach and is functional in order to eliminate an information gap that precludes the implementation of the triple bottom line: social, economic, environmental sustainability. Therefore, the methodological approach presented in this paper is in line with the international and national policies and existing literature (Segrè, 2011a, b; FAO, 2011; BCFN, 2013; NRI, 2009; Parfitt *et al.*, 2010; Schneider, 2007) aiming at analyzing and investigating the food losses challenges and impacts.

Food scraps or losses represent irrational use of resources producing a negative direct impact on the income of entrepreneurs and consumers and in special way on the rate of undernourishment of the population; a coordinated strategy that improves the efficiency of the entire supply chain is, therefore, required. A rational use of resources at consumption level and optimization of production and distribution logistics is an improvement of fundamental usefulness for the companies and for the entire socio-economic system in the light of the intra/inter-generational equity too. In fact, it is clear that we need to find new models to address behavior consumer since even the most health conscious people are not always able to change their eating habits and attitudes which are influenced by advertising and other forms of promotion on a daily basis. Price issues may also influence people's choices, especially those who are not able to evaluate the alternatives of purchase correctly due to lack of information. A further element of novelty/originality can be arise from the correlation of the shelf life extension with the reduction of food losses; additional steps are related to develop a Model Food Losses Break Point with an index of potential reduction in food losses. The starting point is creating a model with a value indicating the maximum acceptable loss, expressed in volume of production, which is part of the normal management of the firms. The index of potential reduction in food losses is a value (in percent) according to the actual amount of losses and a value that ranges in a predefined range depending on the weight assigned to the relevant sub-fund of the supply chain. Here it is not possible to define this model since available and complete data to be tested and analyzed are necessary.

Intergenerational equity is a key concept articulated as a concern for future generations (Golub *et al.*, 2013) as a global framework for sustainable development is based on its reinterpretation that recognizes the interdependence of humans with the rest of the ecosphere (Imran et a., 2014; Martinet, 2012; Alvarez-Cuadrado and Van Long, 2009). Enhancing the environment, human well-being and social equity could be possible by means an inter-disciplinary approach in a mutual process that emphasizes strategic decision-making. As evocated by all international organizations, food represents the second most important factor of global sustainability (following the energy industry): furthermore, it is therefore a crucial driver to reduce its economic-social-environmental impact since that many issue can be solved taking in account this challenges. In this context, the family, an important access key for addressing the problem, should be supported by other institutions (starting from schools) and private businesses such as food companies and distribution channels, as well as media tool.

Reference

Alvarez-Cuadrado, F., & Van Long, N. (2009). A mixed bentham-rawls criterion for intergenerational equity: Theory and implications. Journal of Environmental Economics and Management, 58(2), 154-168.

Arnold, R.A. (2008).Microeconomics. Sixth Edition. Mason, OH: South-Western Cengage Learning.

Baumol, W.J. and Blinder, A.S. (2007). Microeconomics: Principles and policy. Tenth Edition. Mason, OH. Thomson South-Western

BCFN Barilla Center for Food and Nutrition, (2012) Food Waste: causes impact and proposals. Milano: BCFN.

Buchanan, J. M. (1969). Cost and Choice. Chicago: Markham

Damnyag, L., Tyynela, T., Appiah, M., Saastamoinen, O., Pappinen, A. (2011). Economic cost of deforestation in semi-deciduous forests – a case of two forest districts in Ghana. Ecological Economics, 70: 2503–2510.

FAO (2011). The State of Food Insecurity in the World. Rome: FAO.

FAO (2013). Food wastage footprint, Summary Report. Rome: FAO.

Golub, A., Hertel, T., Lee, H.-L., Rose, S., Sohngen, B. (2009). The opportunity cost of land use and the global potential for greenhouse gas mitigation in agriculture and forestry. Resource and Energy Economics, 31: 299–319.

Golub, A., Mahoney, M., & Harlow, J. (2013). Sustainability and intergenerational equity: Do past injustices matter? Sustainability Science, 8(2): 269-277.

Gustavsson, J., Cederberg, C., Sonesson, U., Otterdijk, R. van & Meybeck, A. (2011). Global Food Losses and Food Waste. Extent, Causes and Prevention. Study conducted for the International Congress Save Food!, at Interpack 2011 Düsseldorf, Germany, Rome: Food and Agriculture Organization of the United Nations.

Imran, S., Alam, K., & Beaumont, N. (2014). Reinterpreting the definition of sustainable development for a more ecocentric reorientation. Sustainable Development, 22(2): 134-144.

Martinet, V. (2012). Economic theory and sustainable development: What can we preserve for future generations. Oxford: Taylor and Francis.

Merrill, A.L. & Watt, B.K. (1973). Energy value of foods: basis and derivation. Agriculture Handbook No. 74. Washington, DC, ARS United States Department of Agriculture.

Natural Resources Institute (2009). Framework paper on postharvest loss reduction in Africa. Rome: NRI.

Parfitt, J., Barthel, M. & Macnaughton, S. (2010). Food waste within food supply chains: quantification and potential for change to 2050, Phil. Trans. R. Soc., 365: 3065-3081.

Schneider, F. (2007) Wasting food – An insistent behavior. BOKU- University of Natural Resources and Applied Life Sciences, Vienna, Austria

Segrè, A. (2011), What is needed is a more sustainable agro-food system that reduce [sic] waste, in "Fresh Point Magazin", Il sole 24 Ore, Milan: 3-4.

Segrè, A. and L. Falasconi (2011), Il libro nero dello spreco in Italia: il cibo, Edizioni Ambiente.

Smil, V. (2010). Improving Efficiency and Reducing Waste in Our Food System. Environmental Sciences, 1(1): 17-26.

Sitography

http://faostat.fao.org/site/354/default.aspx

2.2- Attitude toward food waste reduction: the case of Italian consumers

The purpose of this session is to investigate the dynamics of household food waste, analysing food waste minimization from a food-related Italian behaviour perspective, in order to define which are the principal factors determining food losses. Furthermore, the author wants to verify the influence of Shelf Life Extension (SLE) on food-related behaviour aimed to minimize food waste, as well as to build a consumer behaviour model.

2.2.1Food waste and consumer's behaviour

There is no doubt that to move towards a sustainable future involves a profound transformation of the food sector, because this food style in our society has proved harmful to health and environment (Pellegrini et al., 2016). Food scraps or losses represent irrational use of resources producing a negative direct impact on the income of entrepreneurs and consumers; therefore, a coordinated strategy that improves the efficiency of the entire supply chain is required (Garnett, 2008). Worldwide, 1.3 billion tonnes of food is lost or wasted annually in production, manufacture, distribution and human consumption (FAO, 2016). There are three broad stages of the food supply chain (i.e., at the farm, retail, and consumption levels). Although many of the causes are similar across developed countries (Quested et al., 2013), such as food that has pass its 'use-by' dates, some factors have greater variation, such as the socio-demographic characteristics (Marangon et al., 2014), and cultural traditions manifested through individual behaviour (Nassivera e Sillani, 2015).

Stenmarck et al., (2016) assessed the percentage of food waste in 2012, by sector (among 28 European countries): at households level the higher food waste percentage occurs (53%) following by Processing (11%), Food Service (12%) and Production (11%) phases.

There are several reasons that drive food loss and waste prevention (Buzby et al., 2011). The first reason is due to the growth of world population, thus more food is needed to ensure food security. The second reason is that food waste represents significant economic resources invested throughout food's entire lifecycle to produce, store, transport, and otherwise handle something that does not ultimately meet its intended purpose of feeding people.

Stenmarck et al. (2016) found that costs associated with edible food (in EU-28, 2012) is equal to 11334 € per tonne. Particularly the cost at households level is equal to 3529 € per tonne (31.1%), 3148 € per tonne (27,8%) for food service phase, 2790 € per tonne (24.4%) in wholesale and retail phase, 1490 € per tonne (13.1%) in processing phase, and 399 € per tonne (3.5%) in production phase. The third reason is that food production generates negative externalities such as production of GHG emissions (Fiore et al., 2015).

According to FAO (2013) and Griffin *et al*. (2009), consumers are the biggest contributors in the world to the total volume of food waste: the carbon footprint of wastage in the consumption phase reaches 37% of total, whereas consumption only accounts 22% of total food wastage.

Nowadays ethical values guide the behavior of the all kind of buyer (Contò et al. 2015; Burkhardt, 2012; Olsen and Banati, 2013, Olsen et al., 2010); indeed several researches focus on the decisive role of ethics that is health, quality, trust, environmental welfare aspects in influencing consumer behavior (Krystallis et al., 2012; Liu and Kwon, 2013; Mcdonough et al., 2014; Munro, 1995; OECD, 2008; Young et al., 2010). Others (Guido et al., 2010) highlighted ethics personal beliefs on what is right or wrong can be considered the main motivator of purchasing intention.

Few authors have investigated the consumer behaviour on food's choice and the main reasons of wasting food (Doron, 2012; Lyndhurst, 2007; Parfitt et al., 2010; Stefan et al., 2012; Williams et al., 2012), in Italy (Capone et al., 2014; Segrè and Falasconi, 2008 and 2011).

The main reasons of wasting food are attributed to:

- shopping routine such as buying and/or cooking too much, failing to compile or comply with a shopping list, failing to carry out a food inventory before shopping, impulse;
- planning routines: not planning meals in advance.
- purchasing behaviour: price consciousness and sale proneness, store type (food wastage is higher for families that purchase from supermarkets and hypermarkets) (Marangon et al., 2014)
- low public awareness of the negative impact of household food waste

Williams et al., (2012), studied the reasons for food waste in household and especially how and to what extent packaging influences the amount of food waste. They found that about 20–25% of the households' food waste could be related to packaging.

It is clear that a significant improvement in the capacity of estimating the food losses is required, protocols and procedures are needed, as well as actions towards the consumers' education are very crucial (Schneider 2007). In this context, this paper is aimed to study food waste minimization from a food-related behaviour perspective and build a consumer's behaviour model. According to Purchase Behaviour Model (PBM), Intentions (IM) and Attitude to Minimize (AM) influence consumers' behaviour and in turn they are influenced by some motivations to minimize food waste (Homer &Kahle, 1988; Thogersen e Grunert-Beckmann, 1997; Bredahl, 2001; Nassivera e Sillani, 2015).

The Social learning theory (Bandura, 1977c) affirms that people observe and imitate social models acquiring some behaviours. According to this theory, behaviours are determined by expectancies and incentives. People will change their behaviour if they appreciate (in terms of threats reduction) perceived effects of changed lifestyle.

The Broken Windows Theory states that people are willing to violate some norms if they observe others are violating norms as well (Keizer et al., 2008; Alford, 2012; Engel et al., 2014; Aiyer et al., 2015). The Theory of Normative Conduct (TNC), discern two types of norms that influence human actions: injunctive norms (what most others approve or disapprove) and descriptive norms (what most others do) (Cialdini et al., 1990). The descriptive norm determines behaviour, but if it contradicts the injunctive norm, the behaviour effect is cancelled.

According to this approach, waste's absence and the intention to minimize can be considered the injunctive norm, instead observed waste is the descriptive norm. If the consumers waste increases, consumers' willingness to waste increases as well. In this context, the Theory of Planned Behavior (TPB) can gives important insights concerning the purchase behavior (Ajzen, 1991; Bandura, 1997;a 1997b). According to this theory, human behaviours are managed not only by personal attitudes, but also by social pressures and a sense of control (Ajzen, 2011a; 2011b).

The above-mentioned theories suggest the use of constructs in order to measure observed causes of wasting food. Furthermore, the study is aimed to verify if Shelf Life Extension (SLE), realized by food firms, can have an effect on food-related behavior aimed to food waste minimization. This was realized through the measure of SLE advantages' awareness. Among household food waste minimization barriers there is a liability waiver (Graham-Rowe et al., 2014); this means that consumers attribute food waste causes to others. According to Graham-Rowe et al., (2014) and Stefan et al., (2012), household food management determines food waste related behaviours. In this paper the authors propose a measure scale for attitude and intention to minimize, referring to food management.

2.2.2Material and methods

Data were collected from April 2015 to January 2016 by means of a web-based questionnaire using an on line software. Items were developed by the authors based on previous studies. (Stefan et al. 2012; Spielmann e Richard, 2013; Alford e Biswas, 2002; Balderjahn et al., 2013; Black, 2004; Graham-Rowe et al., 2014; Williams et al., 2012, Nassivera e Sillani, 2015). Pilot test with 12 respondents was developed to support questionnaire design with the objective, to recognize the limits of the questionnaire, and to know whether the participants understand the items. Minor revisions were made to pilot survey before distributing the final questionnaire.

The questionnaire was developed in Italian, translated in English for its replicability, and distributed to Italian consumers through online platforms (Email, Facebook, LinkedIn). The survey was structured into 111 items connected to 9 selected constructs, evaluated with Likert scales from “strongly disagree” to “strongly agree” anchoring the scale. The constructs were selected according the following criteria:

1. Price Consciousness (PC): basing on Neff et al. (2015) study, the attention to waste of money influences consumer behaviour related to food waste. La Price Consciousness was measured with a 10 items scale proposed by Alford e Biswas (2002).
2. Environmental Concern (EC): according to Roberts & Bacon (1997), Williams and Wikström (2011), Williams et al. (2012) e Quested et al. (2013), environmental concern can affect consumer behaviour related to food waste. The intensity of environmental concern was assessed through 8 items scale proposed by Balderjahn et al. (2013).
3. Moral and other-orientated Reasoning (MR): according to Conner and Armitage (1998), Largo-Wight et al. (2012), Graham-Rowe et al. (2015), and *The Prosocial Personality Battery* of Penner *et al.* (1995) and Penner (2002) moral and other oriented reasoning can have an effect on consumer behaviour. The degree of influence was calculated using a 6 items scale according to Black (2004).
4. Time Management (TM): according to Marangon et al. (2014), Porpino (2016) time management influence consumer behaviour. The intensity of influence was assessed through 3 items scale proposed by Black (2004).

5. SLE Awereness (SLEA): basing on the assumptions of Kantor et al. (1997), Terpstra et al. (2005), Parfitt et al. (2010), Koivupuro et al. (2012), Williams et al. (2012), Abeliotis et al. (2014), Neff et al. (2015) and Porpino et al. (2015), the authors consider the awareness of shelf life extension advantages influence consumer behaviour. This aspect was measured with a 6 items scale according to Graham-Rowe et al. (2014). The objective is to evaluate if technological innovation can be consider as a lever for food firms to influence consumers' behaviour.

6. Advertising Involvement (AImess) (AImedia): according to Quested et al. (2013), Whitehair et al. (2013) and Porpino (2016) the advertising involvement has an effect on consumer behaviour. This aspect was measured with a scale divided into two subscale: 8 items scale for Advertising Involvement – message involvement (AImess) (Spielmann e Richard, 2013); 6 items scale for the Advertising Involvement – media involvement (AImedia). The objective is to study if:
   - messages transmitted by adverting influence the consumer behaviour
   - advertising of food items can be a channel to convey messages against food waste
7. Attitude to Minimize (AM), Intention to Minimize (IM): several authors state that household consumer behavior that determine food waste are principally related to food management (Stefan et al., 2013; Graham-Rowe et al., 2014; Porpino et al., 2015; Porpino, 2016; Stancu, 2016). The authors propose a 6 items scale for measuring attitude to minimize and intention to minimize (Graham-Rowe et al., 2014). Considering that food waste breaks a shared social norm (Cialdini et al., 1990; Cialdini et al., 1991; Cialdini and Goldstein, 2004) to reduce the tendency to give socially desirable responses, the items were carefully built and the questionnaire was individually filled (Paulhus, 1998)

A link was sent to potential respondents who were asked to forward it to friends and acquaintances (Stefan et al., 2012). A total of n=580 Italian consumers participated in the survey. In effect, the questionnaire sent through online platforms presented an initial message that urged to respond only those who were in charge of shopping or cooking (Stefan et al., 2012). During data screening, 3 cases were removed as they did not complete the questionnaire. The resulting final sample was equal to 577 respondents. The several steps of data analysis has been performed by using STATA 14 software for the analysis (StataCorp, 2015). Data analysis was carried out through the following steps:

Step A: descriptive statistic analysis.

Step B: internal consistency or reliability was examined considering the Cronbach's alpha coefficient (Gliem and Gliem, 2003) ($\alpha \geq 0.9$: excellent; $0.7 \leq \alpha < 0.9$: good; $0.6 \leq \alpha < 0.7$: acceptable; $0.5 \leq \alpha < 0.6$: poor; $\alpha < 0.5$: unacceptable).

Step C: exploratory factorial analysis (EFA) to identify the number of latent factors for constructs. The least value of the loading retained was 0.45; it was examined the sampling adequacy of items by the Kaiser–Meyer–Olkin (KMO) measure according to Kaiser (1974)($0.5 \leq KMO \leq 0.7$acceptable, $0.7 < KMO \leq 0.8$ good, $0.8 < KMO \leq 0.9$ great,$KMO > 0.9$ superb).

Step D: confirmatory factorial analysis (CFA) to test the validity of the resulting latent factors by means of a structural equation model (SEM). In the context of Structural Models of equations, it is recommended a minimum of five sample units for each observed variable up to a maximum of over 50 (Jaccard& Wan, 1996). In this study, the sample size n = 577 satisfies the required limits, for each observed variable.

Step F: SEM’s evaluation through indices of goodness fit (1-4) and indices of validity (5-6) (Schumacker & Lomax, 2010).

1. RMSEA: Root mean square error of approximation, with a good fit less than 0.10 (Chen, et al., 2008).
2. TLI : Tucker-Lewis index, with a good fit at least 0.95
3. CD: provides information similar to the R-squared value using OLS and other forms of regression (range 0-1)
4. CFI: a comparative fit index, with a good fit at least 0.95.
5. CR: Composite Reliability, with a good validity > 0.7
6. AVE: Average Variance Extracted, with a good validity > 0.45.

2.2.3Results and Discussions

This section gives a sample description of socio-demographic characteristics (as shown in Table 2.2.1). The sample is composed by 40.60% of male and the 59.4% of female with an age ranging from 30 to 50 (37.4% of the sample), above 50 for 32.9% and under 31 for 26.9%. The frequency of interviewed families in which there is the presence of children is 18%. The 30.0% has 4 components in the family, 25.0% has 3 family units and a 20.5% of the families has 2 units. The 51.1% has high school as educational qualification. Finally, the income for 50.0% of sample ranges from 1000 € to 2000 € (Table 2.2.1). Marangon et al., (2014) found that family composition and habits are the main factors that can explaining the wastage of food: families with higher number if children have no enough time to devote to shopping and have to concentrate purchases once a week. Furthermore, consumers with higher educational qualification devote a lot of time to work.

Table 2.2.1-Sample description

		Number	%
Gender	Male	234	40.6
	Female	343	59.4
	Total	577	100.0
Age	<31	171	29.6
	31-50	216	37.4
	>50	190	32.9
	Total	577	100.0
Educational qualification	Primary	140	24.4
	High School	294	51.1
	University	141	24.5
	Total	575	100.0
Family unit	1	49	8.5
	2	118	20.5
	3	144	25.0
	4	190	33.0
	5	60	10.4
	6	12	2.1
	7	3	0.5
	Total	576	100.0
Children	yes	103	18.0
	No	472	82.0
	Total	575	100
Income €/month	<1000	94	16,4
	1000-2000	281	49,0
	2001-3000	123	21,4
	3001-4000	41	7,1
	4001-5000	13	2,3
	>5000	22	3,8
	Total	574	100,0

Exploratory Factor Analysis results

The factor loadings of items on their respective factors were mainly higher than 0.45. All the variables of selected items present a good FL as shown in Table 2.2.2
The *Advertising Involvement* items (*AImess* and *AImedia)* have an excellent internal consistency or reliability α Cronbach coefficient (Table 2.2.2);
PC, EC, MR, SLEA, point out a good acceptable; TM, IM and AM show an acceptable internal consistency. KMO index results acceptable for TM and AM, good for IM and great for AImess, AImedia, PC, EC, MR and SLEA (Table 2.2.2).

Confirmatory Factor Analysis results

In order to assess the validity of the resulting latent factors, and therefore the item convergence was also assessed through the average variance extracted (AVE) and construct reliability (CR). According to Fornell and Larcker (1981) an AVE value equal to or greater than 0.50 and a CR value equal to or greater than 0.70 avoid to reach a good convergence.
As shown in Table 2.2.6 all the considered constructs exceeded the cut-off value, excepted EC, IM and AM that show the AVE's valueless than cut off value. The good convergence of AVE and CR indices means that indicators effectively measured their construct.
The indices of goodness fit were assessed in order to evaluate the Structural Equation Model (SEM). These indices RMSEA, TLI, CD, CFI were measured firstly for a SEM with each selected constructs (Table 2.2.3) and secondly for a SEM with the selected items and respectively Attitude to Minimize (AM) (Table 2.2.5) and Intention to Minimize (IM) (Table 2.2.4). The values of RMSEA for the first analysis indicate a good fit for all selected items except AImedia and MR. CFI index is good for all construct; TLI index reveal a good fit for AImedia, AImess, AM, PC, SLEA, TM,CD shows a good fit for all the items (Table 2.2.3). The values of RMSEA for the SEM with selected items and IM indicate a good fit for EC, SLEA, TM CFI index is good only for TM; the results were obtained with TLI; CD shows a good fit for all the items(Table 2.2.4). Concerning SEM with selected items and AM the results show the same trend seen before (Table 2.2.5).

Conceptual model: drivers of food waste

As shown in Fig 2.2.1 results reveal that the model converged well and its fit was satisfactory. Results show that all the selected constructs, including the new items introduced by the authors, determine the intention and attitude to minimize food losses. Consumers' attitudes as AImedia, SLEA, EC, TM, MR and PC determine their attitude not to waste, as expected by previous researches (Ajzen, 1991; Conner & Armitage, 2002; Stefan et al.,2014; Spielmann e Richard, 2013; Alford e Biswas, 2002; Balderjahn et al., 2013; Black, 2004; Graham-Rowe et al., 2014; Williams et al., 2012, Nassivera e Sillani, 2015); The same consideration can be done with the same constructs for the intention not to waste; in particular EC and MR made a significant contribution towards explain food waste-related consumer's behaviour; the AImess did not have effects on the intention and attitude to minimize. AM seems to have no effect on the amount of food waste, thus did not contributes to reduce it.

Table 2.2.2 Factor analysis results with a FL and αCronbach coefficient

Variable number		FL	αCronbach	KMO
	ADVERTISING INVOLVEMENT - message involvement (Aimess)		0.95	0.846
v062	I think it is important	0.83		
v060	I think it is of my interest	0.79		
v065	I think it is relevant	0.73		
v061	I think it is significant	1.00		
v059	I think it is valuable	0.74		
v069	I think it does well	0.71		
v070	I think it is essential	0.69		
v071	I think it is motivating	0.72		
	ADVERTISING INVOLVEMENT - media involvement (AImedia)		0.94	0.818
v068	I'm careful to the content	0.86		
v058	I pore on the content	0.80		
v063	I think to content	0.92		
v064	I focus on the content	0.96		
v067	I'm struggle looking the content	0.78		
v066	I carefully read the content	0.84		
	PRICE CONSCIOUSNESS (PC)		0.83	0.88
v011	I'm willing to make an extra effort to find lowest prices	0.46		

v046	I would buy in more of a shop for take advantage of lowest prices	1.00		
v044	I would always buy in more of a shop to find lowest prices	0.72		
v038	The money saved by finding lowest prices, usually is worth the time and effort	0.53		
v019	Usually it is worth "spending" the time for try lowest price	0.52		
v051	If a product is in discount, it can be a good reason to buy it	0.48		
v008	When I buy a discount brand, I know I'm doing a good affair	0.50		
v002	I have my favourite brands, but often I buy the discount brand	0.95		
v027	I'm more inclined to buy discount brands	0.45		
v001	Compared to most people, I'm more inclined to buy special brands.	-0.14		
	ENVIRONMENTAL CONCERN (EC)		0.70	0.82
v039	I'm afraid for future generations when I think environmental conditions	0.40		
v056	If we continue with the current lifestyle, we get closer to an environmental catastrophe	0.55		
v045	Often I'm embarrassed and it makes me angry watch TV or read newspaper about environmental problems	0.39		
v042	There are limits to economic growth that the industrialized countries world has already reached or will reach very soon	0.45		
v030	The majority of people are not environmentally responsible	0.39		
v036	In my opinion, the environmental problems are extremely exaggerated by supporters of the environmental movement	-0.09		
v033	The politicians do not make enough efforts to protect environment.	1.00		

v053	We should change own current lifestyle for protect the environment	0.56		
v013	Measures of environmental protection must be taken although this can reduce jobs.	0.40		
	MORAL AND OTHER ORIENTATED REASONING (MR)		0.75	0.86
v023	Usually my decisions are moved by my concern for other people	0.83		
v043	Usually my decisions are based on equity and fairness issues	0.32		
v021	I choose alternatives that satisfy the demand.	0.48		
v040	My behavior is aimed to help other people	0.30		
v048	My behavior respects the rights of the people involved	0.45		
v024	My decisions are usually based on concern for the welfare of others	0.92		
	TIME MANAGEMENT (TM)		0.62	0.59
v020	I organize my time better than others	0.45		
v052	I like to organize my activities based on hours	0.49		
v022	I'm able to do many more things because I manage my activities based on hours	0.88		
	SLE AWARENESS (SLEA)		0.73	0.82
v034	Gli alimenti che posso conservare più a lungo mi aiutano a risparmiare denaro.	0.59		
v054	Food that I can keep in the time, pollute more	-0.01		
v031	Food with a longer shelf life help me to reduce food waste	0.86		
v009	The foods that I can store longer help me to provide food for my family	0.99		
v035	Purchasing food with a longer shelf life is right	0.54		
v025	Food with a longer shelf life help me to make stocks and spend less time for shopping	0.45		
	INTENTION TO MINIMIZE (IM)		0.57	0.72

v047	I plan to cook lots of food to be frozen for use them at the appropriate time in order to decrease the amount of food waste.	0.05		
v006	I plan to prepare meals with leftover food to reduce food waste	1.00		
v012	With my experience in the food management (shopping, preparation, storage, ...) I can minimize the amount of food that throw away	0.35		
v018	In order to reduce food waste should pay more attention to food storage and check the expiration dates of the products in the fridge	0.55		
v037	In order to reduce food waste should pay more attention to food storage and check the expiration dates of the products in the fridge.	0.39		
v049	In order to reduce food waste it is necessary to improve conservation and preparation of food	0.71		
	ATTITUDE TO MINIMIZE (AM)		0.57	0.56
v004	A proper food management helps to minimize household food waste	0.61		
v032	Observing others (parents, friends, ...) I learned to cut / discard only the damaged portion of a food and consume the rest	0.56		
v041	When I prepare a meal I discard only the damaged portion of the foods and I consume the rest	0.73		
v005	Do you check your food inventories before to prepare a meal	0.41		
v017	When I throw away food I feel guilty.	0.36		
v026	Despite you try to plan food purchases you always end up buying more than you consume	0.23		

Table 2.2.3- Results of SEM for each item

	RMSEA	CFI	TLI	CD
AImedia	0,28	0,95	0,90	0,95
AImess	0	1	1	0,91
AM	0,00	1	1	0,80
EC	0,06	0,92	0,89	0,76
IM	0,09	0,93	0,88	0,73
MR	0,15	0,92	0,84	0,89
PC	0,02	1	0,99	0,86
SLEA	0,05	0,99	0,98	0,89
TM	0	1	1	0,81

Table 2.2.4 - Results of SEM considering each item ad intention to minimize

Intention to minimize

	RMSEA	CFI	TLI	CD
AImedia	0,18	0,80	0,74	0,95
AImess	0,14	0,84	0,81	0,96
EC	0,07	0,82	0,79	0,82
MR	0,15	0,65	0,566	0,81
PC	0,16	0,62	0,50	0,85
SLEA	0,11	0,74	0,69	0,84
TM	0,02	0,99	0,99	0,72

Table 2.2.5- Results of SEM considering each item ad attitude to minimize

Attitude to minimize

	RMSEA	**CFI**	**TLI**	**CD**
Aimedia	0,19	0.88	0,81	0,95
AImess	0,14	0,85	0,81	0,96
EC	0,08	0,78	0,74	0,80
MR	0,14	0,64	0,55	0,87
PC	0,14	0,82	0,74	0,86
SLEA	0,11	0,84	0,80	0,84
TM	0,07	0,97	0,91	0,70

Table 2.2.6- Results of SEM considering AVE and CR coefficient

	AVE	**CR**
ADVERTISING INVOLVEMENT - message involvement (Aimess)	0.696	0,992
ADVERTISING INVOLVEMENT - media involvement (AImedia)	0.740	0,996
PRICE CONSCIOUSNESS (PC)	0.474	0,988
ENVIRONMENTAL CONCERN (EC)	0.241	0,966
MORAL AND OTHER ORIENTATED REASONING (MR)	0.406	0,985
TIME MANAGEMENT (TM)	0.412	0,973
SLE AWERENESS (SLEA)	0.402	0,987
INTENTION TO MINIMIZE (IM)	0.259	0,976
ATTITUDE TO MINIMIZE (AM)	0.223	0,969

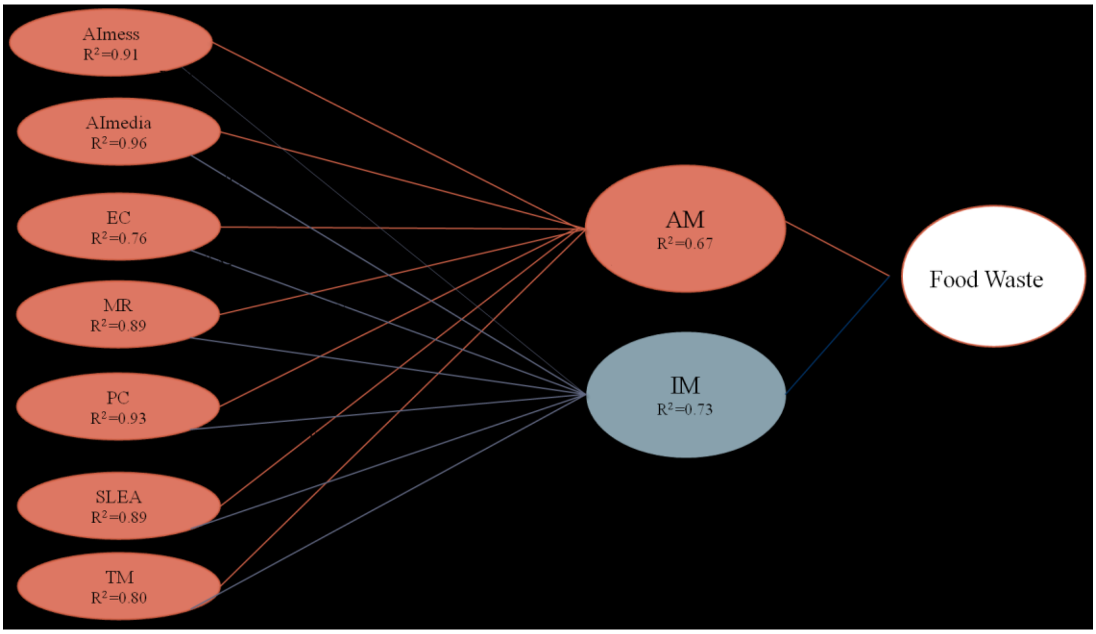

Fig 2.2.1- Drivers of food waste based on structural model results.

2.2.4- Conclusions

The study provides important insights revealing that environmental concern can strongly influence consumer behavior related to food waste minimization. Furthermore, the new item tested: shelf life awareness shows a significant contribution towards explain food waste-related consumer's behaviour. Thus, food firms could develop new advertising program in order to promote the product innovation (shelf life extension) as a tool to reduce environmental impact of food waste.

The present study shows that the consumers are aware about the amount and the kind of food that they throw away. They are trying not to throw away food because they feel guilty and worried. They are aware that food waste is a problem for environmental despite it is natural and biodegradable. Probably they try to reduce food waste and so its environmental impact. Consumers are also conscious about the amount of money that they spend weekly for food waste due to the fact that they buy too much food, more than they plan to buy. Moreover, models of consumers' food waste should take into account both general and moral attitudes, together with consumers' perceived behavioural control. Food waste may be perceived mainly as a food-related behaviour embedded in consumers' routines and not driven by conscious intentions.

Waste prevention approaches should focus on avoiding returns, transfer of best practices, information and education of employees and customers as well as strengthening the donation to social services (Lebersorger and Schneider F., 2014). In line with other works (Liang, 2014), the authors believes that the conclusions of this study may be used by the food policy to avoid food-related habits in consumers' everyday lives not respecting the issues of the food waste. It can be underlined that new models to address consumers' behaviour have to be identified in order change eating habits and attitudes.

Because of culture is known to have an impact on consumers' food waste behaviour (Stuart, 2009), it may be, also, interesting to compare our results with ones, that involved other countries. This can be crucial to provide basic guidelines for developing policies and campaigns aimed at decreasing the level of food waste generated in household.

Consumers consider food waste to be a food-related behaviour and as such more related to factor that influence food choice (Steptoe et al., 1995) or they perceive its environmental and social implications? To explore whether framing food waste-related messages as environmental ones or social ones would increase the role of norms in explaining food waste behaviour.

References

Abeliotis, Konstadinos, Katia Lasaridi, and Christina Chroni (2014), "Attitudes and behaviour of Greek households regarding food waste prevention", Waste Management & Research : The Journal of the International Solid Wastes and Public Cleansing Association, ISWA, 32(February), 237–240.

Ajzen, I. (1991). The theory of planned behavior. Organizational behavior and human decision processes 50(2): 179-211.

Ajzen, I. (2001). Nature and operation of attitudes. Annual review of psychology 52: 27-58.

Ajzen, I. (2011). The theory of planned behaviour: reactions and reflections. Psychology and health 26(9): 1113-1127.

Al-Swidi, S., Huque, S.M.R., Hafeez, M.H., & Shariff, M.N.M. (2014). The role of subjective norms in theory of planned behaviour in the context of organic food consumption. British Food Journal 116(10): 1561-1580.

Alford, B. L., Biswas, A. (2002) The effects of discount level, price consciousness and sale proneness on consumers' price perception and behavioral intention, Journal of Business Research, Volume 55, Issue 9, September 2002, Pages 775-783, ISSN 0148-2963. doi: 10.1016/S0148-2963(00)00214-9

Arvola, A., Vassallo, M., Dean, M., Lampila, P., Saba, A., Lähteenmäki, L., Et Al. (2008). Predicting intentions to Purchase Organic Food: The role of affective and moral attitudes in the theory of planned behaviour. Appetite 50(2–3): 443-454.

Balderjahn, I., Peyer, M., & Paulssen, M. (2013). Consciousness for fair consumption: conceptualization, scale development and empirical validation. International Journal of Consumer Studies, 37(5), 546-555.

Bandura, A. (1977) a. Self-reinforcement: The power of positive personal control. In P. G. Zimbardo & F. L. Ruch (Eds.), Psychology and life (9th ed.). Glenview, IL: Scott Foresman.

Bandura, A. (1977) b. Social learning theory. Englewood Cliffs, NJ: Prentice-Hall. [purchase at amazon.com]

Bandura, A. (1977) c. Social learning theory. In B. B. Wolman & L. R. Pomroy (Eds.), International encyclopedia of psychiatry, psychology, psychoanalysis, and neurology (Vol. 10). New York: Van Nostrand Reinhold

Barr, S., Gilg, A. W., & Ford, N. J. (2001). Differences Between Household Waste Reduction, Reuse And Recycling Behaviour: A Study Of Reported Behaviours, Intentions And Explanatory Variables. Environmental & Waste Management 4(2).

Bell, D. R., Corsten, D., & Knox, G. (2011). From Point Of Purchase To Path To Purchase: How Preshopping Factors Drive Unplanned Buying. Journal Of Marketing 75(1): 31–45.

Biswas, A., Licata, J. W., Mckee, D., Pullig, C., & Daughtridge, C. (2000). The Recycling Cycle: An Empirical Examination Of Consumer Waste Recycling And Recycling Shopping Behaviors. Journal Of Public Policy & Marketing 19(1): 93–105.

Black, G. S. (2004). The impact of the English language on cross-cultural consumer research in Asia and Latin America. Asia Pacific Journal of Marketing and Logistics, 16(4), 3-35.

Bolton, L. E., & Alba, J. W. (2012). When Less Is More: Consumer Aversion To Unused Utility. Journal Of Consumer Psychology 22(3): 369–383.

Burkhardt, J. (2012). The Ethics Of Food Safety In The Twenty-First Century: Who Keeps The Public Good? The Philosophy Of Food 140-160.

Capone, R., Debs, P., El Bilali, H., Cardone, G., Lamaddalena N. Water Footprint in the Mediterranean Food Chain: Implications of Food Consumption Patterns and Food Wastage. International Journal of Nutrition and Food Sciences. Vol. 3, No. 2, 2014, pp. 26-36. doi: 10.11648/j.ijnfs.20140302.13

Chandon, P., & Wansink, B. (2006). How Biased Household Inventory Estimates Distort Shopping And Storage Decisions. Journal Of Marketing 70(4): 118–135.

Cialdini, R. B., & Goldstein, N. J. (2004). Social influence: Compliance and conformity. Annu. Rev. Psychol., 55, 591-621.

Cialdini, R. B., Kallgren, C. A., & Reno, R. R. (1991). A focus theory of normative conduct: A theoretical refinement and reevaluation of the role of norms in human behavior. Advances in experimental social psychology, 24(20), 1-243.

Cialdini, R. B., Reno, R. R., & Kallgren, C. A. (1990). A focus theory of normative conduct: recycling the concept of norms to reduce littering in public places. Journal of personality and social psychology, 58(6), 1015.

Conner, M., & Armitage, C. J. (1998). Extending The Theory Of Planned Behavior: A Review And Avenues For Further Research. Journal Of Applied Social Psychology 28(15): 1429–1464.

Conner, M., & Armitage, C. J. (2002). The Social Psychology Of Food. Buckingham: Open University Press.

Contò F., Fiore M., Dicecca R. (2015). Ethics Approach In Food Choices Along The Agri-Food Supply Chain: A Survey In Apulia Region, Eursafe 2015 Book, Food Ethics And Innovation, Romania, 27-29 May 2015.

Doron N. (2012) A clear plate means a clear conscience. In: Doron N, editor. Revaluing food. London: Fabian Society.

Evans, D. (2012). Beyond The Throwaway Society: Ordinary Domestic Practice And A Sociological Approach To Household Food Waste. Sociology 46(1): 41–56.

Fiore M., Contò F., Pellegrini G. (2015). Reducing Food Losses: A (Dis)-Opportunity Cost Model. Revue Of Studies On Sustainability 1: 151–166.

Fornell, C. & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. Journal of marketing research, 39-50.

Graham-Rowe E., Jessop D.C., Sparks P. (2014) Identify Motivations And Barriers To Minimising Household Food Waste. Resources, Conservation And Recycling 84: 15-23.

Graham-Rowe, E., Jessop, D. C., & Sparks, P. (2015). Predicting household food waste reduction using an extended theory of planned behaviour. Resources, Conservation and Recycling, 101, 194-202.

Guido, G., Prete, M. I., Peluso, A. M., Maloumby-Baka, R. C., & Buffa, C. (2010). The Role Of Ethics And Product Personality In The Intention To Purchase Organic Food Products: A Structural Equation Modeling Approach. International Review Of Economics 57(1): 79-102.

Herath, C. S. (2013a). Does Intention Lead To Behaviour? A Case Study Of The Czech Republic Farmers. Agricultural Economics (Czech Republic) 59(3): 143-148.

Herath, C. S., & Wijekoon, R. (2013b). Study On Attitudes And Perceptions Of Organic And Non-Organic Coconut Growers Towards Organic Coconut Farming, Idesia 31(2): 5-14.

Hoppe, A., Vieira, L. M., & Barcellos, M. D. (2013). Consumer Behaviour Towards Organic Food In Porto Alegre: An Application Of The Theory Of Planned Behaviour. Revista De Economia E Sociologia Rural 51(1):69-90.

Jensen, B. B., Lähteenmäki, L., Grunert, K. G., Brown, K. A., Timotijevic, L., Barnett, J.,Et Al. (2012). Changing Micronutrient Intake Through (Voluntary) Behavior Change. The Case Of Folate. Appetite 58(3):1014–1022.

Kantor, Linda, Kathryn Lipton, Alden Manchester, and Victor Oliveira (1997), "Estimating and addressing American food loss", Food Review, 20(1), 2-12

Koivupuro, Heta-Kaisa, Hanna Hartikainen, Kirsi Silvennoinen, Juha-Matti Katajajuuri, Noora Heikintalo, Anu Reinikainen, and Lotta Jalkanen (2012), "Influence of sociodemographical, behavioural and attitudinal factors on the amount of avoidable food waste generated in Finnish households", International Journal of Consumer Studies, 36(2), 183–191.

Krystallis, A., Grunert, K.G., De Barcellos, M.D., Perrea, T., Verbeke, W. (2012). Consumer Attitudes Towards Sustainability Aspects Of Food Production: Insights From Three Continents. Journal Of Marketing Management 28: 334–372.

Largo-Wight, E., Bian, H., & Lange, L. (2012). An empirical test of an expanded version of the Theory of Planned Behavior in predicting recycling behavior on campus. American Journal of Health Education, 43(2), 66-73.

Lebersorger S., Schneider F., (2014) Food Loss Rates At The Food Retail, Influencing Factors And Reasons As A Basis For Waste Prevention Measures. Waste Management 34: 1911-1919.

Lyndhurst, B., (2007) Food behaviour consumer research: quantitative phase.

Liang, A. R. -. (2014). Enthusiastically Consuming Organic Food: An Analysis Of The Online Organic Food Purchasing Behaviors Of Consumers With Different Food-Related Lifestyles. Internet Research 24(5), 587-607.

Liu, P., & Kwon, J. (2013). Perceived Availability Of And Attitudes Toward Healthy Food Choices In Assisted-Living Facilities In Kansas. Journal Of Foodservice Business Research 16(2): 183-196.

Marangon, F., Tempesta, T., Troiano, S., Vecchiato, D. (2014) Rivista di Economia Agraria, Anno LXIX, n. 2-3, 2014: 201-209. ISSN (print): 0035-6190, ISSN (online): 2281-1559, doi: 10.13128/REA-16922.

Mcdonough, T., Hendrickson-Nelson, M., & Plourde, H. (2014). Modifying Students' Intentions To Eat Sustainably. International Journal Of Sustainability Education 9(2): 31-49.

Munro, R. (1995). The Disposal Of The Meal. In D. Marshall (Ed.), Food Choice And The Consumer: 13-324. London: Blackie.

Nassivera F., Sillani S. (2015),"Consumer perceptions and motivations in choice of minimally processed vegetables", British Food Journal, Vol. 117 Iss 3 pp. 970 – 986.

Neff, Roni A., Marie Spiker, and Patricia Truant (2015), "Wasted Food: U.S. Consumers' Reported Awareness, Attitudes, and Behaviors", PLOS One, 10(6), 1-16.

OECD (Ed.) (2008). Environmentally Responsible Food Choice. Oecd Journal. General Papers 2: 125-62.

Olsen, N.V., Bánáti, D. (2013). Ethics In Food Safety Management. Food Safety Management: A Practical Guide For The Food Industry: 1115-1125.

Olsen, N. V., Sijtsema, S. J., & Hall, G. (2010). Predicting Consumers' Intention To Consume Ready-To-Eat Meals. The Role Of Moral Attitude. Appetite 55(3): 534–539.

Parfitt J, Barthel M, MacNaughton S. (2010) Food waste within food supply chains: quantification and potential for change to 2050. Philosophical Transactions of the Royal Society B, 365:3065–81.

Paulhus D.L., (1998) Paulhus Deception Scales (PDS). Multi-Health Systems Inc., NY.

Penner, L. (2002) Dispositional and organizational influences on sustained volunteerism: an interactionist perspective. Journal of Social Issues, 58, 447–467.

Penner, L. A., Fritzsche, B. A., Craiger, J. P., & Freifeld, T. R. (1995). Measuring the prosocial personality. Advances in personality assessment, 10, 147-163.

Porpino, G. (2016). Household Food Waste Behavior: Avenues for Future Research. Journal of the Association for Consumer Research, 1(1), 41-51.

Porpino, G., Parente, J., & Wansink, B. (2015). Food waste paradox: antecedents of food disposal in low income households. International Journal of Consumer Studies, 39(6), 619-629. PDF

Porpino, G., Wansink, B., & Parente, J. (2016). Wasted Positive Intentions: The Role of Affection and Abundance on Household Food Waste. Journal of Food Products Marketing, 1-19.

Quested, T. E., Marsh, E., Stunell, D., & Parry, A. D. (2013). Spaghetti Soup: The Complex World Of Food Waste Behaviours. Resources, Conservation And Recycling 79: 43-51.

Roberts, J. A., & Bacon, D. R. (1997). Exploring the subtle relationships between environmental concern and ecologically conscious consumer behavior. Journal of Business Research, 40(1), 79-89

Segrè A., Falasconi L. (2008). Eccedenze e spreco alimentare: i paradossi delle società sviluppate. In: Segrè A., edited by, Politiche per lo sviluppo agricolo e la sicurezza alimentare, Rome: Carocci Editore, 205-228.

Segrè A., Falasconi L. (2011). Il libro nero dello spreco alimentare in Italia: il cibo, Milan: Edizione Ambiente.

Spielmann, N., & Richard, M. O. (2013). How captive is your audience? Defining overall advertising involvement. Journal of Business Research, 66(4), 499-505.

Stancu, V., Haugaard, P., & Lähteenmäki, L. (2016). Determinants of consumer food waste behaviour: Two routes to food waste. Appetite, 96, 7-17.

Stefan V., Van Herpen E., Tudoran A.A., Lähteenmäki L. (2012). Avoiding food waste by Romanian consumers: The importance of planning and shopping routines. Food Quality and Preference, 28(1): 375-381. doi:10.1016/j.foodqual.2012.11.001.

Steptoe, A., Pollard, T.M., Wardle, J. (1995) Development of a measure of the motives underlying the selection of food: The Food Choice Questionnaire Appetite, 25 (3), pp. 267-284.

Stuart T. (2009). Waste: uncovering the global food scandal. London: Penguin Books; Turrentine TS, Kurani KS. Car buyers and fuel economy? Energy Policy 2007;35:1213–23.

Terpstra, M. J., Steenbekkers, L. P. A., Maertelaere, N.C.M. and Nijhuis,S. (2005) "Food storage and disposal: consumer practices and knowledge", British Food Journal, 107, 526–533.

Whitehair, K. J., Shanklin, C. W., & Brannon, L. A. (2013). Written messages improve edible food waste behaviors in a university dining facility. Journal of the Academy of Nutrition and Dietetics, 113(1), 63-69.

Williams, H., & Wikström, F. (2011). Environmental impact of packaging and food losses in a life cycle perspective: a comparative analysis of five food items. Journal of Cleaner Production, 19(1), 43-48.

Williams H., Wikström, F., Otterbring, T., Löfgren, M., Gustafsson, A. (2012) Reasons for household food waste with special attention to packaging, Journal of Cleaner Production, Volume 24, Pages 141-148, ISSN 0959-6526, doi: 10.1016/j.jclepro.2011.11.044.

Wrap (2009). Household Food And Drink Waste In The Uk. Uk: Banbury.

Young, W., Hwang, K., Mcdonald, S., Oates, C.J. (2010). Sustainable Consumption: Green Consumer Behavior When Purchasing Products. Sustainable Development 18(1): 20-31.

3. ECONOMIC AND ENVIRONMENTAL IMPACT: THE CASE STUDY OF EXTRA VIRGIN OLIVE OIL (EVOO)

The choice of this food item is connected to the importance of the EVOO production for the Apulia region. In this section the authors discuss the economic and environmental impact of the EVOO's shelf life extension obtained throught the merely choice of cultivar. Consequently, the system boundaries of the analysis includes only production phase. Therefore, the economic and environmental analysis will focus on the comparison of the different olive growing systems, considering that che choice of cultivar is strictly correlated with the choice of latters.

The fisrt part of this study is aimed to compare important quality parameters of oils extracted from traditional cultivars (Coratina and Ogliarola di Bari) and recently introduced cultivars (Arbequina, Koroneiki) in Apulia region. These parameters influence producs SL, and could extend the latter. The second part of the research focuses on the economic impact of two different olive growing systems taking into account results obtained in the previous analysis. The third part is dedicated to environmental analysis of three different olive growing systems considering the findings coming out the two previous analysis. The research implications are linked with the optimization of EVOO supply chain providing to producers important insights to increase farm's profitability.

Some some parts of this research were taken from:

Pellegrini, G., La Sala P., Camposeo, S., Contò, F., Economic sustainability of the olive oil high and super-high density cropping systems in Italy. Global Business and Economics Review, Vol. X, No. Y, xxxx (in press)

Pellegrini, G., Ingrao, C., Camposeo, S., Tricase, C., Contò, F., Huisingh, D. (2016) Application of water footprint to olive growing systems in the Apulia region: A comparative assessment Journal of Cleaner Production, 112, pp. 2407-2418.

3.1 Shelf life extension of EVOO

The research is addressed towards high healthy value food as EVOO, able to maintain a proper state of health and reduce the occurrence of certain diseases. The importance of EVOO is mainly attributed both to its high content of oleic acid, a balanced contribution amount of polyunsaturated fatty acids and its richness in phenolic compounds, which act as natural antioxidants. Besides antioxidant action, phenolic compounds shows several physiological properties, such antiallergenic, antiatherogenic, anti-inflammatory, antimicrobial, antioxidant, a cardio protective effects, and antithrombotic vasodilators properties. The phenolic compounds content in olive oil is influenced by several factors such as variety, environment (soil and climate), agronomic factor (irrigation, fertilization), time of harvest, technological factors (extraction procedure and storage) (Gambacorta et al., 2012; Dag et al., 2011; Hajimahmoodi et al., 2008; Gómez-Rico et al., 2007; Fernández-Escobar, 2006; Berenguer et al., 2006; Grattan et al., 2006;Aguilera et al., 2005; Morelló et al., 2005; Vinha et al., 2005; Beltrán et al., 2005; Rotondi et al., 2004). This study is aimed to compare the phenolic profiles and other quality parameters among different oils extracted from traditional cultivars (Coratina and Ogliarola di Bari) and recently introduced cultivars (Arbequina, Koroneiki) during one year. The experimentation helps to define which is the product (defined by cultivar) that lead to obtain a longer shelf life. In this regard an evaluation of economic and environmental sustainability is crucial considering that SLE could result in an increase of global sustainability of the entire supply chain. In order to reach these objectives, the authors considered the same type of soil, climate condition, irrigation (volume and method), fertilization and time of harvest extraction procedure and storage type. The only variable factor considered in the study was the type of cultivar.

3.1.1-The high healthy value of EVOO

The nutritional value of EVOO is mainly attributed both to its high content of oleic acid, a balanced contribution quantity of polyunsaturated fatty acids and richness in phenolic compounds, carotenoids and tocopherols which act as natural antioxidants and may contribute to the prevention of several human diseases (Perez-Jimenez,2005). The letter compounds have an antioxidant action, therefore they prevent oil deterioration. The amount of tocopherols in extra virgin olive oil is about 250 mg per kg of oil (Sciancalepole, 2002). The phenolic compound are located in the mesocarp of the fruit, where they represent at least the 2.5% of the fresh weight. The olive contains different classes of phenolic compounds: phenolic acids, phenyl ethyl alcohols, hydroxy-isochromans, flavonoids, lignans and secoiridoids (Tsimidou, 1998; Montedoro et al., 1992; Macheix et al., 1990; Amiot et al., 1986). The most important compound among phenolic compounds are: secoiridoids and lignans (Vasquez Roncero 1978; Kuwajima et al., 1988; Montedoro et al., 1993; Angerosa et al., 1996).

There is also an isomer of oleuropein aglycone (3,4-DHPEA-EA) and an isomer of ligstroside aglycone (p-HPEA-EA) (Amiot et al., 1989).
Phenols in EVOO are active compounds in the first step of oxidation: induction phase. During this phase an accumulation of hydroperoxides occurs. The latter are neutralized by phenolic compounds promoting a longer product shelf life (Caponio e Gomes, 2001). Several studies on antioxidant and nutraceutic properties of phenolic compounds were carried out (Servili et al., 2004a,b; El Riachy et al, 2011), especially oleuropein characheristics (Angerosa et al., 2004; Andrewes et al., 2003;Baldioli et al., 1996 Gutierrez-Rosales et al., 2003 Servili et al., 2009) According to these authors the antioxidant action is linked to two derivates of oleuropein (3,4-DHPEA e 3,4-DHPEA-EDA) and to 3,4-DHPEA-EA. Its quality characteristics, such as polyphenols and volatile compounds, can be influenced by a number of factors, from agronomic and climatic aspects to technological ones. Inside the olive orchard, factors affecting EVOO composition can be classified into four main groups: genetic (variety), environmental (soil and climate), agronomic (planting system, irrigation, fertilization), and cultivation (plant management).
Besides antioxidant action, phenolic compounds (Tutour and Guedon,1992; Benavente-Garcia et al., 2000) shows several physiological properties, such anti-allergenic, antiatherogenic, anti-inflammatory, antimicrobial, antioxidant, protective action on heart, and antithrombotic vasodilators (Benavente-Garcia et al., 1997; Manach et al., 2005; Middleton et al., 2000; Puupponen-Pimiä et al., 2001; Samman et al., 1998)
The anticancer properties of olive oil have been attributed to its high levels of monounsaturated fatty acids, squalene, tocopherols, and phenolic compounds (Fazio and Ricciardiello, 2014). Furthermore EVOO contribute to the lower incidence of coronary heart disease and reduce colon cancer insurgence (Covas, 2008).
The phenolic compounds content in olive oil is influenced by several factors such as variety, environment (soil and climate), agronomic factor (irrigation, fertilization), harvest and degree of maturation, technological factors (extraction procedure and storage) (Abaza et al., 2005; Baccouri et al., 2007; Ben Temime et al. 2006; Dag et al., 2009; Rotondi et al., 2004;)
The oil composition is influenced by irrigation: the stability and polyphenols amount increase with low irrigation volume, considering the high solubility of these compounds (Aparicio and Luna 2002; Patumi et al., 2002; Tovar et al., 2002; Connor

& Fereres, 2005; Berenguer et al., 2006; Marsilio et al., 2006; Gomez-Rico et al. 2007; Tognetti et al., 2008);

High level of fertilization determines a reduction of polyphenols and then a reduction of oil stability (Morales-Sillero et al.,2007; Erel et al.,2008 Fernández-Escobar et al.,2006). The polyphenol amount is also influenced by virus, fungi and insects damages and other stress (Fernández-Escobar, 1998, 2004). Another important factor that strongly influences the polyphenol content is time of harvest (Beltran et al., 2004):early harvest contributes to high level of polyphenols (Camposeo et al., 2013, Dag et al.2011; Ayton et al., 2007; Caponio et al., 2001; Rotondi et al., 2004;Dıraman and Dibekliõglu, 2009; Osman et al., 1994).

The amount of antioxidant phenols and volatile compounds depends on type of oil extraction (Servili et al.,1999, Servili et al., 2000): the content increases with two phase system (Gambacorta et al., 2012). The malaxation temperature and the period of olive paste exposition to air influence the volatile and phenolic compounds composition (Servili et al.,2004a,b). Therefore the control of O_2 concentration becomes very important (Sciancalepole, 1998). According to Dabbou et al., (2011) the packaging directly influences oil stability protecting oil from light and oxygen during storage. Oils stored in glass or stainless steel maintain their antioxidant compounds content (Dabbou et al., 2011).

3.1.2- Materials and methods

The EVOO shelf-life is strictly connected with polyphenols content: the higher amount of phenolic compound increases the product shelf life (Benavente-Garcia et al., 2000; Caponio e Gomes, 2001, Tutour and Guedon,1992).

The research was conducted in a olive farm located in the province of Bari (Southern Italy; 41° 01 N; 16° 45 E; 110 m a.s.l.) on a sandy clay soil (sand, 630 g kg−1; silt, 160 g kg−1; clay, 210 g kg−1) classified as a Typic Haploxeralf (USDA) or Chromi–Cutanic Luvisol (FAO). The farm is identified by the presence of two oil olive growing system: intensive or high-density system (HDS) and superintensive or super high-density system (SHDS). The site is characterized by a typical Mediterranean climate with a long-term average annual rainfall of 560 mm, two-thirds concentrated from autumn to winter, and a long-term average annual temperature of 15.6 °C. The experimentation was conducted maintaining constant the following variables: type of soil, climate condition, irrigation (volume and method), fertilization and time of harvest extraction procedure and storage type. The only variable factor considered in the study was the type of cultivar. The oils obtained by this farm were successively analysed by SAMER s.r.l. lab. On the same oils obtained from four different cultivars (Arbequina, Koroneiki, Coratina and Cima di Bitonto or Ogliarola) the chemical and organoleptic parameters were analysed. The oils were stored in dark condition at room temperature. The analysis were performed at least every three months: at month 0, month 3, month 6 and month 12. As chemical parameters, the acidity, peroxide value, K_{232}, K_{270},, total polyphenols were evaluated on 48 samples (three repetition for four cultivar multiply four times).

The research involved the Department of Agro-Environmental and Territorial Science, University of Bari, Department of Economic, University of Foggia and SAMER lab.

3.1.3 Results and Discussion

Results denote that after one year all the oils maintained the quality characteristic (classified as EVOO) as resulted by organoleptic evaluation (Fig. 3.1.1). As shown in Fig 3.1.1, after one year, for all analysed cultivars, rancidification and breakdown of polyphenols did not occur. Results of chemical analysis for month 0, 3, 6 and 12 were reported respectively in (Tables 3.1.1, 3.1.2, 3.1.3, 3.1.4) where the average value of three repetitions were considered. In the tables were reported also the standard error of the measurements. During one year oil obtained from Coratina (Fig. 3.1.1) shows the higher value of polyphenols content: 390 ±34 ($g \cdot kg^{-1}$ of caffeic acid) after milling, 354±31 ($g \cdot kg^{-1}$ of caffeic acid) at month 3, 359±39 ($g \cdot kg^{-1}$ of caffeic acid) at month 6 and finally 367±30 ($g \cdot kg^{-1}$ of caffeic acid) at month 12. The K_{232} value (which gives information concerning the primary oxidation), in the latter cv, moved from 2.0 (month 0) to 2.29 (month 12). After one year also oil obtained by Ogliarola maintains good quality parameter (Fig. 3.1.1). As shown in Fig. 3.1.1 the total polyphenols value moved from 295 ($g \cdot kg^{-1}$ of caffeic acid) after milling, to 255 ($g \cdot kg^{-1}$ of caffeic acid) after 12 months. The K_{232} value decreased as well, from 2.0 (moth 0) to 2.28 (month 12) maintaining the same values found for Coratina (Tables 3.1.1, 3.1.4). The oil that shows a lower shelf life parameters is obtained by Arbequina. During the year the polyphenols content decrease from 240 ($g \cdot kg^{-1}$ of caffeic acid) after milling, to 212 ($g \cdot kg^{-1}$ of caffeic acid) at the end the of year (Tables 3.1.1, 3.1.4). The K_{232} value moved from 1.92 (moth 0) to 2.25 (month 12). (Tables 3.1.1, 3.1.4). In conclusion, after one year, Coratina shows higher value of quality parameter and therefore a longer shelf life (Fig. 3.1.1). The organoleptic evaluation and chemical composition will be analysed until18 months in order to confirm the EU directive 2015/16 (EU, 2015) that legislates the EVOO shelf life on the label.

Table3.1.1- Shelf life parameters of EVOO sampled at month 0

month 0									
ANALYSIS	**Unit**	**Arbequina**	**St Err**	**Koroneiki**	**St Err**	**Coratina**	**St Err**	**Ogliarola**	**St Err**
Acidity	% Oleic acid	0,13	± 0,05	0,19	± 0,05	0,18	± 0,05	0,16	± 0,05
Peroxide number	meq O_2/kg	7,00	± 2	9,00	± 2	8,00	± 2	8,00	± 2
Spectrophotometric analysis (UV)									
K268		0,12	± 0,03	0,15	± 0,03	0,16	± 0,03	0,14	± 0,03
K232		1,92	± 0,13	1,90	± 0,13	2,00	± 0,13	2,11	± 0,13
Delta K		0,003	± 0,002	0,003	± 0,002	0,003	± 0,002	0,004	± 0,002
Fatty acid methyl ester	%								
C14:0-Myiristic acid	%	0,01	± 0,01	0,01	± 0,01	0,01	± 0,01	0,01	± 0,01
C16:0-Palmitic acid	%	14,41	± 0,7	12,82	± 0,7	12.67	± 0,7	13.53	± 0,7
C16:1-Palmitoleic acid	%	1,51	± 0,1	0,97	± 0,1	0,94	± 0,1	1,11	± 0,1
C17:0-Heptadecanoic acid	%	0,04	± 0,02	0,03	± 0,02	0,03	± 0,02	0,04	± 0,02
C17:0-Heptadecenoic acid	%	0,09	± 0,02	0,05	± 0,02	0,05	± 0,02	0,09	± 0,02
C18:0-Stearic acid	%	1,63	± 0,2	2,03	± 0,2	1,76	± 0,2	1,97	± 0,2
C18:1- Oleic acid	%	72,79	± 1	76,98	± 1	76,79	± 1	75,80	± 1
C18:2-Linoleic acid	%	7,90	± 0,2	5,67	± 0,2	6,19	± 0,2	5,87	± 0,2
C20:0-Arachic acid	%	0,35	± 0,1	0,32	± 0,1	0,33	± 0,1	0,35	± 0,1
C18:3- Linolenic acid	%	0,81	± 0,05	0,73	± 0,05	0,74	± 0,05	0,79	± 0,05
C20:1-Ecosenoic acid	%	0,30	± 0,10	0,27	± 0,10	0,34	± 0,10	0,30	± 0,10
C22:0- Behenic acid	%	0,13	± 0,03	0,10	± 0,03	0,11	± 0,03	0,11	± 0,03
C22:1- Erucic acid	%	<0.01		<0,01		<0,01		<0,01	
C24:0-Lignoceric acid	%	0,04	± 0,04	0,04	± 0,04	0,04	± 0,04	0,04	± 0,04
Total polyphenols	g/kg caffeic acid	240,00	± 34	250,00	± 35	390,00	± 51	295,00	± 40

Source: our processing data

Table 3.1.2- Shelf life parameters of EVOO sampled at month 3

		month 3							
ANALYSIS	Unit	Arbequina	St Err	Koroneiki	St Err	Coratina	St Err	Ogliarola	St Err
Acidity	% Oleic acid	0,17	± 0,05	0,23	± 0,05	0,22	± 0,05	0,17	± 0,05
Peroxide number	meq O2/kg	8,00	± 2	10,00	± 2	7,00	± 2	9,00	± 2
Spectrophotometric analysis (UV)									
K268		0,08	± 0,03	0,10	± 0,03	0,11	± 0,03	0,10	± 0,03
K232		1,82	± 0,13	2,00	± 0,13	1,80	± 0,13	1,83	± 0,13
Delta K		0,002	± 0,002	0,003	± 0,002	0,002	± 0,002	0,002	± 0,002
Fatty acid methyl ester	%								
C14:0-Myiristic acid	%	0,01	± 0,01	0,01	± 0,01	0,01	± 0,01	0,01	± 0,01
C16:0-Palmitic acid	%	14,77	± 0,7	12,97	± 0,7	12,81	± 0,7	1,,45	± 0,7
C16:1-Palmitoleic acid	%	1,56	± 0,1	0,95	± 0,1	0,77	± 0,1	1,11	± 0,1
C17:0-Heptadecanoic acid	%	0,05	± 0,02	0,03	± 0,02	0,03	± 0,02	0,07	± 0,02
C17:0-Heptadecenoic acid	%	0,18	± 0,02	0,07	± 0,02	0,05	± 0,02	0,19	± 0,02
C18:0-Stearic acid	%	1,89	± 0,2	2,12	± 0,2	2,04	± 0,2	2,17	± 0,2
C18:1- Oleic acid	%	72,10	± 1	76,39	± 1	76,24	± 1	75,31	± 1
C18:2-Linoleic acid	%	7,85	± 0,2	5,86	± 0,2	6,34	± 0,2	6,04	± 0,2
C20:0-Arachic acid	%	0,37	± 0,1	0,38	± 0,1	0,38	± 0,1	0,38	± 0,1
C18:3- Linolenic acid	%	0,73	± 0,05	0,78	± 0,05	0,81	± 0,05	0,79	± 0,05
C20:1-Ecosenoic acid	%	0,32	± 0,10	0,28	± 0,10	0,37	± 0,10	0,34	± 0,10
C22:0- Behenic acid	%	0,11	± 0,03	0,12	± 0,03	0,11	± 0,03	0,10	± 0,03
C22:1- Erucic acid	%	<0.01		<0.01		<0.01		<0.01	
C24:0-Lignoceric acid	%	0,05	± 0,04	0,04	± 0,04	0,04	± 0,04	0,04	± 0,04
Total polyphenols	g/Kg caffeic acid	222,00	± 31	219,00	± 31	354,00	± 47	262,00	± 36

Source: our processing data

Table 3.1.3- Shelf life parameters of EVOO sampled at month 6

		month 6							
ANALYSIS	**Unit**	**Arbequina**	**St Err**	**Koroneiki**	**St Err**	**Coratina**	**St Err**	**Ogliarola**	**St Err**
Acidity	% Oleic acid	0,17	± 0,05	0,25	± 0,05	0,24	± 0,05	0,21	± 0,05
Peroxide number	meq O2/Kg	11,00	± 2	9,00	± 2	10,00	± 2	10,00	± 2
Spectrophotometric analysis (UV)									
K268		0,12	± 0,03	0,12	± 0,03	0,14	± 0,03	0,14	± 0,03
K232		2,01	± 0,13	1,88	± 0,13	1,96	± 0,13	1,94	± 0,13
Delta K		0,003	± 0,002	0,001	± 0,002	0,001	± 0,002	0,002	± 0,002
Fatty acid methyl ester	%								
C14:0-Myiristic acid	%	0,01	± 0,01	0,01	± 0,01	0,01	± 0,01	0,01	± 0,01
C16:0-Palmitic acid	%	14,63	± 0,7	12,66	± 0,7	12,51	± 0,7	13,07	± 0,7
C16:1-Palmitoleic acid	%	1,66	± 0,1	1,05	± 0,1	0,83	± 0,1	1,06	± 0,1
C17:0-Heptadecanoic acid	%	0,12	± 0,02	0,05	± 0,02	0,03	± 0,02	0,10	± 0,02
C17:0-Heptadecenoic acid	%	0,19	± 0,02	0,12	± 0,02	0,07	± 0,02	0,17	± 0,02
C18:0-Stearic acid	%	1,83	± 0,2	2,26	± 0,2	2,03	± 0,2	2,22	± 0,2
C18:1- Oleic acid	%	72,14	± 1	76,21	± 1	76,51	± 1	75,49	± 1
C18:2-Linoleic acid	%	7,85	± 0,2	6,03	± 0,2	6,41	± 0,2	6,21	± 0,2
C20:0-Arachic acid	%	0,34	± 0,1	0,33	± 0,1	0,36	± 0,1	0,36	± 0,1
C18:3- Linolenic acid	%	0,79	± 0,05	0,88	± 0,05	0,82	± 0,05	0,82	± 0,05
C20:1-Ecosenoic acid	%	0,27	± 0,10	0,24	± 0,10	0,25	± 0,10	0,30	± 0,10
C22:0- Behenic acid	%	0,13	± 0,03	0,12	± 0,03	0,12	± 0,03	0,14	± 0,03
C22:1- Erucic acid	%	<0.01		<0.01		<0.01		<0.01	
C24:0-Lignoceric acid	%	0,05	± 0,04	0,05	± 0,04	0,05	± 0,04	0,05	± 0,04
Total polyphenols	g/Kg caffeic acid	286,00	± 39	219,00	± 31	359,00	± 47	275,00	± 38

Source: our processing data

Table 3.1.4- Shelf life parameters of EVOO sampled at month 12

		month 12							
ANALYSIS	Unit	Arbequina	St Err	Koroneiki	St Err	Coratina	St Err	Ogliarola	St Err
Acidity	% Oleic acid	0,2	± 0,05	0,27	± 0,05	0,27	± 0,05	0,23	± 0,05
Peroxide number	meq O2/Kg	8,00	± 2	9,00	± 2	5,00	± 2	9,00	± 2
Spectrophotometric analysis (UV)									
K268		0,23	± 0,03	0,22	± 0,03	0,19	± 0,03	0,18	± 0,03
K232		2,25	± 0,13	2,10	± 0,13	2,29	± 0,13	2,28	± 0,13
Delta K		0,002	± 0,002	0,002	± 0,002	0,001	± 0,002	0,002	± 0,002
Fatty acid methyl ester	%								
C14:0-Myiristic acid	%	0,01	± 0,01	0,01	± 0,01	0,01	± 0,01	0,01	± 0,01
C16:0-Palmitic acid	%	14,49	± 0,7	12,69	± 0,7	12,55	± 0,7	13,02	± 0,7
C16:1-Palmitoleic acid	%	1,58	± 0,1	1,01	± 0,1	0,87	± 0,1	1,11	± 0,1
C17:0-Heptadecanoic acid	%	0,04	± 0,02	0,03	± 0,02	0,03	± 0,02	0,05	± 0,02
C17:0-Heptadecenoic acid	%	0,14	± 0,02	0,05	± 0,02	0,05	± 0,02	0,19	± 0,02
C18:0-Stearic acid	%	1,84	± 0,2	2,23	± 0,2	2,00	± 0,2	2,23	± 0,2
C18:1- Oleic acid	%	72,36	± 1	76,42	± 1	76,29	± 1	75,55	± 1
C18:2-Linoleic acid	%	7,95	± 0,2	5,86	± 0,2	6,51	± 0,2	6,12	± 0,2
C20:0-Arachic acid	%	0,40	± 0,1	0,41	± 0,1	0,42	± 0,1	0,43	± 0,1
C18:3- Linolenic acid	%	0,72	± 0,05	0,77	± 0,05	0,74	± 0,05	0,79	± 0,05
C20:1-Ecosenoic acid	%	0,29	± 0,10	0,32	± 0,10	0,36	± 0,10	0,32	± 0,10
C22:0- Behenic acid	%	0,12	± 0,03	0,12	± 0,03	0,12	± 0,03	0,13	± 0,03
C22:1- Erucic acid	%	<0.01		<0.01		<0.01		<0.01	
C24:0-Lignoceric acid	%	0,05	± 0,04	0,05	± 0,04	0,05	± 0,04	0,05	± 0,04
Total polyphenols	g/kg caffeic acid	212,00	± 30	224,00	± 32	367,00	± 48	255,00	± 35

Source: our processing data

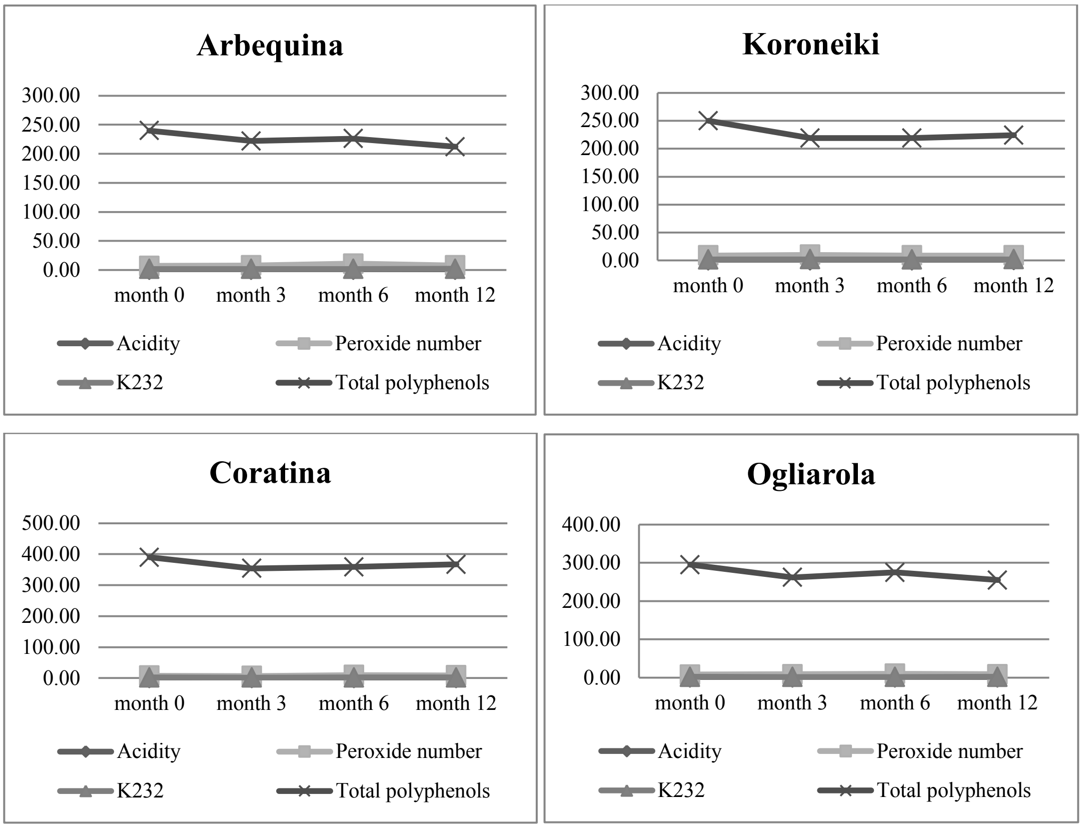

Fig. 3.1.1- Chemical parameters of Arbequina, Koroneiki, Coratina and Ogliarola during one year
Source: our processing data

3.1.3 Conclusions

These first data collected on 4 cultivars could contribute to highlight their shelf life and thus the storage management of the obtained oils. The shelf life showed fundamental differences among the cultivars, as expected. The traditional cultivars show the longest shelf life. In particular Coratina shows the highest polyphenols content and after one year maintains good values of quality parameters, as expected.

Moreover, data obtained in this study contribute to fill the information available in the literature concerning the shelf life of the aforementioned 4 cultivars and to have a comparison of quality parameters. These findings emphasize the importance of setting a priority of criteria for choose the cultivars depending on the market of the final product. For instance, thanks to their health properties, these oils can increase the perceived value, raise consumers'awareness of quality and their willingness to pay a premium price to guarantee a fair income for high quality EVOO producers. In this way, the health attribute becomes a marketing tool able to segment the EVOO. Furtheromore, these findings allow to remark some considerations concerning the trade-off between the economic and environmental sustainability of the different olive growing systems in Apulia region.

3.2 Economic sustainability of different olive growing systems

Basing on the assumption that traditional cultivars are typically grown in high density cropping system (HDS) and generally not compatible with an hedgerow and in turn new introduction cultivars are very suitable with super high density cropping system(SHDS), the second step of this session intends to identify the most sustainable olive growing system (in terms of economic sustainability) using a modular calculation system (Roselli and De Gennaro, 2011). This is important to increase farm's profitability. The results of this analysis allow to draw some crucial criteria for the management of the entire EVOO supply chain. Furthermore, the research provides more insights to decision maker (producer) who is faced with a problem of optimal choice among alternatives that in turn depend on the final product market.

3.2.1 Olive oil sector in Italy

Olive tree (*Olea europaea* L. var. *sativa* Hoffm. and Lk.) is an evergreen species that is well adapted to the Mediterranean climate (Camposeo et al., 2011). This crop contributes to formation of the Mediterranean landscape and it is widely distributed in natural systems, agricultural cropping and agro-forestry (Pellegrini et al., 2015); it grows between 30° and 45° latitude in the two hemispheres (FAOSTAT, 2015).In this area, this crop is an important element of the cultural heritage and has a crucial role in the economy with significant social and environmental impacts. Furthermore, the extra virgin olive oil (EVOO) is the principal source of fat in the Mediterranean diet (Boskou et al., 2015; Clodoveo et al., 2015. 2014; Camposeo et al., 2013). It also represents one of the most important landscape conservation resources and protect the environment against erosion and desertification. According to Food and Agricultural Organisation of the United Nations (FAO) and International Olive Council (IOC), the olive growing areas and oil olives production (from an annual production of 10.93 Mt in 1993 to 20.40 Mt in 2013) (Fig. 3.2.1)have been rapidly expanded due to a significant increase of the olive consumption rates al global scale (FAOSTAT, 2015).

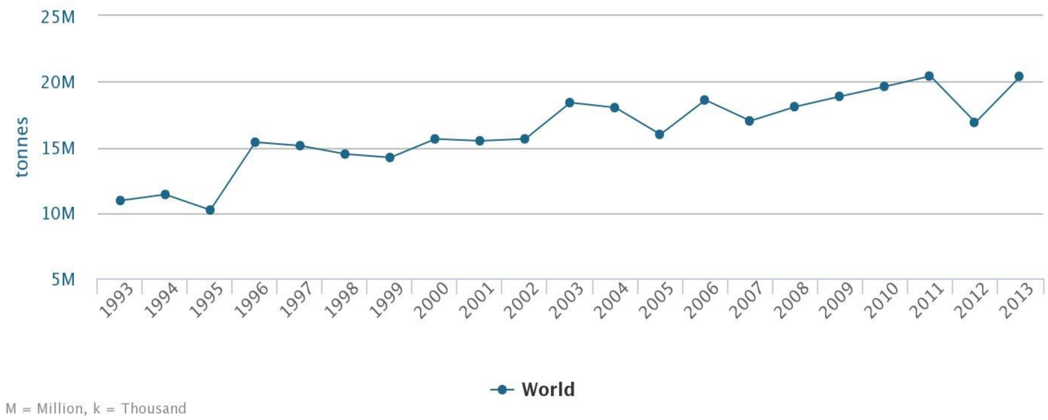

Fig. 3.2.1- Olive production trend at the world level
Source: FAOSTAT, 2015

In recent years, the olive sector is shifting towards sustainable agriculture by the use of solutions and short-term adaptations: such as canopy management, the timing and harvesting system which have strong economic implication. These solutions should be carefully evaluated in order to maximize the profitability. Indeed, the olive growing system is increasingly changing: from traditional or low-density (<200 trees per hectare) to modern intensiveor medium to high density (200–500 trees per hectare) and, mostly to superintensive or super-high density (>1.000 trees per hectare). According to Camposeo et al. (2008), the latter cropping system represents a very interesting approach to enhance olive orchard profitability, since it enables increased production per hectare while reducing the operating costs per kg of final product. In this regard, it should be observed that mechanised harvest technologies are increasingly being used in this field and recently new prototypes have been developed, such as the canopy over-the-row harvesters with a platform. This system improves harvest efficiency and it facilitates discharge into the trailers for transportation to olive mills (Gil Ribes et al., 2012).The Apulia olive production includes very different production realities considering: the natural, social and institutional, cultivar used, production techniques and oil qualitative characteristics (De Gennaro and Roselli, 2013).The Italian olive oil sector is characterised by a high quality production of extra virgin olive oil: indeed, 43 of them are certified by the PDO (Protected Designation of Origin), five of which are from Apulia according to the data recently updated (May 22, 2015) by the Italian Ministry of Agriculture and Forestry (Mipaaf, 2015).

Apulia is the first and most important olive-producing region in Italy, according to the Italian Institute of Statistics (ISTAT, 2015). In particular, in 2011 (the latest available updated data from ISTAT) the agricultural surface invested in Apulia for olive production was equal to 0.374 Mha, thus representing 32.25% of the corresponding national one (1.16 Mha). Moreover, in the same year olive-production levelled out at 1.21 Mt, thereby representing 35.07% of the amount produced at the national level (3.45 Mt). On an average, 90% of that amount (1.21Mt) is used for oil production and the remaining 10% for the production of table olives and derivatives (ISTAT, 2015). Moreover, in Table 3.2.1 the values of production and surface invested in 2011 were shown per each province of the Apulia region. The data in the Table show that the *highest production* areas are in Bari and Lecce, but those with the *highest production intensity* are in the Brindisi-Andria-Trani (BAT) and Taranto regions.

Table 3.2.1- Agronomic data on Italian olive cultivation in six regions within the province of Apulia with a focus upon hectares of olive groves, their olive production and plant density. (Agroquality, 2013)

Area	Surface(kha)	Production (kt)	Production Intensity (t ha^{-1})
Bari	99.5	300.0	3.0
Lecce	90.5	233.7	2.6
Brindisi	63.6	189.0	3.0
Taranto	38.6	173.7	4.5
BAT	32.5	160.0	4.9
Foggia	52.5	157.5	3.0

In particular, the areas of Lecce and Brindisi are characterised by olive trees that are very old (the "secular" ones are up to 500 years old) and that contribute to outlining the regional landscape: they are protected by regional law (14/2007) that regulates and limits the uprooting of ancient, living trees.

3.2.2 Intensive or High Density systems(HDS)

These cropping systems were born between ‘60s and ‘80s and they are characterized by regular tree density ranging from 200 to 500 trees ha^{-1}, with vase or monocone shaped trees. HDSs are based on medium vigor cultivarscompatible with an efficient mechanical harvesting by means of a trunk-shaker, with or without reversed umbrella (Famiani et al., 2014; Tous et al., 2014).The irrigation resulted in yields that could overcome 10 t $ha^{-1}y^{-1}$ with low alternate bearing (Godini et al., 2011; Tous et al., 2014). These are the most common planting systems currently used by growers in modern orchards, with a good reduction of cultural costs, mainly due to harvesting phase.

3.2.3 Superintensive or Super-High Density system (SHDS)

SHDS was born in Spain in the ‘90s and has spread rapidly throughout the olive growing areas of the world. In this system the most diffused spacing of trees is 4.0 m × 1.5 m (1.667 trees ha^{-1}) with central leader shaped trees; it is based on medium-to-low vigor cultivars, such as Spanish Arbequina, Arbosana and Greek Koroneiki, compatible with an hedgerow for the straddle harvesting machines (Caruso et al., 2014; Camposeo and Godini. 2010; Godini et al., 2011; Camposeo et al., 2013); most of the Italian varieties studied showed severe limitations in fitting to SHDS system (Camposeo and Godini. 2010; Camposeo et al., 2012; Vivaldi et al., 2015). SHDS is characterized by early bearing (2^{nd}-3^{rd} year after planting) and yield stabilization starting from 5^{th} year on around 10 t $ha^{-1}y^{-1}$, with very negligible alternate bearing (Camposeo and Godini. 2010). Moreover, recently it has been proved its environmental sustainability (Camposeo and Vivaldi, 2011; Bedbabis et al., 2015; Pellegrini et al., 2015; Russo et al., 2015). The SHDS has a greater flexibility due to its shorter production cycle (about 15-20 years) with respect to HDS (about 40 years); this feature is a strength of SHDS in an olive market scenario characterized by high price uncertainty (De Gennaro et al., 2012). The economic sustainability of this new oliveculture need to be deeply investigated.

3.2.4 Material and Methods

The present work shows a comparison between the production costs of different oil olive growing systems: HDS and SHDS through the analysis of costs’ and incomes’ pattern in the Apulia oil olive sector. For HDS data were collected from 200 olive farms involved in Integrated Project of Food Chains (IPFs) in olive sector. These farms are equal distributed from Foggia to Bari which are traditionally suited for olive production. The common cultivar is Coratina (Godini. 2011).In the case of SHDS data were provided by three different farms distributed in the area from Bari to Foggia with Arbequina as most diffused cultivars (Caruso et al. 2014). In Table 3.2.2the agronomic variables of the two compared cropping systems are reported.

Tab.3.2.2- Cropping systems variables

Variables	**HDS**	**SHDS**
Reference area	1 ha	1 ha
Planting shape	6 m x 6 m	4.0 m x 1.5 m
N° trees	278	1.667
Cultivar	Coratina	Arbequina
Trees age	40 years	6 years
Yield (t)	9.0	9.0
Oil yield (t)	1.6	1.6

Source: our processing

The estimation of the production costs represents a key element for comparison among farms' production costs, selling prices and used technologies. In order to search the best production models it is important to keep in mind a framework model able to determine the effects of different technical and economic choices on costs and revenues and therefore the farm's profitability. This model can be adapted by the farmers for the calculation of production costs and economic margin achieved. With the purpose of discriminate the two different production systems, the following variables were considered: growing system, mechanization and operations degree, soil and climate condition.

This modular calculation system (Roselli and De Gennaro, 2011) allows to measure the production costs and it is aimed at determining the efficiency benchmarks for olive production seeking to establish firstly minimum levels of economy and secondly to determine which are the best performing systems, considering factors connected to production costs and production level per production unit (hectare).

According to this methodology, the production costs include: interest on stock capital and on anticipation capital, the price of land capital use, wages and salaries, taxes, fees and contributions, depreciation charges and insurance policy. The specific costs (expressed as percentage of gross production value) was calculated.

The costs and revenues values were reported in a single production unit (hectare). The depreciation of plant and equipment were considered only for the HDS. The depreciation is calculated pro-rata per hectare. It is assumed that the farms have a medium-high level of mechanization and also an high level of specialization. In SHDS it is assumed that all agricultural practices (soil and disease management, fertilization, harvest and pruning) were supplied on behalf of a third party. The CAP's contribution (granted only to HDS) as an average value over the last few years is included in revenues. These results were elaborated to obtain an analysis of an Apulia farm type that could represent an average of the farms in the region.

In order to assess the revenues, an average sales price of extra virgin olive oil about 4.00 € kg^{-1} was considered. Aware of the strong heterogeneity of agricultural practices among different farms in different areas, the authors proposed to respondents, two schemes of agronomic management. The used schemes are considered rational for the two different olive growing systems.

3.2.5 Results and Discussions

These results represent an average of the production realities of the Apulia region. As shown in the Table 3.2.3 the total cost for HDS ranges from 6905.81 €·ha^{-1} to 5206.66€·ha^{-1} depending on the type of harvesting and the used technologies. Therefore, The farmer's income is mainly determined by the used technologies and management costs. The solution with a mechanised harvesting is less economic sustainable than the others , indeed the farmer's income id equal to 750.5€·ha^{-1}, due to a higher values of operation costs (4645.8 €·ha^{-1}), input costs (445.7 €·ha^{-1}) and depreciation/interests of machines (533.8 €·ha^{-1}). The solutions that requires lower costs are the management systems with a mechanical harvesting on behalf of a third party, equal to 5206.6 €·ha^{-1},and with tree shaking brought (5866.8 €·ha^{-1}). The former requires a smaller value of maintenance/insurance for machines (91.3 €·ha^{-1}), depreciation/interests of machines (481.3 €·ha^{-1}), operating costs (568.3 €·ha^{-1}) and input costs (298.4 €·ha^{-1}).The latter requires an higher levels of depreciation/interests of machines (746.1 €·ha^{-1}), operating costs (3393.3 €·ha^{-1}) and input costs (518.7 €·ha^{-1}), but a smaller value of maintenance/insurance for machines (248.5 €·ha^{-1}) and input costs (518.7 €·ha^{-1}) compared to the solution with moving tree shaking.

The most economically sustainable solution was found in SHDS in which all agricultural practices (soil and disease management, fertilization, harvest and pruning) were provided on behalf of a third party as shown in the Table 3.2.4. In this system the operating costs (1035.0 €·ha^{-1}) are low due to the abatement of harvesting and pruning costs. Despite this system requires high input costs (934.0 €·ha^{-1}), it presents higher economic performances than others HDSs. It is demonstrated by higher net income (equal to 4323.2 €·ha^{-1}) than 2249.66 €·$ha^{-1}$for HDS with mechanical harvesting on behalf of a third party.

Besides the economic sustainability analysis of two different oil olive cropping systems, the authors provide an overview of local situation coming from the IPFs' farms case study. It must be considered that Apulia olive growing sector is characterized by a wide variety of farm's situations related to different olive-growing areas. These differ in physical size and cost, for structural/organizational characteristics and, consequently, for market strategies. There are several areas with a low level of mechanization. The study gives an analysis of pruning man productivity expressed in man hours, considering data provided by IPFs'farms. The analysis is based on olive oil, not considering bottling. There are deep differences between the production techniques used in the province of Bari and Foggia (Table 3.2.5).

Tab. 3.2.3- Costs analysis (**€ ha^{-1}**) in HDS

Type of Harvest	**Mechanised harvesting**	**Tree shaking brought**	**Moving tree shaking**	**Mechanical harvesting on behalf of a third party**
Revenues	7200.00	7000.00	7000.00	7000.00
CAP premium	456.31	456.31	456.31	456.31
Tatal revenues	**7656.31**	**7456.31**	**7456.31**	**7456.31**
Costs				
Planting costs (Godini. 2010)				
Land preparation	500.00	500.00	500.00	500.00
Install Trellis System	2400.00	2400.00	2400.00	2400.00
Trees plants	9600.00	9600.00	9600.00	9600.00
Reinforcement. anchor wires	1200.00	1200.00	1200.00	1200.00
Drip line	860.00	860.00	860.00	860.00
Total costs to establish	14560.00	14560.00	14560.00	14560.00
Amortisation of planting costs	**242.67**	**242.67**	**242.67**	**242.67**
Operating Costs (€/ha)				
Disease Control	37.50	37.50	37.50	37.50
Field beans green manure	52.50	52.50	52.50	52.50
Pruning and geen pruning	6285.44	6285.44	6285.44	6285.44
Shredding of prunining waste	37.50	37.50	37.50	37.50
Fertilization	65.39	65.39	65.39	65.39
Shredding of weed	45.00	45.00	45.00	45.00
Handpicking	45.00	45.00	45.00	45.00
Mechanised harvesting	2077.50	0.00	0.00	0.00
Mechanical harvesting	0	825	270	0.00
Total operating costs	**8645.83**	**7393.33**	**6838.33**	**6568.33**
Input costs (€/ha)				
Fuel	245.61	318.54	438.39	98.22
Energy	3.81	3.81	3.81	3.81
Disease control and leaf fertilization	29.75	29.75	29.75	29.75
Fertilization	114.89	114.89	114.89	114.89
Field beans seeds	51.70	51.70	51.70	51.70
Total input costs	**445.76**	**518.69**	**638.54**	**298.37**
Amortization and interests of machines (€/ha)				
Spray nozzle	12.22	12.22	12.22	12.22
Tractor	381.48	381.48	381.48	381.48
Harrow	24.50	24.50	24.50	24.50
Shredder	33.00	33.00	33.00	33.00

Electric scissors	13.32	13.32	13.32	13.32
Fertilizer spreaders	13.26	13.26	13.26	13.26
Trailer	3.50	3.50	3.50	3.50
Aids and compressor	50.97	0.00	0.00	0.00
Tree shaking brought	0.00	263.15	0.00	0.00
Moving tree shaking	0.00	0.00	943.30	0.00
Harvest net	1.63	1.63	0.00	0.00
Total amortization and interests	**533.88**	**746.06**	**1424.58**	**481.28**
Maintenance and insurance for machines (€/ha)				
Spray nozzle	3.50	3.50	3.50	3.50
Tractor	87.2	117.31	74.31	74.31
Harrow	1.40	1.40	1.40	1.40
Shredder	5.66	5.66	5.66	5.66
Electric scissors	3.81	3.81	3.81	3.81
Fertilizer spreaders	2.27	2.27	2.27	2.27
Trailer	0.40	0.40	0.40	0.40
Aids and compressor	0.00	114.05	0.00	0.00
Tree shaking brought	11.67	0.00	0.00	0.00
Moving tree shaking	0.00	0.00	240.31	0.00
Harvest net	0.40	0.14	0.00	0.00
Total maintenance and insurance	**116.3**	**248.53**	**331.65**	**91.34**
General and administrative expenses (€/ha)				
Total expenses	**151.75**	**141.15**	**141.15**	**141.15**
Mechanical harvesting on behalf of a third party (€/ha)				
Total harvesting costs	**0.00**	**0.00**	**0.00**	**650.00**
Services purchased (€/ha)				
Field beans seeding	97.09	97.09	97.09	97.09
Olive trasport	87.96	81.17	81.17	81.17
Olive milling	525.63	484.95	484.95	484.95
Oil packaging	175.24	161.65	161.65	161.65
Total Services purchased	**885.92**	**824.86**	**824.86**	**824.86**
Total costs	**6905.81**	**5866.76**	**6110.13**	**5206.66**
Net income	750.50	1589.55	1346.18	2249.65

Source: our processing

Tab.3.2.4- Costs analysis **(€ ha^{-1})** in SHDS

Type of Harvest	
	Continuous mechanical harvesting on behalf of a third party (€/ha)
Revenues (€/ha)	7200
Costs (€/ha)	
Cost to establish (€/ha)	
Land preparation	500.00
Install Trellis System	1002.00
Trees plant	2505.00
Reinforcement. anchor wires	1302.60
Drip line	840.00

Total planting costs	6149.60
Amortisation of planting costs	**204.99**
Operating costs (€/ha)	
Mechanical weed control	15.00
Mechanical weed control	100.00
Chemical weed control	160.00
Fertilization	50.00
Disease control	210.00
Harvest	200.00
Pruning and green pruning	200.00
Chopping	100.00
Total of operating costs	**1035.00**
Input costs (€/ha)	
Mechanical weed control (harrowing)	
Mechanical weed control	
Chemical weed control	20.00
Fertilization	240.00
Disease control and leaf fertilization	270.00
Harvest	
Pruning and green pruning	
Shredding	
Fuel	400.00
Energy	4.00
Total input costs	**934.00**
Services purchased (€/ha)	
Olive trasport	81.17
Olive milling	484.95
Oil packaging	161.65
Total services	**727.77**
General and administrative expenses (€/ha)	
Total expenses	**100.00**
Total costs	**3001.76**
Net income	**4198.24**

Source: our processing

Table 3.2.5-Apulia olive cropping characteristics

	Foggia	***Bari***
Trees/ha	400	416
Olive production (q ha^{-1})	51.65	65
Oil production olio (kg tree^{-1})	2.73	2.39
Man hours for pruning ha^{-1}	82.21	71.68
Pruninig productivity (min. tree^{-1})	20	28

Pruning costs/total cost %	17	21
Source: our processing on indicated source		

Source: our processing

3.3 Conclusions

The estimation of production costs is a useful both as element of comparison between costs production and sales prices and as the analysis of the differences between adoptable technologies and production areas, thus providing real support for decision making. Basing on the assumption that traditional cultivars are typically grown in HDS and generally not compatible with an hedgerow, and in turn new introduction cultivars are very suitable with SHDS, the study provides some tools to determine the economic sustainability of different technical and economic choices and therefore the farm's profitability. Results show that net income obtained by SHDS, equal to 4323.2 €·ha^{-1}, is twice asnet income of HDS that includes mechanical harvesting on behalf of a third party, equal to 2249.65 €·ha^{-1}. Thus, a carefully managed SHDS provides adequate productivity and consequently good economic sustainability. The global sustainability of HDS could increase if the authors consider the shelf life extension and the high healthy value of the oil obtained from these systems. In fact, results show that Coratina maintains a longer shelf life during the analysed period, as well as a good organoleptive and chemical parameters, maintaining the highest polyphenols contet. These results would imply a greater global sustainability: with a shelf life extension, the oil waste amount would be reduced. In this context, the high healthy value, as well as an high environmental value (obtained with a longer shelf life), could be considered an important attributes to segment the product and to increase the competitiveness in the global market. On the other hand, the introduction of new genotypes with an higher production level as well as higher polyphenols content, would largely increased the global sustainability and farm's profitability. The study not provides the calculation of the data uncertainty. The exploratory research is ongoing and its findings are far from being final.

Besides the economic impact, further studies are needed in clarifying the environmental impact that characterized the different olive growing systems, in regionalizing characterization factors. Another further step will be the analysis of other management tools in SHDSs. In Southern Italy in fact, the number of SHDSs is increasing because of the higher profitability. In fact, recent agronomic studies have been assessed in order to increase efficiency of inputs in super high-density olive orchards: water (Cuevas et al., 2013; Gomez del Campo, 2013; Proietti et al., 2012; Vivaldi et al., 2013), soil (Camposeo and Vivaldi. 2011; Russo et al., 2015), light (Connor and Gómez-del-Campo. 2013; Larbi et al., 2015; Rosati et al., 2013; Strippoli et al., 2013), tree and machinery (Allalout et al., 2011; Moutier et al., 2011; Proietti et al., 2015; Tous et al., 2014; Vivaldi et al., 2015). Providing an analysis of the economic sustainability of two different olive growing systems, the authors provide important technical and economic insights. These solutions allow to optimize yield, reduce waste and therefore emissions linked to waste, increase the global sustainability of the entire EVOO supply chain without implement interventions and investments, but optimizing existing solutions and scientific know-how.

Finally, the authors state that an important growth factor for producers is a quality protection: the high healthy value of oils with an high polyphenols level and a longer shelf life could become a marketing levers to increase the competitiveness in the global market, and to find a way out of the EVOO market crisis.

References

Abaza, L., Taamalli, W., Ben Temime, S., Daoud, D., Gutiérrez, F., Zarrouk, M., (2005). Natural antioxidant composition as correlated to stability of some Tunisian virgin olive oils. Riv. Ital. Sos. Grasse 82, 12–18

Agroquality, 2013. Market analysis of the countries covered by the project Towards a Common Quality Control and food chain traceability system for the Greek – Italian primary sector of activity (3.3.2), pp 73

Aguilera, M. P., Beltrán, G., Ortega, D., Fernández, A., Jiménez, A., Uceda, M., Characterisation of virgin olive oil of Italian olive cultivars: Frantoio and Leccino, grown in Andalusia. Food Chem. 2005, 89, 387-391.

Allalout A., Krichene D., Methenni K., Taamalli A., Daoud D., Zarrouk M., (2011) Behaviour of super intensive Spanish and Greek olive cultivars grown in northern Tunisia. J. Food Biochem, 35, 27-43. doi: 10.1111/j.1745-4514.2010.00364.x

Amiot, M.J.; Fleuriet, A.; Mecheix, J.J.(1989) Accumulation of oleuropein derivatives during olive maturation. Phytochemistry, 28, 67-69.

Andrewes P., Busch J.L.H.C., de Joode T., Groenewegen A., Alexandre H. (2003) - Sensory properties of virgin olive oil polyphenols: identifi cation of deacetoxy-ligstroside aglycon as a key contributor to pungency. J. Agric. Food Chem., 51: 1415-1420.

Angerosa F., Servili M., Selvaggini R., Taticchi A., Esposto S., Montedoro G.F. (2004) - Volatile compounds in virgin olive oil. occurrence and their relationship with the quality. J. Chromatogr. A, 1054: 17-31.

Aparicio, R. Luna, G. (2002) Characterisation of monovarietal virgin olive oils. Eur. J. Lipid Sci. Technol. 104, 614–627

Ayton, J., Mailer, R.J., Haigh, A., Tronson, D., Conlan, D., (2007) Quality and oxidative stability of Australian olive oil according to harvest date and irrigation. J. Food Lipids 14, 138–156.

Baccouri, B., Ben Temime, S., Taamalli, W., Daoud, D., M'sallem,M., Zarrouk, M., (2007). Analytical characteristics of virgin olive oils from two new varieties obtained by controlled crossing on Meski variety. J. Food Lipids 14, 19–34.

Baldioli M., Servili M., Perretti G., and Montedoro G.F. (1996) - Antioxidant Activity of Tocopherols and Phenolic Compounds of Virgin Olive Oil. J. Am. Oil Chem. Soc., 73: 1589-1593.

Bedbabis S., Trigui D., Ben Ahmed C., Clodoveo M.L., Camposeo S., Vivaldi G.A., Ben Rouina B., (2015). "Long-terms effects of irrigation with treated municipal wastewater on soil. yield and olive oil quality". Agric. Water Manage, 160, pp. 14–21. doi: 10.1016/j.agwat.2015.06.023

Beltrán, G., Aguilera, M. P., Del Rio, C., Sanchez, S., Martinez, L., Influence of fruit ripening process on the natural antioxidant content of Hojiblanca virgin olive oils. *Food Chem.* 2005, *89*, 207-215.

Beltrán, G., del Río, C., Sánchez, S., (2004) Seasonal changes in olive fruit characteristics and oil accumulation during ripening process. J. Sci. Food Agric. 84, 1783–1790.

Ben Temime, S., Taamalli, W., Bacccouri, B., Abaza, L., Daoud, D., Zarrouk, M., (2006) Changes in olive oil quality of Chétoui variety according to origin of plantation. J. Food Lipids 13, 88–99.

Benavente-Garcia, O., Castillo, J., Marin, F. R., Ortuno, A., & Del Rio, J. A. (1997). Uses and properties of citrus flavonoids. Journal of Agricultural and Food Chemistry, 45, 4505–4515.

Benavente-García, O., Castillo, J., Lorente, J., Ortuno, A., Del Rio, J.A., (2000) Antioxidant activity of phenolics extracted from Olea europaea L. leaves. Food Chem. 68, 457–462.

Berenguer, M.J., Vossen, P.M., Grattan, S.R., Conell, J.H., Polito, V.S. 2006. Tree irrigation levels for optimum chemical and sensory properties of olive oil. Hortic. Sci. 41, 427–432.

Boskou D., Camposeo S., Clodoveo M.L. (2015) "Table Olives as Sources of Bioactive Compounds". Olives and Olive Oil Bioactive Constituents. Boskou D. (Ed.). AOCS Press. Urbana. IL – USA. pp. 217—260. ISBN: 978-1-630670-41-2.

Camposeo, S., Ferrara, G., Palasciano, M., Godini, A., 2008. Varietal behaviour according to the superintensive oliveculture training system. Acta Hort. 791: 271-274.

Camposeo S., Godini A., (2010). “Preliminary observations about the performance of 13 varieties according to the super high density oliveculture training system in Apulia (southern Italy)”. Adv. Hortic. Sci., 24. pp. 16-20.

Camposeo S., Vivaldi G.A., (2011). “Short-term effects of de-oiled olive pomace mulching application on a young super high-density olive orchard”. Sci. Hortic., 129. pp. 613-621. doi: 10.1016/j.scienta.2011.04.034

Camposeo, S., Ferrara, G., Palasciano, M., Godini, A., 2012. About the biological behaviour of cv. Coratina. Acta Hort. 949: 129-133.

Camposeo S., Vivaldi G.A., Gattullo C.E., (2013). “Ripening indices and harvesting times of different olive cultivars for continuous harvest”. Sci. Hortic., 151.pp. 1-10. doi: 10.1016/j.scienta.2012.12.019

Caponio, F.; Gomes, T.; Pasqualone, A. (2001) Phenolic compounds in virgin olive oils: influence of the degree of olive ripeness on organoleptic characteristics and shelf-life. Eur Food Res. Technol., 212, 329–333.

Caruso T., Campisi G., Marra F.P., Camposeo S., Vivaldi G.A., Proietti P., Nasini L., (2014). “Growth and yields of the cultivar Arbequina in high density planting systems in three different olive growing areas in Italy”. Acta Hortic., 1057. pp. 341-348.

Clodoveo M.L., Camposeo S., Amirante R., Dugo G., Cicero N., Boskou D. (2015) “Research and Innovative Approaches to Obtain Virgin Olive Oils with a Higher Level of Bioactive Constituents”. Olives and Olive Oil Bioactive Constituents. Boskou D. (Ed.). AOCS Press. Urbana. IL – USA. pp 179 -216. ISBN: 978-1-630670-41-2.

Clodoveo M.L., Camposeo S., De Gennaro B., Pascuzzi S., Roselli L., (2014). “In the ancient world. virgin olive oil was called “liquid gold” by Homer and “the great healer” by Hippocrates. Why has this mythic image been forgotten? “. Food Res. Int., 62. pp. 1062-1068. doi: 10.1016/j.foodres.2014.05.034.

Connor. D.J., Gómez-del-Campo. M., 2013. Simulation of oil yield and quality of N–S oriented. olive hedgerow orchards in response to structure. Sci. Hortic. 150. 92–99. doi: 10.1016/j.scienta.2012.09.032.

Connor D.J, Fereres E. (2005) The physiology of adaptation and yield expression in olive. Hort Rev 31:155 – 229.

Covas, M.-I. (2008) Bioactive effects of olive oil phenolic compounds in humans: Reduction of heart disease factors and oxidative damage Inflammopharmacology, 16 (5), pp. 216-218.

Cuevas. M. V., Martín-Palomo. M. J., Diaz-Espejo. A., Torres-Ruiz. J. M., Rodriguez-Dominguez. C. M., Perez-Martin. A., Pino-Mejías. R.. Fernández. J. E. (2013). Assessing water stress in a hedgerow olive orchard from sap flow and trunk diameter measurements. Irrigation Science. 31(4). 729-746. doi: 10.1007/s00271-012-0357-x.

Dabbou S., Gharbi I., Dabbou S. , Brahmi F., Nakbi A. Hammamis M. (2011) Impact of packaging material and storage time on olive oil quality. African Journal of Biotechnology Vol. 10(74), pp. 16937-16947, 23. DOI: 10.5897/AJB11.880.

Dag, A., Ben-David, E.A., Fiume, P., Perri, E., (2009) Cultivation: Problems and Perspectives, Sixth Framework Programme Priority 5; Food Quality and Safety Priority, Call 4-C; MAC-oils. The Scientific Handbook, Avellino, Italy, pp. 1–55.

De Gennaro, B., Notarnicola B., Roselli L., Tassielli G., (2012) “Innovative olive-growing models: an environmental and economic assessment”. J. Cleaner Production. 28. pp. 70-80. doi:10.1016/j.jclepro.2011.11.004.

De Gennaro, B., Roselli L., (2013) “La filiera olivicola-olearia pugliese: struttura. organizzazione e competitività”. La Rivista di scienza dell’alimentazione, 42, 1 (Jan-Mar), pp. 165-174.
El Riachy M., Priego-Capote F., León L., Rallo L., Luque de Castr M. D. (2011) - Hydrophilic antioxidants of virgin olive oil. Part 2: Biosynthesis and biotransformation of phenolic compounds in virgin olive oil as aff ected by agronomic and processing factors. Eur. J. Lipid Sci. Technol., 113: 692-707.

Dıraman, H., Dibekliŏglu, H., (2009) Characterization of Turkish virgin olive oils produced from early harvest olives. J. Am. Oil Chem. Soc. 86, 663–674.

Erel R, Dag A, Ben Gal A, Schwartz A and Yermiyahu U, (2008) Flowering and fruit set of olive trees is response to nitrogen, phosphorus and potassium. J AmSocHort Sci 133:639–647.

EU Legislation, legge del 7 luglio 2016, n° 122 “Disposizioni per l'adempimento degli obblighi derivanti dall'appartenenza dell'Italia all'Unione europea”. Law July 7, 2016 n° 122 “Provisions for Italy as member state”.

Famiani, F., Farinelli D., Rollo S., Camposeo S., Di Vaio C., Inglese P., (2014). “Evaluation of different mechanical fruit harvesting systems and oil quality in very large size olive trees”. Spanish J. Agric. Res., 12, 4, pp. 960-972. doi: 10.5424/sjar/2014124-5794.

FAOSTAT. (2015). Food and Agricultural Organisation of the United Nations – Statistics Division (FAOSTAT)”. Available at: http://faostat3.fao.org/browse/Q/QC/E (2015) [accessed October 4-7. 2015].

Fazio, C., Ricciardiello, L. (2014) Components of the Mediterranean Diet with chemo preventive activity toward colorectal cancer Phytochemistry Reviews, 13 (4), pp. 867-879.

Fernández-Escobar R, Beltrán G, Sánchez-Zamora MA, Garciá- Novelo J, Aguilera MP and Uceda M, (2006) Olive oil quality decreases with nitrogen over-fertilization. HortScience 41:215–219.

Fernández-Escobar R. (2004). Fertilización. In: Barranco D, Fernández-Escobar R, Rallo L, editors. El cultivo del olivo. Madrid: Mundi-Prensa. pp 287 – 319.

Fernández-Escobar R. (1998) Diagnostico del estado nutritivo y fertilizacion del olivar. Phytoma 102:54 – 55

Gambacorta G., Faccia M., Trani A., Lamacchia C., Gomes T. (2012) Phenolic composition and antioxidant activity of Southern Italian monovarietal virgin olive oils. Eur. J. Lipid Sci. Technol., 114, 958–967.

Gil Ribes. J.A., Blanco. G.L. and Castro. S. (2012). "El futuro del olivar tradicional y surecolección". *Maq-Vida Rural*, 345, pp. 30-38.

Gómez-del-Campo, M., 2013. Summer deficit irrigation in a hedgerow olive orchard cv. Arbequina: relationship between soil and tree water status. and growth and yield components. Span. J. Agric. Res, 11, pp. 547-557. doi: 10.5424/sjar/2013112-3360.

Gomez-Rico, A., Salvador, M.D, Moriana, A., Perez, D., Olmedilla, N., Ribas, F. and FREGAPANE, G. 2007. Influence of different irrigation strategies in a traditional Cornicabra cv. olive orchard on virgin olive oil composition and quality. Food Chem. 100, 568–578.

Godini, A., Vivaldi G.A., Camposeo S., (2011). "Olive cultivars field-tested in super-high-density system in southern Italy". Calif. Agric., 65, 1, pp. 39-40. doi: 10.3733/ca.v065n01p39.

Grattan, S. R., Berenguer, M. J., Connell, J. H., Polito, V. S., Vossen, P. M., Olive oil production as influenced by different quantities of applied water. Agr. Water Manage. 2006, 85, 133-140.

Gutierrez-Rosales F., Rios J.J., Gomez- Rey M.L. (2003) - Main polyphenols in the bitter taste of virgin olive oil. Structural confirmation by on-line high-performance liquid chromatography electrospray ionization mass spectrometry. J. Agric. Food Chem., 51: 6021-6025.

Hajimahmoodi, M., Sadeghi, N., Jannat, B., Oveisi, M. R., Madani, S., Kiayi, M., Ranjbar, A. M., Antioxidant activity, reducing power and total phenolic content of Iranian olive cultivar. J Biol Sci 2008, 8, 779-783.
ISTAT (2015). Italian Institute of Statics (ISTAT) "Superfici e Produzioni". Available at: http://www.istat.it/it/ (accessed October 4–7. 2015).

Kuwajima, H.; Uemura, T.; Takaishi, K.; Inoue, K.; Inouye, H. (1988) A secoiridoid glucoside from
Olea europea. Phytochemistry, 27, 1757-1759

Larbi, A., Vázquez. S., El-Jendoubi. H., Msallem. M., Abadía. J., Abadía. A., Morales. F., 2015. Canopy light heterogeneity drives leaf anatomical. eco-physiological. and photosynthetic changes in olive trees grown in a high-density plantation. Photosyn. Res, 123, pp. 141-55. doi: 10.1007/s11120-014-0052-2.

Macheix, J. J., Fleuriet A., Billot J. Fruit phenolic. (1990) CRC Press, Boca Raton, Florida, USA, 1-126

Manach, C., Mazur, A., & Scalbert, A. (2005). Polyphenols and prevention of cardiovascular diseases. Current Opinions in Lipidology, 16, 77–84.

MATTM - Ministero dell'Ambiente e della Tutela del Territorio e del Mare, 2006. Decret Legislativo 3 Aprile 2006 n. 152 "Norma in materia ambientale". (ME –

Ministry of the Environment, 2006. Law Decree April 3, 2006 n. 152 "Environmental Standard") (in Italian).

Marsilio, V., R. d'Andria, B. Lanza, F. Russi, E. Iannuci, A. Lavini, and G. Morelli. (2006) Effect of irrigation and lactic acid bacteria inoculants on the phenolic fraction, fermentation and sensory characteristics of olive (Olea europaea L. cv. Ascolana Tenera) fruits. J. Sci. Food Agr. 86:1005–1013.

Middleton, E., Kandaswami, C., & Theoharides, T. C. (2000). The effects of plant flavonoids on mammalian cells: implications for inflammation, heart disease and cancer. Pharmacological Reviews, 52, 673–751.

Ministry, of the Environment, Land and Sea (2006). Law Decree April 3. 2006 n. 152 "Environmental Standard".

Montedoro, G.F.; Servili, M.; Baldioli, M.; Miniati, E. (1992) Simple and Hydrolyzable Phenolic Compounds in Virgin Olive Oil. 2. Initial Characterization of the Hydrolyzable Fraction. J. Agric. Food. Chem., 40, 1577–1580.

Montedoro, G.F.; Servili, M.; Baldioli, M.; Selvaggini, R.; Miniati, E.; Macchioni, A. (1993) Simple and Hydrolyzable Compounds in Virgin Olive Oil. 3. Spectroscopic Characterizations of the Secoiridoid Derivatives. J. Agric. Food Chem., 41, 2228-2234.

Morales-Sillero A, Jiménez R, Fernández JE, Troncoso A and Beltr´an G, (2007) Influence of fertigation in 'Manzanilla de Sevilla' olive oil quality. HortScience 42:1157–1162.

Morelló, J. R., Vuorela, S., Romero, M. P., Motilva, M. J., Heinonen, M., Antioxidant activity of olive pulp and olive oil phenolic compounds of the Arbequina cultivar. J. Agr. Food Chem. 2005, 53, 2002-2008.

Moutier, N., Ricard. J. M., Le Verge. S., (2011) Vigour control of the olive tree in a high density planting system: two experimental approaches. Acta Hort. 924. 185-193.

Osman, M., Metzidakis, I., Gerasopoulos, D., Kiritsakis, A., (1994) Qualitative changes in olive oil of fruits collected from trees grown at two altitudes. Riv. Ital. Sos. Grasse 71, 187–190.

Patumi,M., R. d'Andria,V.Marsilio,G. Fontanazza, G. Morelli, and B. Lanza. (2002) Olive and
olive oil quality after intensive monocone olive growing (Olea europaea L. cv. Kalamata) in different irrigation regimes. Food Chem. 77:27–34

Pellegrini, G., Ingrao C., Camposeo S., Tricase C., Contò F., Huisingh D., (2015). "Application of Water Footprint to olive growing systems in the Apulia region: a comparative assessment". J. Cleaner Production. working paper. doi: 10.1016/j.jclepro.2015.10.088.

Perez-Jimenez, F. (2005) International conference on the healthy effect of virgin olive oil. Eur. J. Clinic. Invest. , 35, 421–424.

Proietti, P., Nasini. L., Ilarioni. L., (2012). Photosynthetic behavior of Spanish Arbequina and Italian Maurino olive (Olea europaea L.) cultivars under super-intensive grove conditions. Photosynthetica 50. 239-246. doi:10.1007/s11099-012-0025-7.

Proietti, P., Nasini. L., Reale. L., Caruso. T., Ferranti. F., (2015) Productive and vegetative behaviour of olive cultivars in super high-density olive grove. Sci. Agric, 72, pp. 20-27. doi: 10.1590/0103-9016-2014-0037.

Puupponen-Pimiä , R., Nohynek, L., Meier, C., Kähkönen, M., Heinonen, M., Hopia, A., (2001). Antimicrobial properties of phenolic compounds from berries. Journal of Applied Microbiology, 90, 494–507.

Rosati, A., Paoletti. A., Caporali. S., Perri. E., 2013. The role of tree architecture in super high density olive orchards. Sci. Hortic, 161, pp. 24-29. doi: 10.1016/j.scienta.2013.06.044.

Roselli, L., De Gennaro B., (2011). Modelli olivicoli innovativi: un'analisi comparativa. AGRIREGIONIEUROPA, vol. 7; p. 78-81, ISSN: 1828-5880

Rotondi, A., Bendini, A., Cerretani, L., Mari, M., Lercker, G., Toschi, T.G., (2004) Effect of olive ripening degree on the oxidative stability and organoleptic properties of cv. Nostrana di Brisighella extra virgin olive oil. J. Agric. Food Chem. 52, 3649–3654

Russo G., Vivaldi G.A., De Gennaro B., Camposeo S., (2015). "Environmental sustainability of different soil management techniques in a high-density olive orchard" J. Cleaner Production, 16, pp. 498-508. doi: 10.1016/j.jclepro.2014.06.064.

Samman, S., Lyons Wall, P. M., & Cook, N. C. (1998). Flavonoids and coronary heart disease: Dietary perspectives. In C. A. Rice- Evans & L. Packer (Eds.), Flavonoids in health and disease (pp. 469–482). New York: Marcel Dekker.

Sciancalepore, V. (1998), Enzymatic Browning in Five Olive Varieties, J. Food Sci. 50:1194–1195.

Sciancalepole V., (2002) L'olio vergine di oliva. Ulrico Hoepli Editore

Servili, M., G. De Stefano, P. Piacquadio, L. Di Giovacchino, and V. Sciancalepore, (1999) Effect of Extraction Systems on the Phenolic Composition of Virgin Olive Oils, Fett/Lipid 101:328–332

Servili, M., M. Baldioli, A.L. Begliomini, R. Selvaggini, and G.F. Montedoro (2000) The Phenolic and Volatile Compounds of Virgin Olive Oil: Relationships with the Endogenous Oxidoreductases During the Mechanical Oil Extraction Process, in Flavour and Fragrance Chemistry, Proceedings of the Phytochemical Society of Europe, edited by V. Lanzotti and O. Taglialatela- Scafati, Kluwer Academic, Dordrecht, The Netherlands, pp. 163–173.

Servili M., Selvaggini R., Esposto S., Taticchi A., Montedoro G.F., Morozzi G. (2004a) - Health and sensory properties of virgin olive oil hydrophilic phenols: agronomic and technological aspects of production that aff ect their occurrence in the oil. J. Chromatogr. A, 1054: 113-127.

Servili, M., M. Baldioli, A.L. Begliomini, R. Selvaggini, and G.F. Montedoro (2004b) Air Exposure Time of Olive Pastes During the Extraction Process and Phenolic and Volatile Composition of Virgin Olive Oil. JAOCS, Vol. 80, no. 7

Servili M., Esposto S., Fabiani R., Urbani S., Taticchi A., Mariucci F., Selvaggini R., Montedoro G.F. (2009) – Phenolic compounds in olive oil: antioxidant, health and organoleptic activities according to their chemical structure. Infl ammopharmacology 17: 76-84.

Strippoli G., Vivaldi G.A., Camposeo S., Contò F., (2013) Sprouts seasonal elongation of two olive cultivars in a high-density orchard. Agric. Sci, 4, pp. 376-381. doi: 10.4236/as.2013.48054.

Tous J., Romero A., Hermoso J.F., Msallem M., Larbi A., (2014) "Olive Orchard Design and Mechanization: Present and Future". Acta Hortic, 1057.

Tovar, M., romero, M., alegre, S., girona, J. motilva, M. 2002. Composition and organoleptic characteristics of oil from Arbequina olive (Olea europaea L.) trees under deficit irrigation. J. Sci. Food Agric. 82, 1755–1763.

Tutour, B., Guedon, D., (1992). Antioxidative activities of Olea europaea leaves and related phenolic compounds. Phytochemistry 31, 1173–1178.

Tsimidou, M. (1998) Polyphenols and quality of virgin olive oil in retrospective. Ital. J. Food Sci.
10, 99-115.

Vasquez Roncero (1978) A Les polyphenols de l'huile d'olive. Revue Franc. Crops Gras, 25, 22- 3

Vinha, A. F., Ferreres, F., Silva, B. M., Valentao, P., Gonçalves, A., Pereira, J. A., Andrade, P. B., Phenolic profiles of Portuguese olive fruits (Olea europaea L.): Influences of cultivar and geographical origin. *Food Chem.* 2005, 89, 561-568.

Vivaldi. G.A., Strippoli. G., Camposeo. S., (2013). Ecophysiological response to irrigation of two olive cultivars grown in a high-density orchard. Agric. Sci, 4, pp. 16-20. doi: 10.4236/as.2013.48A003.

Vivaldi G.A., Strippli G., Pascuzzi S., Stellacci A.M., Camposeo S., (2015). "Olive genotypes cultivated in an adult high-density orchard respond differently to canopy restraining by mechanical and manual pruning". Sci. Hortic., 192, pp. 391-399. doi: 10.1016/j.scienta.2015.06.004.

Sitography

Unaprol- Consorzio Italiano, available at: http://www.unaprol.it/ (accessed October 27–29. 2015).

3.4 Environmental Analysis of different olive growing systems

Besides the economic sustainability analysis of a EVOO obtained by different olive growing systems, the environmental impact analysis is needed. The main objective of the present study is to compare water footprints of different olive cropping systems in order to highlight and to promote usage of agronomic approaches, which reduce water demand at the regional and global levels.

3.4.1 Introduction

Agricultural and food sectors, though contributing to human and health and prosperity, cause many environmental impacts (Ingrao et al., 2015). In this regard, agricultural policies have played a crucial role since they have been designed for decades for increasing yields with emphasis upon external inputs, such seeds, pesticides, mineral fertilisers, and agricultural equipment. (Bagheri, 2010). As a matter of fact, when farming systems are thus (conventionally) designed and managed, they are usually characterised by high productivity rates, but they negatively affect the global environment: therefore, they are not truly ecologically sustainable. Indeed, according to Soussana (2014), if not sustainably managed, agricultural activities contribute to both land degradation, natural resource exploitation and greenhouse gas (GHG) emissions. In particular, with regard to GHGs, those activities cause emissions of carbon dioxide for 25%, of methane for 50% and of nitrous oxide for more than 75% compared to those released at the global level. (Soussana, 2014. Additionally, Lamastra et al. (2014) documented thatagriculture is the largest freshwater consumer, accounting for 70% of the world's freshwater withdrawals. In this regard, Rost et al. (2008) reported that global consumption of basin-water associated with agricultural systems generally range between 1,200-1,800 km^3 per year. In particular, based upon FAO-Aquastat (2012), total freshwater withdrawals in Italy were estimated to be equal to 45.08 km^3 in 2007 (the latest available data), of which 28.59% (12.89 km^3) was used in agriculture. Moreover, Daccache et al. (2014) documented that the Italian areas with the highest irrigation demands are concentrated in the Po Valley and in the Apulia region.

In this context, it was underscored that the increasing over consumption of scarce freshwater resources, as a result of the global population growth, is accelerating freshwater scarcity and quality issues worldwide (Lamastra et al., 2014). In this regard, water availability uncertainties and accelerated water pollution are increasingly making the public, private and research sectors acknowledge that water security is a global concern (Lamastra et al, 2014) that must be addressed now. In addition, the availability and reliability of water resources is a limiting factor for the economic development of many water-stressed countries: the Mediterranean Region (MR) is one of the most water scarce regions at a global level (Daccache et al., 2014). The economy of the MR is based upon agriculture, which is its most productive and vital sectors. It employs more than a fifth of the population in almost half of the MR countries and contributes >10% Gross Domestic Product (GDP) in eight countries of those countries (Daccache et al., 2014). Thanks to its main characteristics of mild winters and hot dry summers, this region is particularly suited to production of a diverse range of crops such as olives, citrus, grapes and cereals, as well as high-value horticulture (Daccache et al., 2014). As precipitation across the region undergoes high inter-annual and seasonal variability (Correia et al, 2009), irrigation is an essential component of production for many farmers to support crop diversification, to help to ensure good, high quality yields and to help to ensure security of food supplies (Hanjra and Qureshi, 2010).

In this context, it is essential and urgent at all levels (local, regional and global) to shift to sustainable food-production systems that reduce water usage and GHG emissions per unit of production in comparison with the systems that are currently in use (van der Werf et al., 2014). In doing so, care should be taken to preserve yield, quality and safety of agro-foods and to ensure that our great-great grandchildren will also have water to use in producing their food and fibre. In this regard, an important guiding role is increasingly, being played by Life Cycle Assessment (LCA) and other tools, such as Carbon Footprint (CF) and Water Footprint (WF) (van der Werf et al., 2014). These tools are useful for quantifying the GHG emissions, water consumption and global environmental impacts of agricultural products' life cycles (Notarnicola et al., 2012). Based upon this definition, according to Baldo et. al. (2008), application of the aforementioned tools enable process revision and streamlining through evaluation of potentials for reduction of: GHG emissions; consumption of fossil fuels and water; environmental impacts, such as climate changes and the exploitation of natural and non-renewable energy resources.

Finally, those tools can be used to compare different products or processes in order to determine preferable options in terms of reduced global environmental impacts, thereby assisting in decision-making. In this context, this study was designed to compare the Water Footprints (WFs) of different cropping systems, which represent

well the current regional practices in the olive sector. Moreover, the groves investigated are located in the province of Bari, which is the most intensive production area of the Apulia region for both the area invested and yearly production. The study is aimed to provide some tools to determine environmental sustainability of different farm's management practices, comparing the three olive growing systems in order to find the most sustainable system in terms of water footprint. The research was focussed upon olive farming, because it is acknowledged as an important element of the cultural heritage of Apulia and has a crucial role in the economy of the Region. In particular, super high-density cropping systems are increasingly being implemented in order to maximise production yields compared to the traditional ones. Therefore, proper environmental evaluations, like those discussed in this paper, are needed to be conducted for identification of the best performing systems. This research is part of broader investigations in the olive sector focussed upon improving global environmental sustainability, which will include research on Carbon and Ecological Footprint reductions, and Life Cycle Assessments for making holistic improvements.
The following section reviewed the methodological approach used for WF estimation, as the foundation for this research.

3.4.2 The theoretical approach to water footprint analysis

The increasing scarcity of freshwater and the important roles that water plays in food production and all other dimensions of human and eco-system health emphasises the need to optimise water use in all human activities and, in particular, in agriculture since, this sector is acknowledged worldwide to be highly water-consuming (Chouchane et al., 2015).
In this context, the Water Footprint (WF) concept was introduced by Hoekstra (2003) to enable correct quantification of both water consumption and pollution, as needed for the planning of mitigation interventions and, as a result, for more sustainable water uses (Lamastra et al., 2014; Schyns et al., 2014).
WF can be considered as an aggregate and multidimensional indicator of water use, because it can help to clarify the different sorts of water consumption as a function of space and time, which differs from the traditional concept of water balance (Hoekstra et al., 2011), because the latter describes only the flow of water in and out of a system by considering only consumptive water use (Lamastra et al., 2014).

In the light of the huge water consumption associated with human activities, water utilisation and management at local, regional and global levels must be centred on sustainable practices. In this context, the importance and the usefulness of WF led to the development of the WF Assessment (WFA) framework that was presented by Arjen Hoekstra in 2011 (Hoekstra et al., 2011) as a distinct field of research and application (Schyns et al., 2014). WFA can be considered, to be a tool for WF quantification, interpretation and reduction in order to guide the evolution towards sustainability enhancement in all human activities, such agricultural practices that use huge amounts of water. According to Boulay et al. (2013), the Water Footprint Network (WFN), together with its partners and other researchers, established a methodology for development of WFAs based upon global WF standards. The WFA methodology addresses appropriation of freshwater resources in a four-step approach including goals and scope setting, water footprint accounting, sustainability assessment, and response formulation (Hoekstra et al., 2011; Boulay et al., 2013). The accounting phase includes the quantification and mapping of freshwater use by three distinct types of water: blue, green and grey (Hoekstra et al., 2011; Boulay et al., 2013). The first one is the consumption of blue water resources considering both the surface and the groundwater components, whilst the second refers to the volume of rainwater consumed during the production process. The last one measures water pollution and is defined as the volume of fresh water that is required to assimilate the load of pollutants given natural background concentrations and existing ambient water quality standards (Chouchane et al., 2015). Therefore, according to Lamastra et al. (2014), it can be asserted that WF, in contrast to water balance, includes other types of water as offered by rainfall (green water) and as polluted by human activities (grey water), and excludes water volume consumption (blue water) insofar as water is returned to its source.

Therefore, it can be concluded that the WFA methodology provides a comprehensive indicator to show the full embedded water volume that is consumed along the life cycles of products (from direct water extraction to water pollution), illustrating the resulting impacts in terms, for instance, of basin-water availability.

Finally, the methodology enables documentation of both detailed information about the different impacts of water consumption and can provide guidance for improved water stewardship in the agro-food sector (Herath et al., 2013; Lamastra et al., 2014; Chouchane et al., 2015).

3.4.3 Materials and methods

Description of the investigated olive growing systems

In the particular case, the olive groves under study are located in a farm near Bari (Southern Italy - 41°01'N; 16°45'E; 110 m a.s.l.), on a sandy-clay soil (sand, 630 g kg−1; silt, 160 g kg−1; clay, 210 g kg−1) classified as a Typic Haploxeralf (USDA) or Chromi-Cutanic Luvisol (FAO). The site is characterised by a typical Mediterranean climate, with a long-term average annual rainfall of 560 mm (two third concentrated from autumn to winter) and a long-term average annual temperature of 15.6 °C (Camposeo et al., 2011). Three different olive cropping systems were compared: Traditional System (TS), Intensive System or High Density System (HDS), Super High-Density System (SHDS). The former is based upon the rain fed growing of trees that are hundreds of years old and, therefore, this system is characterised by both low density and low productivity, thereby providing low economic returns for the growers. As documented by Godini et al. (2011), the latter aspect is also strictly due to the high costs for pruning, harvesting and poor marketing systems. In the analysed case, olive yield was equal to approximately 2.5 t ha-1y-1, which is between 1.5-3 t ha-1y-1, namely the typical range for such cropping systems. Moreover, as usually done in similar cases, harvest is manual or mechanised with the support of platforms, manual stem shakers and trunk shakers with reversed umbrellas for collection of the olives (Famiani et al., 2014; Rafael et al., 2014). In this regard, it should be observed that mechanised harvest technologies are increasingly being used in this field and recently new prototypes have been developed, such as the canopy contact head harvesters with a platform. This system improves efficiency of harvesting because it facilitates olives collection and subsequent discharge into the trailers for transportation to the olive mills (Gil Ribes et al., 2012).

The HDS are the most common planting system currently used by growers in modern orchards and are characterised by regular and medium-density cropping systems (Camposeo et al., 2008). In the analysed case, the grove was characterised by 400 trees per hectare, thus falling in between 250-500 units per hectare, which is the typical range for such growing systems. Moreover, good rates of productivity and mechanisation in the harvest phase were observed compared to the equivalent standards for such systems. The irrigation systems (drip irrigation, with an irrigation volume about 2,000 m3ha-1y-1) resulted in yields that ranged between 9-11 t ha-1y-1 (Godini et al., 2011; Tous et al., 2014). Harvesting was performed using mechanical tools such as, trunk shakers with several frames to collect the fruit, mainly for small orchards (less than 50 ha), or side-by-side shakers for large orchards (over 50 ha) (Tous et al., 2014). In addition,

The SHDS was born in Spain in the ‘90s and has spread rapidly throughout the olive growing regions of the world. For the analysed SHDS olive yields in the full production period range from 8 to 12 t ha^{-1} (Camposeo and Godini, 2010; Tous et al., 2014;). The IR is approximately 1600 m^3ha^{-1} under rain-fed conditions of almost 600 mm y^{-1}: that value of IR was extracted from Vivaldi et al. (2013a,b) that focussed upon the same groves.

Finally, for all of the three systems investigated fertilisation is performed through administration of ammonium nitrate in the amounts reported in Table 3.4.1.

Table3.4.1- Amounts of ammonium nitrate used for grove fertilisation under the single growing system condition

System	Ammonium nitrate ($kgha^{-1}$)
TS	**440**
HDS	**400**
SHDS	**320**

Goal and scope of the study

The study was designed to obtain detailed information about the WF of three different olive cropping systems using experimental data over the period 2009-2014, in order to highlight and promote water use efficiency improvements at the local and regional scale. The study was conducted for the following three reasons:

- the olive sector plays an essential role in the culture, economy and diet of the Apulia region;
- huge amounts of olives, especially for transformation into oils, are produced every year in the region;
- the literature review performed revealed that no studies were done to compare the WFs of different olive growing systems.

Therefore, environmental studies are needed for improving efficiency and effectivity of water management so as to enhance overall improvement and valorisation of the sector.

Finally, for the assessment development the border of the analysed system was outlined to include not only the water consumed for the irrigation and fertilisation activities but also that embedded in the production of the fertiliser utilised.

Methodology

In this study, WF assessment was performed accounting for the three water components (green, blue and grey) as established by Hoekstra et al. (2011). In particular, it was conducted in order to assess the use of freshwater associated with olive growing in three different systems, considering the last five years in the full production period. The research was possible due to the collaboration of local farms involved in providing the necessary agronomic data. In particular, data were collected from 2009 to 2014 with regard to ET_c, P_{eff}, as well as I_{eff}, and N-fertiliser consumption. For greater understanding, it is underscored that the period 2009-2014 was chosen as the reference for the study development, because in the SHDS the full production period started in 2009, thus making it possible to compare the three systems. Climatic data (ET_c and P_{eff}) were monitored at the agro-meteorological station of the village where all the farms are located, and supplied by the agro-meteorological office of the ASSOCODIPUGLIA. In particular, ET_c e P_{eff} were measured daily and, from the values recorded, the related annual averages for each year in the period 2009-2014 were calculated, so resulting in 123.07 mm y^{-1} and 550.22 mm y^{-1}, respectively. Then, the Crop Water Requirement (CWR) was calculated from both ET_c and the growing period length in days (lgp), according to equation (1):

$$\boldsymbol{CWR} = \mathbf{10} \times \sum_{d=1}^{lgp} \boldsymbol{ETc} \quad (1)$$

From calculation, a value of 120.37 mm ha^{-1} was so obtained.

As regards I_{eff} and the N-fertiliser amount, the corresponding values were listed in Table 3.4.2 for each system investigated. In particular, it should be observed that those relating to N-fertiliser refer to the active principle and were calculated from the amounts of ammonium nitrate listed in Table 3.4.1, based upon the N-content (equal to 35%).

Table 3.4.2- I_{eff} and N-fertiliser mean values for WF calculation

Inventory data provided	Unit of measurement	Cropping system

		TS	HDS	sHDS
I_{eff}	$m^3ha^{-1}y^{-1}$	**0**	**2,000**	**1,660**
N-fertiliser	$kgha^{-1}y^{-1}$	**154**	**140**	**112**

Moreover, based upon CWR and P_{eff}, the IR was calculated as a constant value for the three systems according to equation (2) and resulted in 6,534.63 m^3y^{-1}.

$$\boldsymbol{CWR = 10 \times \sum_{d=1}^{lgp} ETc} \quad (2)$$

The aforementioned values were used for calculation of the three WF components (WF_{Green}, WF_{Blue} and WF_{Grey}) following the approach outlined in the Water Footprint Manual provided by the WFN (Hoekstra et al., 2011). Then, the total water footprint (WF_{Tot}), expressed as m^3 t^{-1} hay, was calculated using equation (3):

$$\boldsymbol{WFTot = WF\text{Green} + WF\text{Blue} + WF\text{Grey}} \quad (3)$$

In the following section, the variables used to calculate each WF component are listed based upon the formula used by Hoekstra et al. (2011).

Green Water

For WF_{green} accounting, the related evapotranspiration factor (ET_{green}) was calculated as the minimum between CWR and P_{eff}, so resulting to be equal to 550.22 mm. The latter was, then, used for calculation of the Crop Water Use (CWU_{green}) according to equation (4), so obtaining a value of 5,502.17 m^3ha^{-1}:

$$\boldsymbol{CWUgreen = 10 \times \sum_{d=1}^{lgp} ETgreen}$$

(4)

For greater understanding, it is underscored that the obtained values of ET_{green} and CWU_{green} are the same for the three systems analysed, because the latter are located in the same cultivation area under monitoring and investigation. This means that no variation was recorded in the measured values of P_{eff} and ET_c and, in turn, in the CWR value as calculated according to equation (1). Finally, CWU_{green} was divided by the olive production yield (Y) for calculation of WF_{green}.

Blue Water

As done for the WF_{green}, the blue WF component (WF_{blue}) was obtained dividing the CWU_{blue} by Y; hence, it was needed to calculate the value of CWU_{blue} from ET_{blue} using equation (5), as implemented below:

$$\boldsymbol{CWUgreen} = \mathbf{10} \times \sum_{d=1}^{lgp} \boldsymbol{ETgreen} (5)$$

where ET_{blue} was estimated from IR as the minimum between IR and I_{eff}.

For completeness reasons, Table 3.4.3 shows the values obtained for both ET_{blue} and CWU_{blue} which, as already clarified, are fundamental factors for calculation of WF_{blue}. For enhanced comprehension of the study, it should be noticed that, as evident from Table 3.4.3, both ET_{blue}= 0 and CWU_{blue}= 0 for the analysed TS: this is because TS is rain-fed and so I_{eff} = 0.

Table 3.4.3-Values of ET_{blue} and CWU_{blue} related to the irrigation phase

System	ET_{blue} (mm)	CWU_{blue} (m^3 ha^{-1})
TS	**0.00**	**0.00**
HDS	**2,000.00**	**20,000.00**
SHDS	**1,660,00**	**16,606.30**

Furthermore, for each system considered, calculation was extended to the share of CWU_{blue} associated with the volume of water involved in the production of the ammonium nitrate utilised for fertilisation of 1 ha of grove: for convenience, that share was labelled as $CWU_{blue(fert.prod)}$. For this purpose, due to the difficulty of collecting primary data relating to production of the fertiliser used, Ecoinvent v.2.2 (Ecoinvent, 2011) was accessed so as to extrapolate, from the module contained, the amount of water to produce 1 kg of ammonium nitrate: that is equal to 4.671 $m^3 kg_{amm.nitr}^{-1}$.

This value was multiplied by the amount of ammonium nitrate per ha of grove (Table 3.4.4): the obtained $CWU_{blue(fert.prod)}$ values were shown in Table 5 per single system under investigation.

Table 3.4.4- Values of CWU_{blue}, related to (blue) water consumption for ammonium nitrate production

System	$CWU_{blue(fert.prod)}$ ($m^3 ha^{-1}$)
TS	**2,055.24**
HDS	**1,868.40**
SHDS	**1,494.72**

So, $CWU_{blue(tot)}$ was calculated by summing up the two contributions above, namely CWU_{blue} and $CWU_{blue(fert.prod)}$: the obtained volumes (Table 3.4.5) were then used for WF_{blue} calculation, as clarified at the beginning of this section.

Table3.4.5-Values of $CWU_{blue(tot)}$ calculated as the sum of CWU_{blue} and $CWU_{blue(fert.prod)}$

System	$CWU_{blue(tot)}$ (m^3ha^{-1})
TS	**2,055.24**
HDS	**21,868.40**
SHDS	**18,101.02**

Grey Water

As stated by Lamastra et al. (2014) referring to Hoekstra et al. (2011), calculations for water pollution in WFAs are originated from the concept of a 'critical load' determining the assimilation capacity of a water body by multiplying the total water flow with the difference between the maximum and the natural concentration of a substance. In this regard, the grey WF was calculated following equation (6) as extrapolated from the WFA manual (Hoekstra et al., 2011):

$$\boldsymbol{WFGrey} = \frac{\boldsymbol{NA} \times \boldsymbol{\alpha}}{(\boldsymbol{Cmax} - \boldsymbol{Cnat}) \times \boldsymbol{Y}} \quad (6)$$

where:

- NA stands for N-fertiliser application ($kgha^{-1}y^{-1}$);
- α is the nitrate leaching run-off fraction (constant) that was assumed to be equal to 0.1 (Dichio et al., 2014);
- C_{max} is the environmental water quality standard which was intended as the legal limit end-point of 15 mg L^{-1} (for nitrogen) as established by Italian Law Decree n. 152/2006 (MATTM, 2006).
- C_{nat} is the natural concentration in receiving water body (kg m^{-3}), generally assumed to be 0;
- as already clarified, Y stands for the olive production yield, expressed as $tha^{-1}y^{-1}$.

3.4.4 Results and discussions

This section contains the discussion upon the results gathered for each WF component estimation by using both measurements and calculations presented and discussed in the previous sections. The obtained results were summarised and compared in Table 3.4.6, whilst the values of WF_{Tot}, calculated following equation (3) were depicted in Fig. 5.

Table 3.4.6- Comparison of the WF components (green, blue and grey) in the analysed systems

System	WF_{Green}	WF_{Blue} ($m^3\ t^{-1}$)	WF_{Grey}
TS	**2,200.87**	**822.10**	**0.411**
HDS	**917.03**	**2,186.84**	**0.093**
SHDS	**687.77**	**2,011.22**	**0.083**

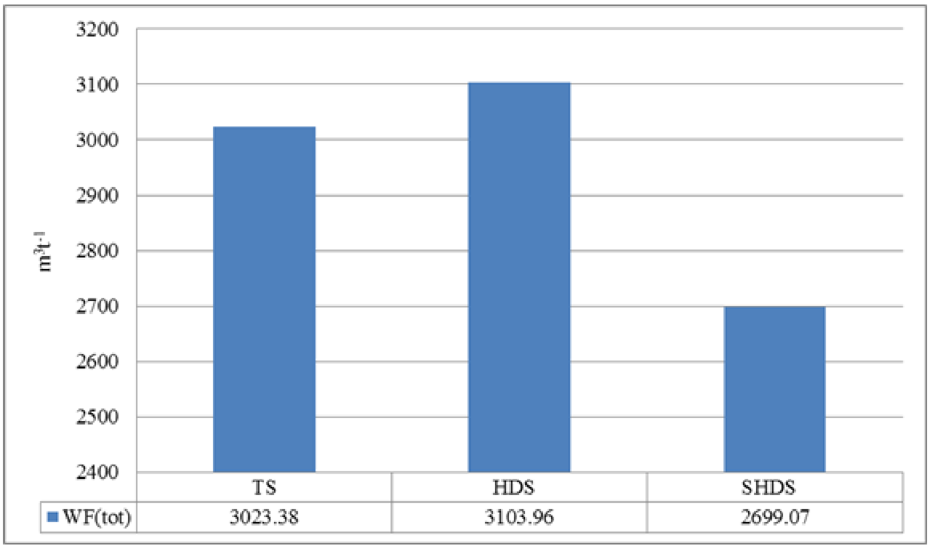

Fig. 3.4.1- WF_{Tot} amounts for the growing systems analysed. Values are expressed as m^3 per tonnes of olive produced

Based upon results from the comparative assessment, SHDS appears to be the less water demanding system with WF rates being almost 13% and 11% lower than those recorded for HDS and TS, respectively. This aspect can be explained by SHDS being characterised by the lowest irrigation volume (1,660 $m^3ha^{-1}y^{-1}$) and ammonium nitrate requirements (320 $kgha^{-1}$) and the high yield (9 tha^{-1}), that so contribute to the lowest value for each of the WF component.

In addition, HDS appears to be a little less sustainable in $WF_{(tot)}$ terms than TS: a 2.5% difference was indeed observed between them, mainly because:

- green and grey WF components are lower in HDS than in TS (Table 3.4.6);
- the contribution to WF_{blue} from ammonium nitrate production is higher in TS than in HDS (Table 3.4.4) due to the higher amounts administered (Table 3.4.2);

- the irrigation volume in TS is equal to zero (Table 3.4.3) due to TS being rain-fed.

The latter point makes the substantial difference since, as resulting for the other systems, the highest contribution to $WF_{(tot)}$ comes right from grove irrigation, thus significantly affecting the comparison results. Therefore, a sensitivity analysis was performed assuming irrigation also for the traditional system, so operating the comparison under the same background conditions and contributing to enhanced reliability and comparability of results.

Sensitivity analysis

In this analysis, the comparison was performed hypothesising that TS is irrigated and not rain-fed, so implying the accounting of the typical I_{eff} value (2,000 m^3ha^{-1}) for such systems (BURP,2015) and the subsequent increase in the production yield. The latter doubles compared to that recorded in the case of non-irrigated TS, thus levelling out at almost 5 t ha^{-1}, as provided by the farm referring to TS olive groves located in other regional areas under the same soil and climate conditions and agricultural practices compared to the area under investigation.

As shown by Fig. 3.4.2, doing so would cause an evident change in the results.

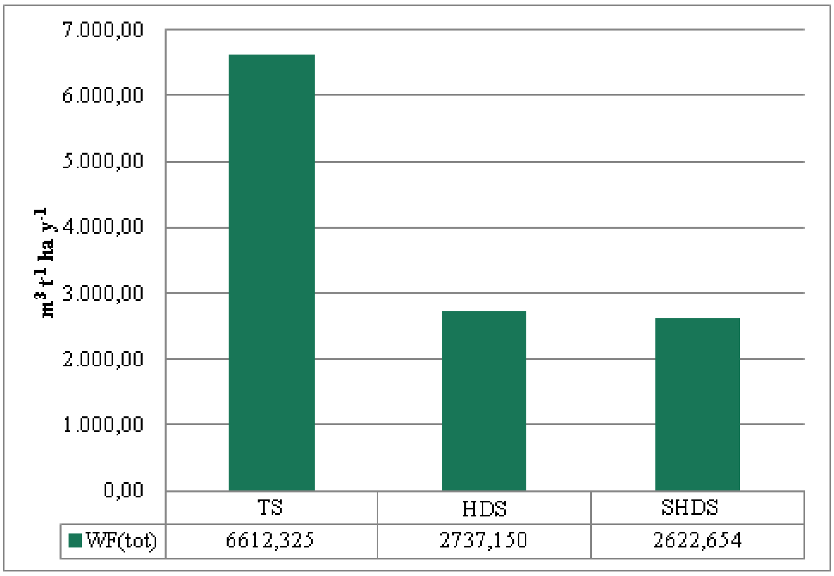

Fig. 3.4.2- WF_{Tot} amounts for the different growing systems: a comparison under TS irrigation conditions

In particular, WF_{Tot}(TS) would be increased to approximately 6600 m^3 t^{-1} ha^{-1} y^{-1}, thus resulting into being almost 2.5 times higher compared to the WF_{Tot} values recorded for the other two systems, namely the intensive and the high density. Therefore, in light of the largely higher yield and lower $WF_{Tot,}$ HDS and SHDS are recommended systems to be implemented for production of olives for transformation into oils and derivatives. In particular, the analyses documented that these two cropping systems are quite comparable in terms of WF_{Tot}.

3.4.5 Conclusions and recommendations

The study attained the proposed objective, namely that of providing valuable insights into the comparative WF performance of three different density olive producing systems. In this regard, the authors hope that the results will be a useful tool to support all the stakeholders involved (i.e. agronomists, farmers, company owners and policy makers) in decision-making for promotion of improved production of olives and derivatives produced by means of more eco-friendly agricultural and industrial processes.

The systems characterised by high density plantations resulted to be the more efficient in terms of WF_{Tot}. Based upon the research findings, the main WF_{Tot} component is blue water considering irrigation conditions for all the three systems analysed: lesser contributions were derived WF_{green} and WF_{grey}. Furthermore, in this case the WF associated with the water embedded in the fertiliser production is almost 9% for TS and 8% for both HDS and SHDS of WF_{blue}, thus remarking its significance in the WF accounting.

The excellent cooperation of the olive grove owners made it possible for the researchers to gather high-quality data, thereby making it possible to develop a scientific-value study that provided reliable and relevant insights. In this regard, the targeted stakeholders (environmental assessment practitioners, agronomists, farmers and company owners) may learn more about the input flows involved in the systems analysed and the related WF rates. In this way, the research-study contributes to enriching the international knowledge on the field, and underscores the potential value of comparative WF analyses in the olive production sector for enhanced water resource management. For better understanding and appreciation of the study, it is underscored that its conclusions relate to the system investigated, to the insights gained, as well as to the growing practices and to the input data used. The researchers are convinced that the insights gained from this research will contribute to the WF approach in this agricultural sector.

So, based upon the findings, it can be concluded that the SHDS is the most competitive approach due to reduced WF_{Tot} and to high agronomic and economic-efficiency rates. Hence, the authors believe that this system could be used as the starting base for implementation of agricultural practices aimed at WF reduction, improved environmental sustainability and management cost optimisation in the olive sector.Therefore, the SHDS are confirmed to be the most economic and environmental sustainable.

The study made it possible to highlight the importance of similar comparative studies at local scales for improved efficiency of different orchard systems in managing water sources. Such information could be combined with results obtained by economic analysis and therefore could be a valuable starting point for beginning to draft guidelines for the best orchard management, such as the choice of cultivar, on order to extend the shelf life of obtained oil, in accordance with environmental policies (Dichio et al., 2014).

Finally, the study will contribute to enriching the international knowledge about the applicability and usefulness of foot-printing tools in the agricultural sector for highlighting most environmentally favourable systems.

References

Bagheri, A., (2010) Potato farmers' perceptions of sustainable agriculture: the case of Ardabil province of Iran. Procedia Soc. Behav. Sci. 5, 1977-1981.

Baldo, G.L., Marino, M., Rossi, S, (2008) Analisi del ciclo di vita LCA, Ed.

Ambiente, Milano.

Bollettino Ufficiale della Regione Puglia (BURP) n. 54 del 16/04/2015, Disciplinare di produzione integrata. Disciplinare di produzione integrata Regione Puglia.

Boulay, A.-M., Hoekstra, A.Y., Vionnet, V., (2013) Complementarities of Water-Focused Life Cycle Assessment and Water Footprint Assessment. Environ. Sci. Technol. 47, 11926-11927.

Camposeo S., Palasciano M., Vivaldi G.A., Godini A., (2011) Effect of increasing climatic water deficit on some leaf and stomatal parameters of wild and cultivated almonds under Mediterranean conditions. Sci. Hortic. 127: 234-241. doi: 10.1016/j.scienta.2010.09.022

Camposeo, S., Ferrara, G., Palasciano, M., Godini, A., (2008)Varietal behaviour according to the superintensive oliveculture training system. Acta Hort. 791: 271-274.

Chouchane, H., Arjen Y. Hoekstra, A.Y., Krol, M.S., Mekonnen, M.M., (2015) The water footprint of Tunisia from an economic perspective. Ecol. Indic. 52, 311-319.

Correia, F.N., Iwra, M., Técnico, I.S., (2009) Water resources in the Mediterranean region. Int. Water Resour. Assoc. 24, 22-30.

Daccache, A., Ciurana1, J.S., Rodriguez Diaz, J.A., Knox, J.W., (2014) Water and energy footprint of irrigated agriculture in the Mediterranean region. Environ. Res. Lett. 9, 1-12.

Dichio, B., Palese, A.M., Montanaro, G., Xylogiannis, E., Sofo, A., (2014) A Preliminary Assessment of Water Footprint Components in a Mediterranean Olive Grove. Acta Hort. 1038, 671-676.

Ecoinvent (2011) The Swiss Centre for Life-cycle Inventories. Ecoinvent v2.2.

Famiani, F., Farinelli, D., Rollo, S., Camposeo, S., Di Vaio, C., Inglese, P., (2014) Evaluation of different mechanical fruit harvesting systems and oil quality in very large size olive trees. Spanish J. Agric. Res. 12(4): 960-972. doi: 10.5424/sjar/2014124-5794

FAO Aquastat Country fact sheet Italy (2012) Available from: http://www.fao.org/nr/water/aquastat/countries_regions/index.stm; Accessed: 02-13-2015.

Gil Ribes, J.A., Blanco, G.L. and Castro, S. (2012) El futuro del olivar tradicional y surecolección. Maq-Vida Rural. 345:30-38.

Godini, A., Vivaldi, G.A., Camposeo, S., (2011) Olive cultivars field-tested in super-high-density system in southern Italy. California Agriculture 65(1): 39-40. doi: 10.3733/ca.v065n01p39.

Hanjra, M., Qureshi, M.E., (2010) Global water crisis and future food security in an era of climate change. Food Policy 35, 365-77.

Herath, I., Green, S., Singh, R., Horne, D., van der Zijpp, S., Clothier, B., (2013) Water footprinting of agricultural products: a hydrological assessment for the water footprint of New Zealand's wines. J. Clean. Prod. 41, 232–243.

Hoekstra, A.Y. (Ed.), (2003) Virtual water trade: Proceedings of the International Expert Meeting on Virtual Water Trade, Value of Water Research Report Series No. 12, Delft, 12–13 December 2002, UNESCO-IHE, Delft, The Netherlands.

Hoekstra, A.Y., Chapagain, A.K., Aldaya, M.M., Mekonnen, M.M., (2011) The Water Footprint Assessment Manual: Setting the Global Standard Earthscan, London, UK.

Ingrao, C., Matarazzo, A., Tricase, C., Clasadonte, M.T., Huisingh, D., (2015) Life Cycle Assessment for highlighting environmental hotspots in Sicilian peach production systems. J. Clean. Prod. 92, 109-120.

Lamastra, L., Suciu, N.A., Novelli, E., Trevisan, M., (2014) A new approach to assessing the water footprint of wine: An Italian case study. Sci. Total Environ. 490, 748-756.

MATTM - Ministero dell'Ambiente e della Tutela del Territorio e del Mare, (2006) Decret Legislativo 3 Aprile 2006 n. 152 "Norma in materia ambientale". (ME – Ministry of the Environment, 2006. Law Decree April 3, 2006 n. 152 "Environmental Standard") (in Italian).

Notarnicola, B., Hayashi, K., Curran, M.A., Huisingh, D., (2012) Progress in working towards a more sustainable agri-food industry. J. Clean. Prod. 28, 1-8.

Rafael R. Sola-Guirado, Sergio Castro-García, Gregorio L. Blanco-Roldán, Francisco Jiménez-Jiménez, Francisco J. Castillo-Ruiz, Jesús A. Gil-Ribes,(2014)Traditional olive tree response to oil olive harvesting technologies, Biosystems Engineering, Volume 118, Pages 186-193.

Rost, R., Gerten, D., Bondeau, A., Lucht, W., Rohwer, J., Schaphoff, S., (2008) Agricultural green and blue water consumption and its influence on the global water system. Water Resour. Res. 44, 1-17.

Schyns, JF., Hoekstra, A.Y., (2014) The Added Value of Water Footprint Assessment for National Water Policy: A Case Study for Morocco. PLoS ONE 9, 1-14.

Soussana, J.F., (2014) Research priorities for sustainable agri-food systems and life cycle assessment. J. Clean. Prod. 73, 19-23.

Tous, J., Romero, A., Hermoso, J.F., Msallem, M. and Larbi, A. (2014) OLIVE ORCHARD DESIGN AND MECHANIZATION: PRESENT AND FUTURE. Acta Hort. (ISHS) 1057:231-246.

van der Werf, H.M.G., Garnett, T., Corson, M.S., Hayashi, K., Huisingh, D., Cederberg, C., (2014) Towards eco-efficient agriculture and food systems: theory, praxis and future challenges. J. Clean. Prod. 73, 1-9.

Vivaldi, G.A., Strippoli, G., Camposeo, S., (2013a)Ecophysiological response to irrigation of two olive cultivars grown in a high-density orchard. Agric. Sci. 4(8A): 16-20.

Vivaldi, G.A., Camposeo, S., Rubino, P., Lonigro, A., (2013b)Microbial impact of different types of municipal wastewaters used to irrigate nectarines in Southern Italy. Agric. Ecosys. Environ. 181: 50-57. doi: 10.1016/j.agee.2013.09.006

4. ENVIRONMENTAL IMPACT: THE CASE STUDY OF OLIVE PATE'

This product was selected considering the importance of olives, oil and derivate in Apulia region, as well as perishability of olive patè. Furthermore it was selected due to high healthy value properties, able to maintain a proper state of health and reduce the occurrence of certain diseases. The study was aimed to evaluated the environmental impact of the olive patè SLE through a Life Cycle Assessment Analysis (LCAA). The olive patè SLE was implemented by the Department of Soil, Plant and Food Sciences, University of Bari, using two different types of MAP and a garlic extract. A LCAA was implemented in the traditional product and in the innovated one, in order to assess the environmental impact of innovation. In the analysis were included also food waste amount and environmental impact at retail level, as well as the environmental burden linked to landfill disposal of food waste.

4.1. Introduction

Olive patè is a product obtained by the crush of table olives and the addition of EVOO. Table olives as well as EVOO are important components of the Mediterranean diet with potential beneficial effects on human health due to the antioxidant properties of phenolic compounds described in previous chapter. These products are traditionally cultivated in the Mediterranean countries (Spain, Italy, Greece and Turkey, mainly) and, more recently, in America, Australia and the Middle East (IOC, 2012).

In Mediterranean area, olive farming is an important element of the cultural heritage and has a crucial role in the economy with significant social and environmental impacts. Moreover, traditional production systems both contribute to landscape conservation and protect the environment against erosion and desertification. The areas of the world that are most suitable for olive-tree production are depicted in Fig.4.1: there is evidence that olive trees are planted in all regions of the globe mostly between 30 and 45° latitude in the two hemispheres (FAOSTAT, 2015).

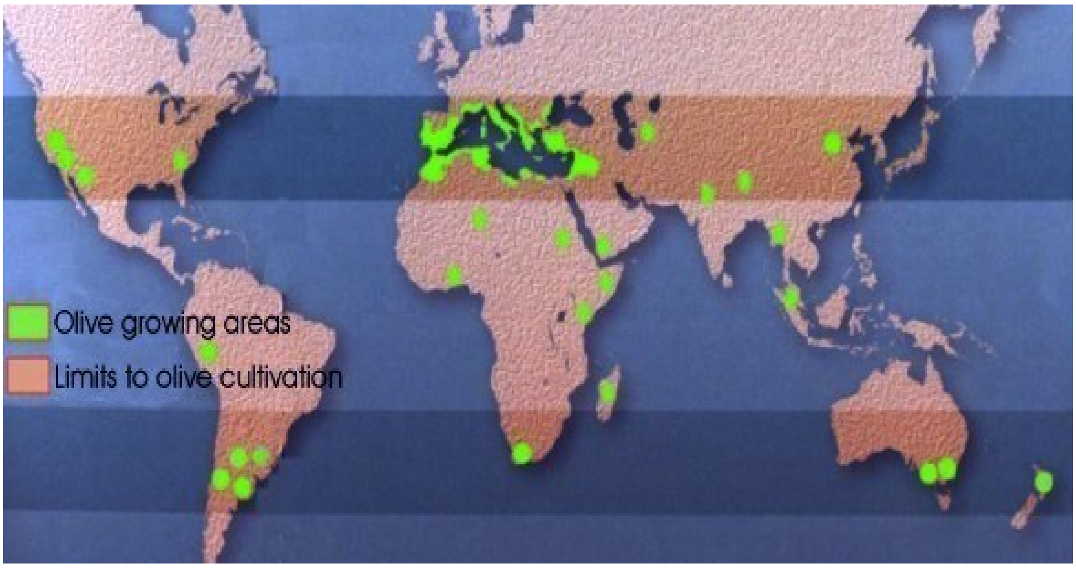

Fig.4.1- Geographical distribution of suitable areas for olive-tree production in the world
Source: International Olive Council[1]

According to the International Olive Council (IOC) estimates, over the last decades the olive-growing areas have been rapidly expanding, mainly due to the development of production systems using new mechanisation technologies for harvesting and pruning, based upon intensive growing systems. Moreover, there has been a significant increase of the olive consumption rates in those countries that are not acknowledged as “olive-oil consumers” and, as a result, an intensification of trade and a growing internationalisation of the markets. Although it accounts for less than 3% of the world edible oil market, olive oil is attracting growing interest from new countries (Barjol, 2014).

There is evidence that Europe (Fig. 4.2) is the largest producer with almost 11 Mt produced annually between 1993 and 2013. Other olive producers are from Asia (2.43 Mt/y) and Africa (2.39 Mt/y) (FAOSTAT, 2015); others are located in the “emergent” countries (Chile, Australia, Argentina, US etc.) that are increasingly gaining new important roles in global markets.

[1]The International Olive Council is the world’s only international intergovernmental organization in the field of olive oil and table olives. Members account for 98% of world olive production that are located primarily in the Mediterranean region.

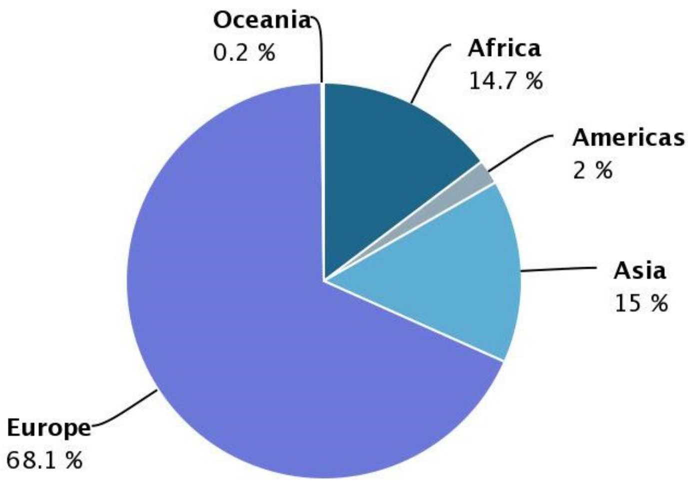

Fig.4.2- Annual production of olives at the global level (average 1993-2013)

In the European context, as documented by Fig. 4.1.1, the Mediterranean countries clearly dominate world olive production, consumption and trade, subsequently; the three leading producers are: Spain, Italy and Greece (Fig. 4.3). In particular, a production of an average of 3.22 Mt/y, during the period 1993-2013, was recorded in Italy, thus being the second largest producer worldwide after Spain, with an annual production of almost 5.21 Mt (average 1993-2013) (FAOSTAT, 2015).

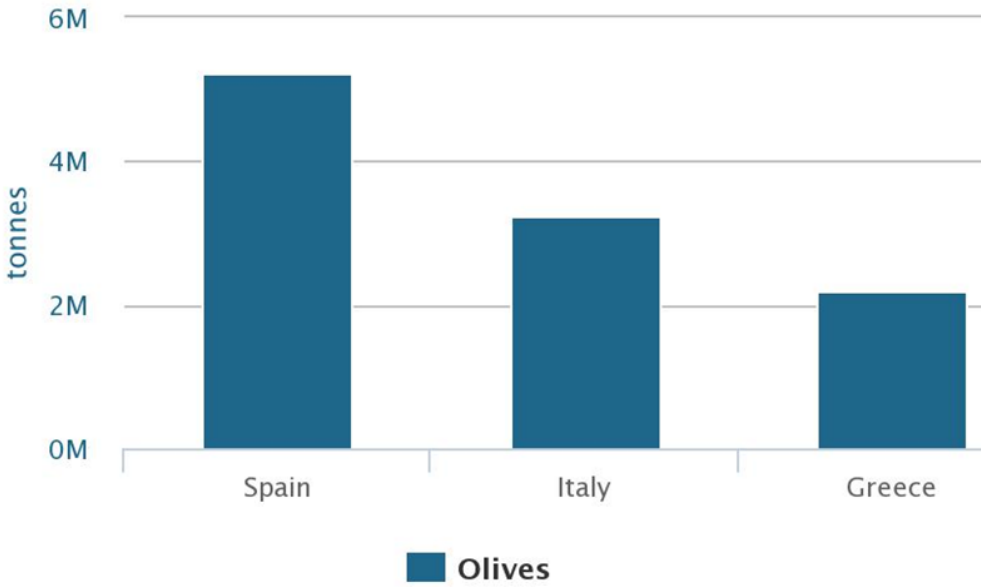

Fig.4.3- Spain, Italy and Greece are the global leaders in the production of olives. (ty^{-1}, average 1993–2013).

In the EU context, olive farming is very heterogeneous since there are several differences not only in terms of olive farming area, ranging from the very small (<0.5 ha) to the very large (>500 ha), but also of organisation of the farm (traditional, intensive, and high density plantations).

Particularly, the Italian olive sector, and particularly Apulia's olive sector, is characterised by an extreme fragmentation of companies and by the prevalence of traditional plantings (mostly hand harvested). This fragmentation was caused by different cultivation techniques, the varietal heritage (about 500 varieties of native olives), secular adaptation of cultivation techniques to the environmental and climatic conditions, and the economic and social structure. In the Table 4.1 a comparative strengths and weaknesses in the Apulia olive supply chain were proposed:

Tab.4.1- Strengths and weaknesses in the Apulia olive supply chain

Strengths	Weaknesses
Presence of large areas dedicated to the production of high quality olive oils;	Small size of farms;
High potential for offer differentiation, thanks to the presence of different olive cropping systems;	Secular olive groves and little chance of irrigation;
Considerable historical, social and landscape of the cultivar that can make a strong contribution to the development of rural tourism;	Variability of production, especially in the basin south central region;
Availability of product and process innovations;	Little meaningful role of cooperatives and consortia in marketing activities.
Vast supply basin.	

The small size, fragmentation, variability of production caused low productivity rates(Contò, 2008) that is not able to provide good level of profitability. In some regions, the olive growing is a key element of the landscape, of society and of the rural economy. For this reason, in certain contexts, the olive production and specifically high quality olive oil production and product differentiation are a key elements to increase farm's profitability. The choice of high quality olive oil production and product differentiation could become opportunities for business developmentand also an element of the entire local context promotion., despite the higher manufacturing costs, and costs generated by the application of the highest standards.

4.2 Material and Methods

4.2.1. Product shelf life extension

The shelf life extension was implemented by the Department of Soil, Plant and Food Sciences, University of Bari, involved in a National project: PRIN "Long Life High

Sustainability". The extension was obtained thought the use of three different innovations:

1. Use of MAP 1 with 25% of CO_2 and 75% of Ar (Argon)
2. Use of MAP 2 with 30% of CO_2 and 70% of N (Nitrogen)
3. Garlic extract: 110134 (Proallium DMC), provided by DOMCA® with a dosage equal to 0.2 g per kg of final product.

All the samples were packaging through thermosealing/vacuum gas machine,mod. VGGPP 2255nn, provided by ORVED ®.
With all three innovations, was obtained an extension of 14 days, from 14 to 28 days. The shelf life was tested at 4 °C.

4.2.2 Life Cycle Assessment Analysis

The analysis is based upon Life Cycle Thinking approach (LCTA) "from cradle to grave" that seeks the energy and environment production process impact improvement(Toepfer, 2000). Life Cycle Assessment (LCA) has ben defined by Society of Environmental Toxicology and Chemistry (SETAC) as an objective process of evaluation of energy and environmental loads related to a process or activity (Vermount congress in Canada, 1993). The analysis includes the extraction and processing of raw materials, manufacture, transport, distribution, product use, reuse and recycling and finally product final disposal. In the present case, LCA was performed for evaluating the environmental burdens associated with new innovations aimed to extend the product shelf life, according to ISO 14040:2006 and 14044:2006. As established by these International Standards, the following phases were included within the study: 1) Goal and scope definition; 2) Life Cycle Inventory (LCI) analysis; 3) Life Cycle Impact Assessment (LCIA); and, finally, Life Cycle Interpretation.

Goal and scope definition

The study was aimed to assess the environmental impact of a product SLE. In order to reach this goal a LCA for both product with a normal shelf life (NSLP) and olive patè with a SLE (SLEP) was carried out. Furthermore, in order to evaluate what are the impacts of the extension at retail level, the retail burdens, linked to refrigeration cabinet, were also includes. Finally it was hypothesized a landfill disposal scenario, thus end of life environmental burdens were assessed.

Functional unit and system boundaries

As functional unit was considered an olive patè box (PET), with a weight equal to 70 g.The two analyzed products, NSLP and SLEP have the same formulation (olives, oil and zucchini) and packaging. The innovations consist in the application of two different MAPs and a garlic extract. Considering that crop cultivation, transformation and transport phases are equal in both two products, they were excluded from the assessment (Fig. 4.4). Therefore, the analysis takes into account the following phases: packaging, retail distribution and end of life (Fig 4.4).

Data concerning theProallium DMC production were not provided from DOMCA®. For this reason it was not possible to include the environmental analysis of this innovation. Therefore the comparison was implemented only on MAP0 (product with a standard atmosphere), MAP1 (product with Ar and CO_2atmosphere) and MAP2 (product with N and CO_2 atmosphere).

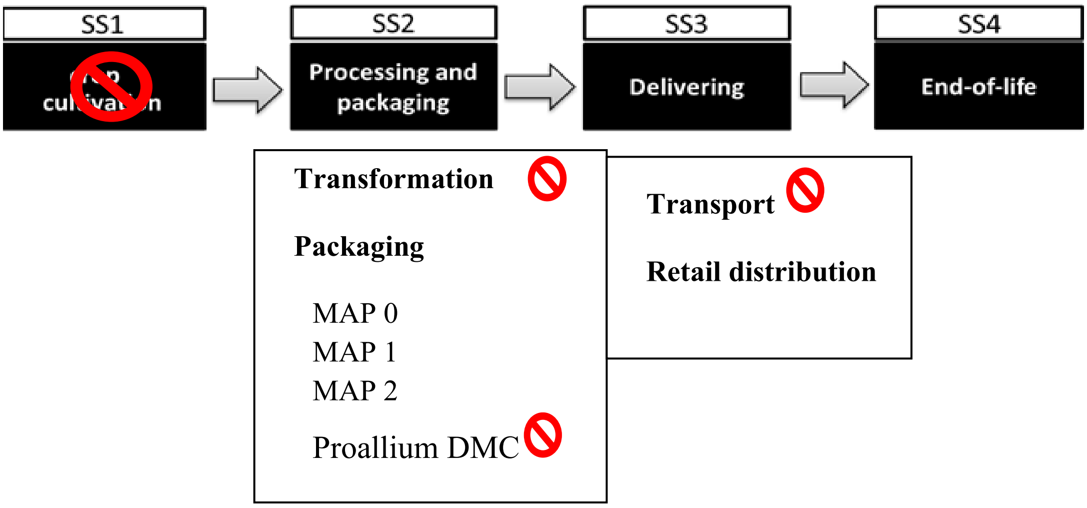

Fig. 4.4- Phases included ad excluded within the system under study.

Life cycle Inventory

The impact of different MAPs was assessed considering the consumptions of thermosealing/ vacuum gas machine, mod. VGGPP 2255nn, provided by ORVED ®. This machines insufflates gas and seals packaging at the same time. In the Table 4.2 energy burdens in different MAPs were reported. The value of machinery energy consumption was not influenced by the type of MAP (Table 4.2).

Table 4.2- Energy consumption machinery in different MAPs

	Concentration (%)	Amount (kg)	Energy consumption (kWh)
MAP 0			3.135
N_2	78	54.6	
O_2	21	14.7	
Ar	1	0.7	
MAP 1			3.135
Ar	75	52.5	
CO_2	25	17.5	
MAP 2			3.135
N_2		49	
CO_2		21	

The retail energy burdens for a NSLP and SLEP were assessed using the following formula proposed by Eriksson et al., 2016:

$$E_{KS} = \left(\frac{E_{Kspec} + E_{Kspec\,add}}{V_K} \times \frac{100}{N} \times V_P \times t\right) + (m_P \times c_V \times (T_A - T_k)$$

Electrical energy demand (E_{KS}) for a NSLP is equal to 0.076 kg CO_2eq kWh and for SLEP is equal to 0.152 kg CO_2eq kWh (Table 4.3)

Table 4.3-Electrical Energy demand for storage for NSLP and SLEA

T= 4°C			**NSLP = 14**	**SLEP= 28**
Parameter	Description	Units	Value	
EKspec	specific electric demand of vertical cabinet	MJd-1m-1	35.3	35.3
EKspec add	extra energy consumed above the specific electric demand	MJd-1m-1	38.124	38.124
VK	Capacity	dm3m-1	400	400
n	rate of utilization of capacity	%	90	90
VP	volume of product storage	dm^3	1	1
tS	duration of storage in supermarket	days	2.33	4.67
mP	mass of the product for storage	kg	1	1

cV	Specific heat capacity	kJ kg-1 K-1	2.65	2.65
TA	Average T of the product at the beginning of the storage	K	277	277
TK	Average T during storage	K	277	277
EKS	Electrical Energy demand for storage	MJ kg-1	0.952	1.903
g CO_2eq kWh (Axfood et al., 2014)			76.048	152.096
kg CO_2eq kWh			0.076	0.152

Source: our processing data

The reduction in relative waste (RW) resulting from increased shelf life was calculated using the following equation, proposed by Eriksson et al., (2016):

$$Log(RW) = 0.351 - 0.909 \times Log(T) - 0.888 \times Log(SL) + 0.156 \times Log(MOS)$$

This equation connected food waste reduction and extended shelf-life taking into account the relative waste (RW), turnover (T), shelf life (SL) and minimum order size (MOS). It was hypothesized a T equal to 2 products per day for NSLP and a T equal to 4 products per day for SLEP. The MOS value were equal for both NSLP and SLEP. The percentage of relative waste is equal to 18.3 in NSLP and 5.27 in SLEP, with a value of waste equal to 0.256 kg and 0.074 kg respectively (Table 4.4)

Table 4.4- Relative waste for for NSLP and SLEA

T (product ·day)	SL (days)	MOS (days)	RW (%)	Waste (kg)	Patè (kg)	Packaging (kg)
2	14	20	18.3	0.256	0.238	0.018
4	28	20	5.27	0.074	0.069	0.005

Source: our processing data

4.3 Results and Discussion

4.3.1 Life cycle impact assessment

Results show that impacts weight increase with the extension of shelf life. In NSLP with MAP0 the impact weight is equal to 62 µpt (Fig 4.5). Considering a SLEP, there are at least no differences between the two different MAPs: in MAP1 and MAP2 the impact weights are equal to 106 µpt and 110 µpt respectively. The authors tried to assess the environmental breakeven point, in order to provide information concerning the trade-off between the optimal SLE and environmental impact. As shown in Fig 4.6 the optimal SLE, with a minimum impact on the environment, is 1 day, therefore the product's SL becomes 15 days with an impact weight equal to 60 µpt.

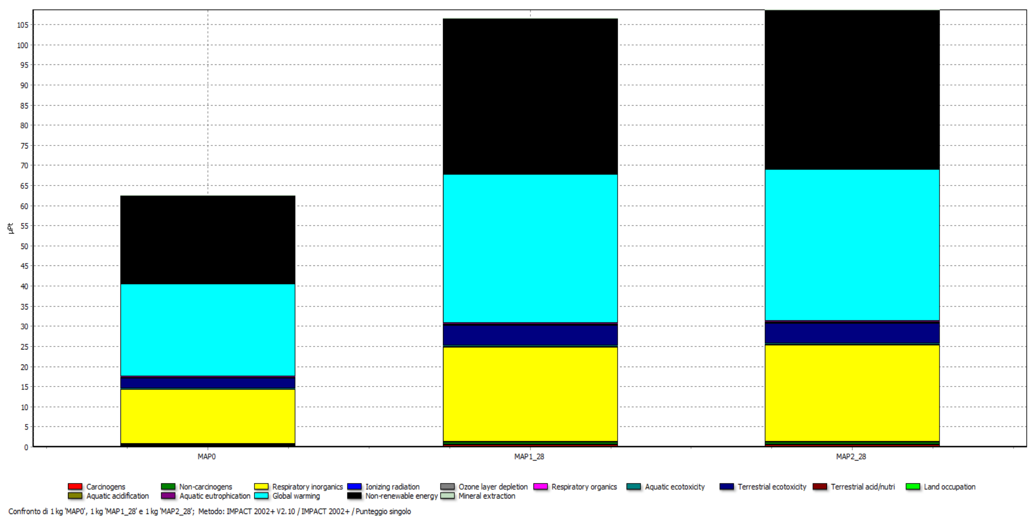

Fig 4.5- Comparison among different MAP and related impacts
Source: Personal elaboration of LCIA results from Impact 2002+

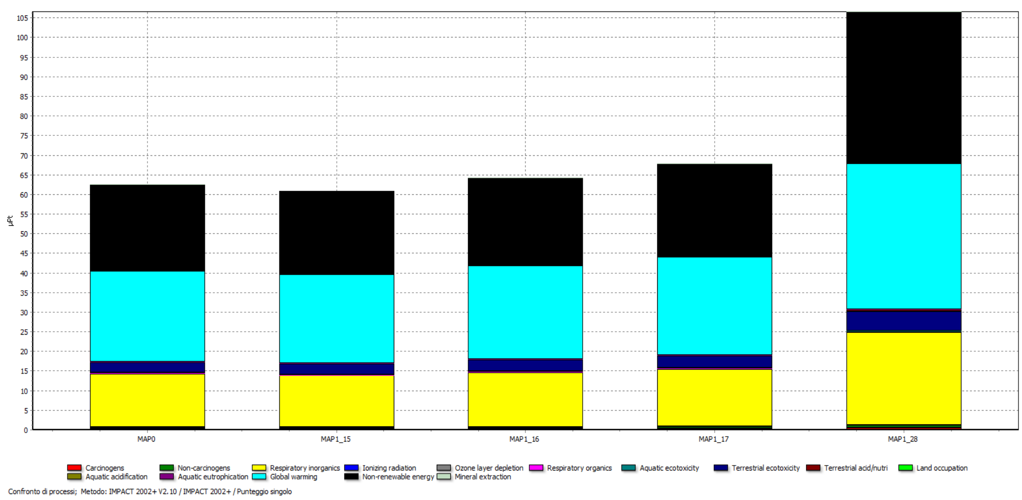

Fig. 4.6-Optimal SLE with low level of environmental impacts.
Source: Personal elaboration of LCIA results from Impact 2002+

4.3.2 Life cycle impact interpretation

The SLE seems to have a negative effect on the environment despite a food waste reduction. This was due to the huge weight of electrical energy demand in the analysis. The energy saving related to food waste reduction not levelsoff cabinet energy consumption at retail distribution level.

4.4 Conclusions

The refrigeration cabinet has a huge impact on the environment in LCA of olive patè. For this reason the a SLE determines more impact on the environment, despite a food waste reduction. However, as end of life scenario, a landfill disposal was considered. Therefore, other scenarios, based on food waste re-use and re-cycle could be hypothesized, in order to reduce environmental burdens of this phase. Through the environmental breakeven point analysis, the a SLE of one day seems to be the only convenient solutions in terms of environmental impact. This solution could not be interesting for firms' profitability due to the higher manufacturing and SLE costs. The next step of the innovation implementation will be the use of antioxidant compounds extracted from leaves. In this context, further research is needed, in order to evaluate the new innovations, and compare the results with the previous ones.

References

Barjol J.L.,(2014) L'économie mondiale de l'huile d'olive, Oilseeds & fats Crops and Lipids, 21(5) D502 DOI: 10.1051/ocl/2014010.

Contò F. (2008) Olivicoltura e ambiente. Un nuovo equilibrio tra: marginalità, condizionalità, multifunzionalità e sviluppo del territorio. Franco Angeli. Milano. ISBN 9788846467416.

Eriksson, M., Strid, I., Hansson, P.-A. (2016) Food waste reduction in supermarkets - Net costs and benefits of reduced storage temperature Resources, Conservation and Recycling, 107, pp. 73-81.

FAOSTAT, 2015. Food and Agricultural Organisation of the United Nations – Statistics Division (FAOSTAT). Available at: http://faostat3.fao.org/browse/Q/QC/E (2015) [accessed May 24-27, 2015].

International Olive Oil Council, 2014. Statistics data, November 2014

International Organization for Standardization (ISO), 2014. ISO 14046: Water footprint – Principles, requirements and guidelines.

Toepfer K., (2000) Evaluation of Environmental Impacts in Life Cycle Assessment. UNEP "United Nations Environment Programme Division of Technology, Industry and Economics Production and Consumption Branch.

5. SLE IMPACTS ON LOGISTICS: THE CASE STUDY OF FRESH CUT SALAD

The main objective of this study is to evaluate the impact of fresh cut salad SLE on logistics investigating which decisions may be altered/re-optimized because of longer shelf-life considering as the objective the minimization of CO_2. In this regard firstly an analysis of the most critical phases within fresh cut supply chain was carried out. Than a re-optimization solutions for each phase of fresh cut salad supply chain were proposed. After the identification the re-optmization solution the fresh cut salad supply chain was simulated by meas of simulation model. This model is aimed to assess retail benefits of food waste reduction considering a shelf life extension and environmental burdens saving. In particular, the model takes into account the fill rate cost and potential CO_2 savings on increasing cooling temperature in the supermarkets considering an increased product shelf life. The SL is tested at a fixed temperature. The simulation conducted by means of simulation package Enterprise dynamics ™, takes into account the environmental burdens of each analysed phase (transports, transformation and retailer phases) and consider four different storage temperature (T=4,6,8,10) at retailer level. The choice of the first product is mainly linked to the growing market of fresh cut products and to perishability of this product.

5.1 Introduction

The food sector has to deal with some complexities of the supply chain management such as products perishability (Van der Vorst *et al.*, 2005). The efficient management of food waste along the supply chains is receiving a lot of attention by institutions (Boxstael *et al.*, 2014). In recent year food wastage is a problem of increasing severity: reducing food losses and waste is considered to be one of the most promising policy measures to improve food security in the coming decades (Fiore *et al.*, 2015). Wasting food in the supply chain affect consumers economically and have an unnecessary environmental impact produced in vain (Eriksson *et al.*, 2012). According to FAO (2013) the global carbon footprint (CF) of annual food wastage is about 3.3. Gt CO_2 equivalent(CO_2). In Europe, the consumption of food accounts for about 20-30% of GHG emissions from consumption of all products, and globally, agriculture is the primary cause of increasing atmospheric concentrations of CH_4 and N_2O and produces

10-12% of total anthropogenic GHG emissions (Tukker et al.,2006). The amount of annual food waste in Europe is estimated to increase from over 100 million tons in 2014 to about 126 million tons by 2020 (European Commission, 2016). Perishable products are among the most wasted food items within supply chains and households. Fruits and vegetables usually account for the highest proportion of food waste in many developed countries (Stefan *et al*., 2012).

The development of shelf life solutions is considered one of the key challenge in food industry to reduce the amount of food waste, besides to improve their quality and nutritional benefits (Amani and Gadde, 2015). However, an increased product shelf life determines the impact on logistics assessment.

In order to assess environmental impacts on logistics the analysis of the the most critical Italian fresh-cut salad phases (in terms of energy and environmental loads) is needed.

The Carbon Footprint of the whole fresh cut salad supply chain is principally attributed to Packaging's, Distribution's and Retailer's burden (Fusi at al., 2015; Pagani et al., 2015; Davis et al., 2011; Strid et al 2014;). According to Pagani et al., (2015), at retail level, the environmental impact is principally caused by direct consumption of cabinet refrigeration (92% of total consumption). The 8% of total consumption is due to indirect consumption (supermarket refrigeration, lighting). In the transport phase, long distances contribute to increase the environmental impact, considering that the truck's second way is empty (Pagani et al., 2015).

Strid et al., (2014), in a study conducted on Swedish fresh cut salad supply chain, analysed the amount of food losses for each supply chain phase, and the CF related to these food losses. The results show that retail's losses CF is relatively large, despite there are more losses in production phase (Table 5.1). Therefore, the smallest amount wasted at retail stage still can be more important on climate change than the larger amount wasted at production level.

Table 5.1- Loss percentage ad relative CF in Swedish fresh cut salad

	Loss percentage	**CF of lettuce at different stage [kg $CO_{2\text{-}e}$ per kg product**	**Lost amount of lettuce at national level [ton per year]**	**CF of losses at national level [ton $CO_{2\text{-}e}$ per year**
Primary production	15%	0.18	5900	1060
Whole sale	3%	0.33	100	330
Retail	11%	0.43	3500	1500
Total CF of losses				2900

Therefore, the Fig. 5.1 shows a theoretical framework with the set of possible solutions for each phase considering as the main objectivies: the fresh cut salad environmental burdens reduction and food waste amount reduction. The supply chain re-optimization interventions could occur at transport level (Controlling the existing networks, designing new networks, sourcing, replenishing the cycle policy) and at retail phase (reducing the energy input of refrigeration in the supermarkets).

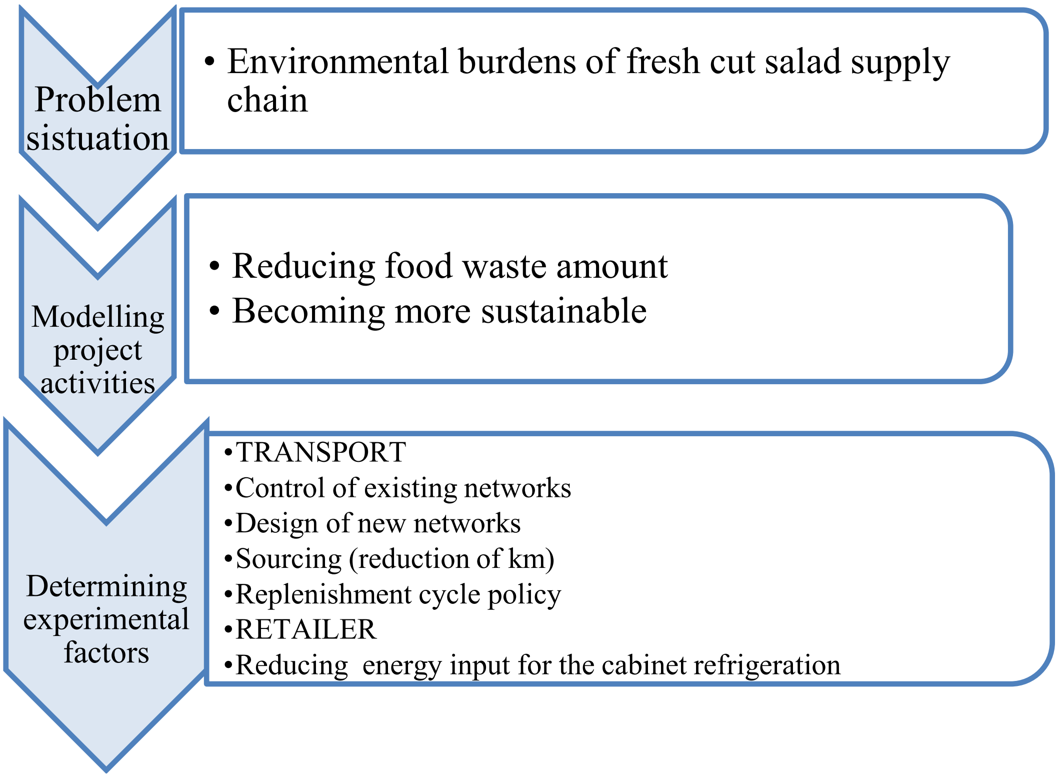

Fig. 5.1- Theoretical framework

Considering the possibility to reduce the energy inputs at retail level, Eriksson et al. (2016), evaluates the potential costs and potential food waste reduction reducing the supermarket's storage temperature (Fig 5.2). Results reveal that the costs in terms of GHG emissions depend on product items. For instance, taking into account dairy products and moving from 8 to 2 °C, the costs increase by 20 times. Therefore a reduction in storage temperature, would efficiently reduce food waste, but it could lead to a large costs (monetary and GHG emissions costs) (Eriksson et al.,2016).

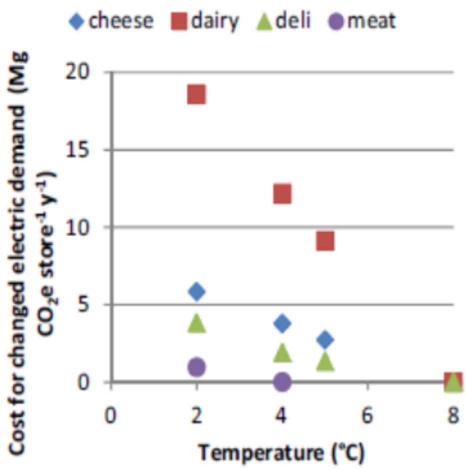

Fig.5.2- Cost in terms of GHG emissions ($MgCO_{2e}$) of the increased energy demand at different storage temperature

In ligh of these assumptions, the study is aimed to measure the retail benefits (in terms of trade-off between fill rate cost and potential CO_2 savings) adopting an higher storage temperature and considering a product SLE. Therefore, the authors assess the environmental costs (CO_2 emissions produced by a bag of fresh cut salad and CO_2 emissions produced by relative food waste), considering four different supermarket's cooling temperature.

5.2 Material and methods

The fresh cut salad supply chain was simulated by means of simulation model in a package Enterprise dynamics™. This model is aimed to assess the fill rate cost and potential CO_2 savings on increasing cooling temperature in the supermarkets considering an increased product shelf life. Therefore, it takes into account the environmental burdens of each analysed phase (transports, transformation and retailer phases) and CO_2 related to four different refrigeration temperatures (T=4,6,8,10) at retail level (as show in Fig. 5.3).

The model input are summerized as follow:

- Temperature (T);
- Shelf life (SL);
- Replenishment level (S)

The key performance indicators are:

- Average stock time (hr);
- Average time on shelf (hr);
- Sold salad (boxes);
- Discarded salad (boxes);
- CO_2 emissions for each phase (kg CO_2eq/box);
- Shortage;

the model output are:

- percentage of relative loss (at retail level);
- total CO_2 emissions (kg CO_2eq/box);
- fill rate.

Total CO_2 emissions value includes emissions for each phase as well as emissions linked to food losses. For the calculation of food losses impact was considered a landfill disposal as end of life scenario. The functional unit was a fresh cut salad box with a weight equal to 125g. All environmental burdens data were referred to a kg of final product (kg_P) and converted into boxes during the modelling phase.

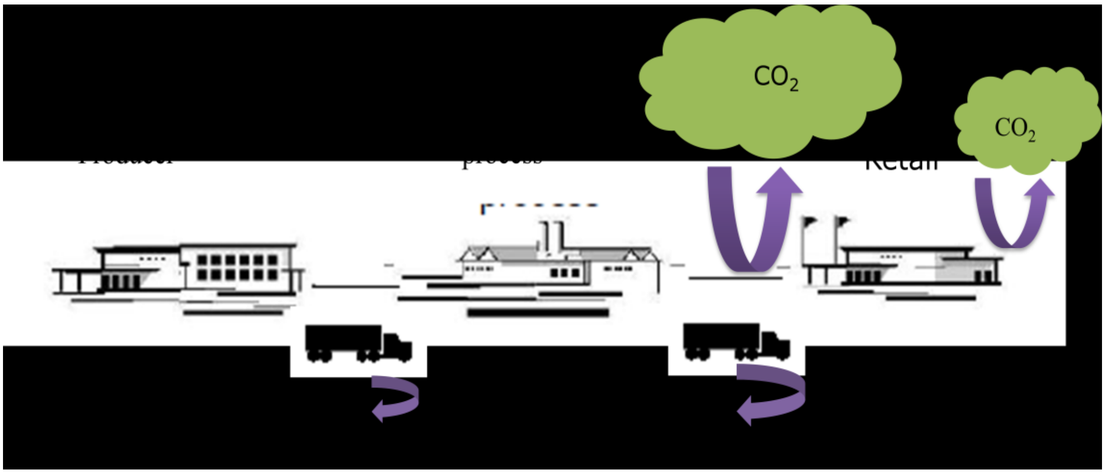

Fig5.3-Physical processeswithinthe fresh cut salad supplychain. The arrows' thickness is related to emissions that in turn depend on distances

According to Tromp et al., (2011) modelling vision, there are three main levels:

1) Physical level that includes physical condition such as temperature, MAP, SL;

2) Logistic level that includes lead times. Lead times are inputs for physical level;

3) Commercial and relational level that includes relations between chain actors in a chain level (inputs for logistic level).

5.2.1 Modelling logistics

The modelled planning and scheduling mechanisms and the values of the logistics model parameters are based on an Italian fresh cut salad supply chain. One average supply chain was modelled considering sale average data Italian supermarkets. It was assumed that consumer's demand exists between 8 h and 20 h (opening time of the supermarket). During these 12 hours, every hour each consumer intends to buy a consumer unit of a fresh cut salad (125 g box). Therefore, the average daily demand is equal to 12 products (Table 5.2). Daily demand is poisson distributed (Table 5.2).

The model considers both First In First Out (FIFO) and Last In First Out (LIFO) shelf management policy. Two order up to level (S) values were considered (S=29; S=87).

Table 5.2- Logistics parameters

Name	Unit	Assumption/distribution
Inter- arrival time product	hr	24 (fixed)
Warehouse capacity	products	2000
Inter arrival time order	hr	24 (fixed)
Demand at day	boxes	Poisson (μ_d)
Average daily demand on Monday-Saturday	boxes	12
Transport time from producer to TC	min	Normal(μ=100; σ=10)
Transport time from TC to retailer	min	Normal(μ=210; σ=25)
Transformation time	min	Normal(μ=100; σ=10)
Selling time	min	NegExp(μ=60)

5.2.2 Collecting Data-transport burdens

Trasport burdes were evaluated through energy content of diesel for the two ways. The journey from producer (P) to transformation center (TC) and from transformation center (TC) to retailer (R) were included (Table 5.3). In the first way, for each journey, was considered energy consumption linked to cooling system as well.The refriferation load of truck was assessed for each temperature (T=4,6,8,10).

For the refrigeration load of trucks was assessed considering the following formula, proposed by Pagani, et al., (2015):

$$e_{RT} = (E_M + E_R) \cdot \frac{d}{m}$$

$$E_R = \frac{Q}{V} E_M = 38{,}86(MJl^{-1}) \cdot c(lkm^{-1})$$

where:

E_M	Specific Energy consumed per unit of distance ($MJ \cdot km^{-1}$)
E_R	Additional specific Energy requie for refrigeration
Q	Total amount of heat transfer (W)
c	Veicle fuel consumption ($l \cdot km^{-1}$)
d	Travel distance (km)
m	Truck load (K_P)
V	Average speed of veicle ($km\ h^{-1}$)
e_{RT}	Specific energy input for the refrigerated transport ($MJ \cdot k_P^{-1}$)

No difference among different temperatures were found.

The highest emissions value occur in the first way from TC to R (0.0412 kg CO_2 eq).

Table 5.3- Transport burdens considering cooling system

Transport from P to TC	**M J kg_{P-1} Pagani et al., 2015**	**Conversion factor from MJ to kWh^{-1} Evans(2014)**	**Average energy factor (g $CO_{2\ eq}$ /kWh) Axfood et al., 2014**	**kg $CO_{2\ eq}$ /kWh**	**Tot**
energy content of diesel fuel: 1st way (cooling system)	0.120	0.033	2.656	0.0027	
energy content of diesel fuel: 2nd way	0.084	0.023	1.859	0.0019	
					0.0045

Transport from TC to R					
energy content of diesel fuel: 1st way (cooling system)	1.860	0.515	41.166	0.0412	
energy content of diesel fuel: 2nd way	1.300	0.361	28.852	0.0289	
					0.070

5.2.3 Collecting Data-tranformation burdens

The transformation burdens were calculated basing on data found in literature (Pagani et al., 2015) expressed in MJ kg_P^{-1}.Through a conversion factor, proposed by Evans et al., (2014) and Axfood et al., (2014), the kg CO_2 eq /kWh were assessed. Packaging phase (Table 5.4) has the highest environmental impact, as expected from literature (Fusi at al., 2015; Pagani et al., 2015; Davis et al., 2011; Strid et al 2014)

Table 5.4- Transformation burdens

	MJ kg_{P-1} (Pagani et al., 2015)	**Conversion factor from MJ to kWh^{-1} Evans(2014)**	**Average energy factor (g $CO_{2\ e\ /kWh}$) Axfood, et al 2014**	**kg $CO_{2\ e}$ /kWh**	**Tot**
Packaging	11		3.0547	244.0705	0.2441
Product transformation	2.5		0.6943	55.47058	0.0555
Tot					0.3000

5.2.4 Collecting Data-retailer burdens

The energy consumption for cabinet refrigeration, for each storage temperature and shelf-life, were assessed using the following formula proposed by Eriksson et al., 2016:

$$E_{KS} = \left(\frac{E_{Kspec} + E_{Kspec\,add}}{V_K} \times \frac{100}{N} \times V_P \times t\right) + (m_P \times c_V \times (T_A - T_k)$$

In Table 5.5 all the parameter were explained

Table 5.5- of retail burdens parameters

Parameter	Description	Units
$\mathbf{E_{Kspec}}$	specific electric demand of vertical cabinet	$MJd^{-1}m^{-1}$
$\mathbf{E_{Kspec\,add}}$	extra energy consumed above the specific electric demand	$MJd^{-1}m^{-1}$
$\mathbf{V_K}$	capacity	dm^3m^{-1}
n	rate of utilization of capacity	%
$\mathbf{V_P}$	volume of product storage	dm^3
$\mathbf{t_S}$	duration of storage in supermarket	d
$\mathbf{m_P}$	mass of the product for storage	kg
$\mathbf{c_V}$	specific heat capacity	$kJ\ kg^{-1}\ K^{-1}$
$\mathbf{T_A}$	average T of the product at the beginning of the storage	K
$\mathbf{T_K}$	average T during storage	K
$\mathbf{E_{KS}}$	electrical energy demand for storage	$MJ\ kg^{-1}$

Table 5.6- Energy consumption for cabinet refrigeration

	E_{KS}	g $CO_{2e\ kWh-1}$ (Axfood et al., 2014)	kg $CO_{2e\ kWh-1}$
T= 4°C, SL = 7 days	3.242	259.003	0.076
T= 4°C, SL = 12 days	3.984	318.338	0.135
T= 6°C, SL = 7days	0.110	8.775	0.009
T= 6°C, SL = 11days	1.266	101.119	0.101
T= 8°C, SL = 3 days	0.094	7.521	0.008
T= 8°C, SL = 5 days	0.497	39.696	0.040
T= 10°C, SL = 2 days	0.078	6.268	0.006
T= 10°C, SL = 5 days	0.458	36.562	0.037

As shown in Table 5.6, the higest value of energy consumption, obviously occurs with 4 °C and a SL equal to 12 days.

5.3 Results and Discussion

The results show that a FIFO policy determine an higher amount of food waste than LIFO policy considering both two order up to level (S=29, S=87). Taking into account S=29, in FIFO policy (Table 5.8), the percentage of food waste was equal to 0 until 6 °C, then it increases, reaching the maximum value (9.74%) with a T=10°C and SL=2 (Table 5.7). The higest values of service level occur with T=4°C and SL=12 (0.91) and with T=10°C and SL=5 (0.89). The smallest service level values were reached with T=10°C and SL=2 (0.84), and T=8°C and SL=5 (0.85). The smallest CO_2 emissions values occur with T=6°C and SL=7 (0.32), and T=8°C and SL=5 (0.35). The highest CO_2 emissions value was obtained with T=10°C and SL=2 (5.12kg COeq/box).

With the same S, in a LIFO policy (Table 5.7), the waste percentage increases, ranging from 1.44 to 4.45. The higest values of service level (0.89) occur with T=4°C and SL=7 and with T=6°C and SL=11 (0.87). The smallest service level values were reached with T=8°C and SL=3 (0.64), and 10°C and SL=2 (0.68). The smallest CO_2 emissions values occur with T=4°C and SL=12 (0.58), and T=6°C and SL=11 (0.87). The highest CO_2 emissions values were obtained with T=10°C and SL=2 (8.05kg COeq/box) and with T=8°C and SL=3 (5.59COeq/box)

Considering S= 87 and LIFO policy (Table 5.9), the waste percentage value ranges from 28.11 to 42.33. The higest values of service level (0.93) occur with T=8°C and SL=5 and with T=4°C and SL=12 (0.93). The smallest service level values were reached with T=6°C and SL=7 (0.67), and T=10°C and SL=5 (0.71). The smallest CO_2 emissions occur with T=4°C and SL=12 (9.97), and T=8°C and SL=5 (10.54). The highest CO_2 emissions values were obtained with T=8°C and SL=3 (27.15 COeq/box) and with T=10°C and SL=2 (21.51 COeq/box) (Table 5.9)

Considering S= 87 and FIFO policy (Table 5.10), the waste percentage value ranges from 0 to 25.77. The higest values of service level (1) occur with T=10°C and SL=5 and with T=8°C and SL=5 (0.99). The smallest service level value was reached with T=10°C and SL=2 (0.75). The smallest CO_2 emissions values occur with T=4°C and SL=12 (0.93), and T=10°C and SL=2 (0.85). The highest CO_2 emissions values were obtained with T=8°C and SL=5 (1.03 COeq/box) and with T=10°C and SL=5 (1.02 COeq/box) (Table 5.10)

Table 5.7-Food waste and service level amount with S=29 and LIFO policy

LIFO								
shelf life after production	7	12	7	11	3	5	2	5
Temperature	4	4	6	6	8	8	10	10
Waste Percentage	1,436	0,282	1,574	0,941	10,575	2,316	15,520	4,454
CO_2 emission in the supply chain	0,387	0,444	0,322	0,402	0,319	0,353	0,319	0,429
Service level	0,897	0,795	0,824	0,870	0,635	0,812	0,683	0,841
Total CO_2 emissions	1,103	0,584	1,106	0,871	5,586	1,506	8,048	2,647

Table 5.8-Food waste and service level amount with S=29 and FIFO policy

FIFO								
shelf life after production	7	12	7	11	3	5	2	5
Temperature	4	4	6	6	8	8	10	10
Waste percentage	0,000	0,000	0,000	0,000	0,830	0,000	9,739	0,000
CO_2 emission	0,389	0,447	0,321	0,402	0,320	0,353	0,318	0,429
Service level	0,876	0,911	0,873	0,820	0,871	0,855	0,837	0,886
Total CO_2 emissions	0,389	0,447	0,321	0,402	0,734	0,353	5,169	0,429

Table 5.9-Food waste and service level amount with S=87 and LIFO policy

LIFO								
shelf life	7	12	7	11	3	5	2	5
Temperature	4	4	6	6	8	8	10	10
Waste percentage	28,107	19,107	40,469	24,632	53,866	20,457	42,553	42,326
total CO2 emission	**0,388**	**0,452**	**0,321**	**0,492**	**0,319**	**0,352**	**0,318**	**0,430**
Service level	0,816	0,927	0,672	0,918	0,861	0,931	0,585	0,710
Total CO_2 emissions	14,385	9,967	20,475	12,759	27,145	10,539	21,509	21,508

Table 5.10-Food waste and service level amount with S=87 and FIFO policy

FIFO								
shelf life	7	12	7	11	3	5	2	5
Temperature	4	4	6	6	8	8	10	10

Waste percentage	2,010	0,000	0,117	0,000	20,457	10,057	25,770	5,243
total CO_2 emission	0,383	0,447	0,322	0,492	0,319	0,353	0,318	0,492
Service level	0,981	0,927	0,987	0,996	0,931	0,987	0,752	1,000
Total CO_2 emissions	0,991	0,927	0,988	0,996	1,016	1,033	0,854	1,024

5.4 Conclusions

The results show that a FIFO policy determine an higher amount of food waste than LIFO policy. With S=29 the percentage of food waste and service level both decrease. The opposite consideration can be done if S=87 was considered. Moving from S=29 to S=87 the CO_2 emissions related to fresh cut supply chain and landfill of discarded salad at retail level, increase by 1,6 time in LIFO and by 2.6 time in FIFO.

With a FIFO policy and S=29 the best solution seems to be option with 4°C and SL=7; instead when S= 87 the best option is obtained with 10°C and SL=5.

Considering a LIFO policy and S=29, the best solutions is option with 6°C and SL=11, the same result was obtained with S=87.

The most important finding is that the solution with a SLE of 11 days and stored at 6° C shows the best performing values. These results will be used to determine the trade-offs between relative waste -fill rate, CO_2 emissions – fill rate, relative waste- CO_2 emissions. These findings furnish important insights for the retailes providing information about the frequency and the amount of replenishment in order to avoid supermarket shortage and at the same time to reduce environmental burdens related to food production emissions and food waste disposal emission. The exploratory research is ongoing and its findings are far from being final. Further steps will be the evaluation of the economic impact associated to fresh cut salads supply chain.

References

Amani P. , Gadde L.E. (2015) Shelf life extension and food waste reductionProceedings in Food System Dynamics, 2015, 131.220.45.179.

Axfood, (2014) Sustainability Program. Axfood AB, Solna.

Boxstael, S.Van, Devlieghere, F., Berkvens, D., Vermeulen, A., Uyttendaele, M. (2014) Understanding and attitude regarding the shelf life labels and dates on pre-packed food products by Belgian consumers. Food Control 37: 85-92.

Davis J, Wallman M, Sund V, Emanuelsson A, Cederberg C., Sonesson U (2011) Emissions of Greenhouse Gases from Production of Horticultural Products : Analysis of 17 Products Cultivated in Sweden.: SIK - Institutet för livsmedel och bioteknik, Göteborg.

Eriksson, M., Strid, I., Hansson, P.-A. (2012) Food losses in six Swedish retail stores: Wastage of fruit and vegetables in relation to quantities delivered Resources, Conservation and Recycling, 68, pp. 14-20.

Eriksson, M., Strid, I., Hansson, P.-A. (2016) Food waste reduction in supermarkets - Net costs and benefits of reduced storage temperature Resources, Conservation and Recycling, 107, pp. 73-81.

Evans, J., (2014) Are Doors on Fridges the Best Environmental Solution for the RetailSector? The Institute of Refrigeration, Refrigeration Developments and TestingLtd and Faculty of Engineering, Science and the Built Environment, LondonSouth Bank University, Langford, Bristol.

Fiore M., Contò F., Pellegrini G. (2015). Reducing Food Losses: A (Dis)-Opportunity Cost Model. Revue Of Studies On Sustainability 1: 151–166.

Fusi, A., Castellani, V., Bacenetti, J., Cocetta, G., Fiala, M., Guidetti, R. (2016) The environmental impact of the production of fresh cut salad: a case study in Italy International Journal of Life Cycle Assessment, 21 (2), pp. 162-175.

Pagani, M., Vittuari, M., Falasconi, L. (2015)Does packaging matter? Energy consumption of pre-packed salads British Food Journal, 117 (7), pp. 1961-1980.

Stefan V., Van Herpen E., Tudoran A.A., Lähteenmäki L. (2012). Avoiding food waste by Romanian consumers: The importance of planning and shopping routines. Food Quality and Preference, 28(1): 375-381. doi:10.1016/j.foodqual.2012.11.001.

Strid I., Eriksson M. (2014) Losses in the supply chain of Swedish lettuce – wasted amounts and theircarbon footprint at primary production, whole sale and retail. Proceedings of the 9th International Conference on Life Cycle Assessment in the Agri-Food Sector.

Tukker A, Huppes G, Guinée JB, Heijungs R, de Koning A, van Oers L, et al. (2006) Environmental impact of products (EIPRO) analysis of the life cycle environmental impacts related to the final consumption of the EU-25, EUR 22284 EN. Seville: European Commission, Joint Research Centre, Institute for Prospective Techno-logical Studies.

Van Der Vorst, J., Beulens, A., Van Beek, P. (2005) Innovations in logistics and ICT in food supply chain networks Innovation in Agri-Food Systems: Product Quality and Consumer, pp. 245-290.

Sitography

http://ec.europa.eu/food/safety/food_waste/index_en.htm

5. CONCLUSIONS

The project attained the proposed objectives, namely that of highlighting problems and opportunities related to the introduction of 'new technology' (SLE). This is realized through the implementation of a technical and economic indicators linked to the production systems, which become crucial for the environmental and economic impacts analysis of innovation. The SLE in EVOO is obtained through the selection of cultivar and consequently the choice of olive growing systems which implies different environmental and economic impact on the global farm's sustainability. The study proposed in the present project states that SLE in EVOO results in an increase of global sustainability of the entire supply chain: the higher environmental value (obtained by sustainable practices, choice of the best growing system, and a reduction of food waste) as well as the higher healthy value (obtained through the high level of phenolic compound and other components), could be considered a crucial attributes to segment the EVOO and to increase the competitiveness in the global market. The study analyzed the solutions to optimize yield, reduce waste and therefore emissions linked to waste, increase the global sustainability of the entire EVOO supply chain without implement interventions and investments, but optimizing existing solutions and scientific know-how. These solutions became fundamental insights for decision maker (producer) who is faced with a problem of optimal choice among alternatives depending on the final product market.

In olive patè case study, the SLE stands in inverse proportion to environmental sustainability: SLE determines more impact on the environment, despite a food waste reduction. There is no doubt that further research is neeed and more scenarios have to be analysed. As regards to SLE impact on logistics, the study furnishs important insights concerning the optimal logistic management solution for the fresh cut salad supply chain considering a longer SL. Findings remark crucial information for retailers about the frequency and the amount of replenishment, in order to avoid supermarket shortage and at the same time to reduce environmental burdens (food production emissions and food waste disposal emissions). The analysis of food losses social impact allow to reveal how the food loss reduction is fundamental for an intra/inter-generational equity and for the entire socio-economic system. Finally, the projects provide insights dealing with consumers' food-related activities aimed to minimize d to food waste. Waste prevention approaches should focus on avoiding returns, transfer of best practices, information and education of employees and customers as well as strengthening the donation to social services. The main results of the project may represent a great opportunity to improve the competitiveness of the food companies, producers, brokers, distribution centers and retailers in a sustainable way. Furthermore this study may furnish data and kwoledge for institutions to build a food policy aimed to reduce household's food waste.

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