LCI PRELIMINARY RESULTS OF IN THE SICILIAN DURUM WHEAT PASTA CHAIN PRODUCTION

AGATA LO GIUDICE (*)[1] - MARIA TERESA CLASADONTE (*)
AGATA MATARAZZO (*)

Abstract

Pasta is still the most characteristic Italian food and, in fact, it is always present in the Mediterranean diet.

This study points out the preliminary results obtained through the application of the Life Cycle Inventory Analysis (LCI) on the dried pasta production.

It has been analyzed the main environmental impacts caused by a small farm industry situated in Floridia (Sicily) and whose managing staff plays a particular attention on the environment.

For this purpose it has been applied the LCI to exploit wisely the available resources, to reduce the power consumption and to limit the environmental impact of the entire production cycle.

This approach focuses on a charge of consumption and emissions produced during the LCI by specific impact categories and whose environmental effects are known. Moreover, it has been also quantified (with appropriate characterization methods) the magnitude of the overall contribution due to the process against the concerned effects.

It has been defined a suitable functional unity which corresponds to 1 kg package of durum wheat short pasta and it has been examined all the different phases of the productive cycle.

(*) Università degli Studi di Catania, Department of Impresa, Culture e Società, Commodity Science Section, Corso Italia, 55, 95129 Catania, ITALY.
[1] Corresponding author: a.logiudice@unict.it
The study is part of the Eco-Management for Food (EMAF) Project (PRIN 2008 No. 2008TXFBYT - http://ww2.unime.it/emaf) co-funded by the Italian Ministry of Education, University and Research (MIUR).
The present work is the result of group collaboration of the authors.

Introduction

Over the last years the manufacturing world has paid a particular attention on the relationship between the use of the resources and the environment in order to combine the requirements of the economic development and of the environmental ecosystems.

Among the different feasible sustainability instruments, the Life Cycle Analysis is gaining an increasing interest (LCA), because it is possible to assess the environmental performances of a product analyzing all its steps from the cradle-to-grave (1).

This methodology is provided for the ISO norms of the 14040 set and it is divided in the following four main phases: definition of the aim and of the application field of the study defining also the functional unit and the boundaries system; the life cycle inventory analysis which concerns the main step of this study and which is represented by the data collection; the LCIA - Life Cycle Impact Assessment; the LCI - Life Cycle Interpretation.

In particularly, the most important step of the LCA is the inventory analysis which allows the building of an analog model of the reality, able to represent as better as possible all the exchanges among the single actions belonging to the effective productive chain.

This analysis follows the Input - Output Flow Material Analysis example, a methodology useful to represent the birth of the environmental impacts and the reduction of the pollutions connected with the industrial activity of a product unity; so, it is possible to value the environmental loads associated with the life cycle of a product analyzing the true consumption of energy and the consumption of the natural capital (2-3).

On the contrary, it hasn't been considered the few input/output significances, that is the environmental damages assessment caused by the raw materials and energetic resources consumptions.

Then, the aim of an inventory is to provide objective data which will be after processed and discussed in order to obtain evaluations and indications useful for future decisions (steps of Life Cycle Impact Assessment and Life Cycle Interpretation).

That being stated, the aim of this work is to realize the life cycle inventory of one of the industrial sector for which Italy is the world's leading producer - the dried pasta- and which could represent the basis for future decisions about the environmentally friendly management of this productive process.

In this work, the LCI has been applied to a lower-middle Sicilian firm placed in Floridia (SR), typical of the Italian industrial fabric and, in particularly, of the southern one. In comparison with other studies about the pasta chain (4-6), this work proposes a simplified approach and the results are easy to read because the single phases of the pasta industrial process have been clearly splitted using illustrative tables and flowcharts.

This analysis could represent a starting point to obtain an ecological label as the Environmental Product Declaration which, in the food-processing sector, could answer to the needs of a right communication about the products environmental quality.

Notes about pasta

The word "pasta" refers to several products which include the dried pasta (or the traditional one), the fresh pasta, the egg pasta, all products which have been produced using the raw materials coming from the durum and soft wheat milling.

To these categories it has been added other ones which are considered "not conventional" and which have been obtained using maize, rice and other cereal flours. This work refers to the dried pasta and in particularly to the durum-wheat semolina pasta.

The dried pasta is obtained by the rolling-mill process, or extrusion, of a dough composed of the mixing of a liquid and of a mealy which will be dried afterwards.

The pasta is "dry" when its residual percentage of humidity allows a long-shelf-life in normal environmental conditions. For this definition, it hasn't been intentionally used the words "water" and "semolina" because these ingredients are compulsory used in Italy but pasta can also be produced with varied raw materials which, however, belong to the above mentioned generic mealy and liquid categories.

The durum-wheat semolina pasta production has been regulated in Italy by the Law n° 580/67 (7) later modified by the D.P.R. n° 187/2001 (8).

Following the art. 6 of this decree, the durum-wheat semolina pasta has to have the requisites listed in Table 1.

TABLE 1

REQUIREMENTS DRY PASTA

Type and denomination	**Moisture content max %**	**About 100 part of dry substance**			**Max acidity in grade**
		Ashes		Proteins (N×5.70)	
		Min.	Max.		
Durum-wheat semolina pasta	12.50		0.90	10.50	4
Refined durum-wheat pasta	12.50	0.90	1.35	11.50	5
Semolina whole-wheat durum pasta	12.50	1.40	1.80	11.50	6

Source: D.P.R. n. 187/2001

Italy has been recognized all over the world as the " home" of pasta and it has always been the main producer of the durum-wheat semolina pasta. The Italian pasta industry is at the first place among the main world pasta producers and it firmly keeps its position thanks to the work of 150 pasta factories operating in Italy and which represent a yearly productive potential of 4 million of tons.

These leadership consolidates with the passing of time through a great industrial development and a following step of modernization and concentration of the productive fabric which has deeply conditioned the entire sector. To the progressive reduction of the number of the plants has corresponded a constant development of the productive capacity.

The world dried pasta production in 2008 reached about the 37.7 mt -Italy and Canada are among the best producers; in the same year in Europe the dried pasta production reached about the 9.3 mt, and the 4.3 mt of it has been produced in Italy, the country which holds also the leadership for the pasta consumption per head (equal to 26 kg in 2009) (9).

In Table 2 it has been reported some data which refer to 2009 and which give a synthetic but complete view of the pasta market.

TABLE 2

DRY PASTA ITALIAN INDUSTRIES (2009)

	Quantities (tons)	**Value (milions of euro)**
Dried Pasta		
Production	3,056,197	3,767
National Market	1,397,706	2,051
Exports	1,658,491	1,716
Of which:		
Semolina dried Pasta		
Production	2,762,818	3,005
National Market	1,299,988	1,705
Exports	1,462,830	1,300
Egg dried Pasta		
Production	176,678	447
National Market	91,568	311
Exports	85,110	136
Stuffed dry Pasta		
Production	116,700	316
National Market	6,150	36
Exports	110,550	280

Source: www.unipi-pasta.it

The LCI applied to the pasta

In order to calculate the in and out material and energy flows, it has been chosen 1 kg pasta pack as the reference functional unit.
As regards the boundaries system, the analysis has been conducted considering the phases of: the durum wheat farm production; the semolina industrial production; the pasta industrial production; the domestic consumption. In Figure 1 it has been reported the pasta productive cycle flowchart.

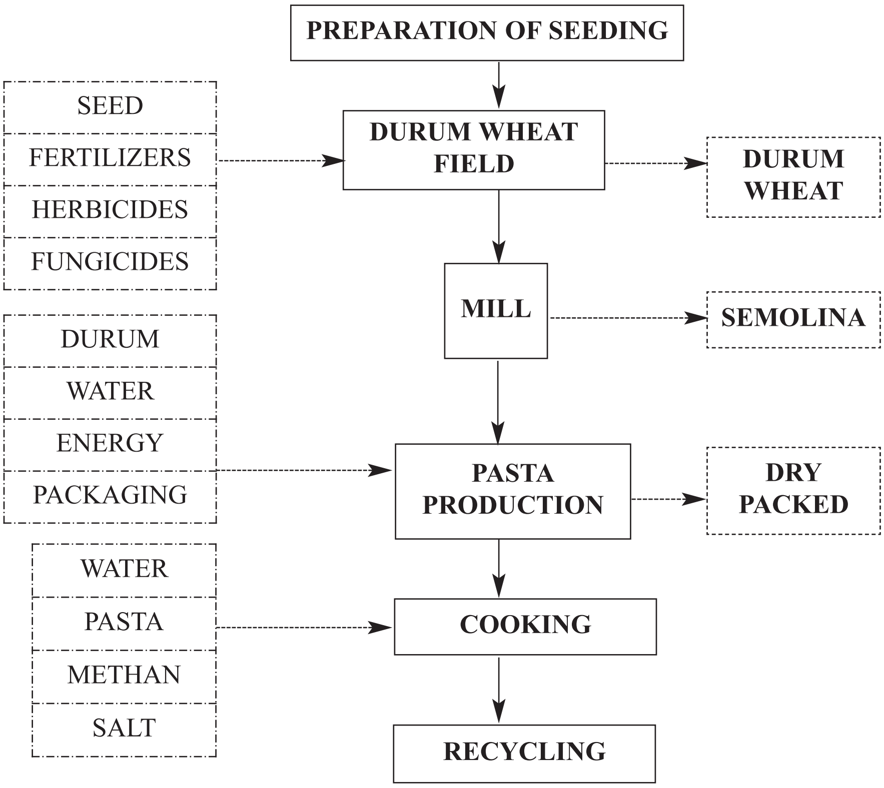

Fig.1 - Pasta production flow chart.
Source: Personal Elaboration

The data has been collected thanks the cooperation of the firms involved in the different phases of the productive cycle, trying to guarantee the same quality, in order to avoid any mistakes during the final analyses; all the other information have been taken from the data bank Ecoinvent Data v 2.0 All the collected data have been reported in the tables of the following subparagraphs.

Durum wheat farm production

In this phase the reference functional unit is 1 ha of a land (situated in Villasmundo district of SR) under intensive farming of durum wheat.

In Figure 2 it has been described the different phases of the durum wheat productive cycle.

On the contrary, the Table 3 reports the input and output quantities necessary for the cultivation of the chosen functional unit considering that, among the inputs, the potassium fertilizers do not appear because the soil in question is rich of potassium.

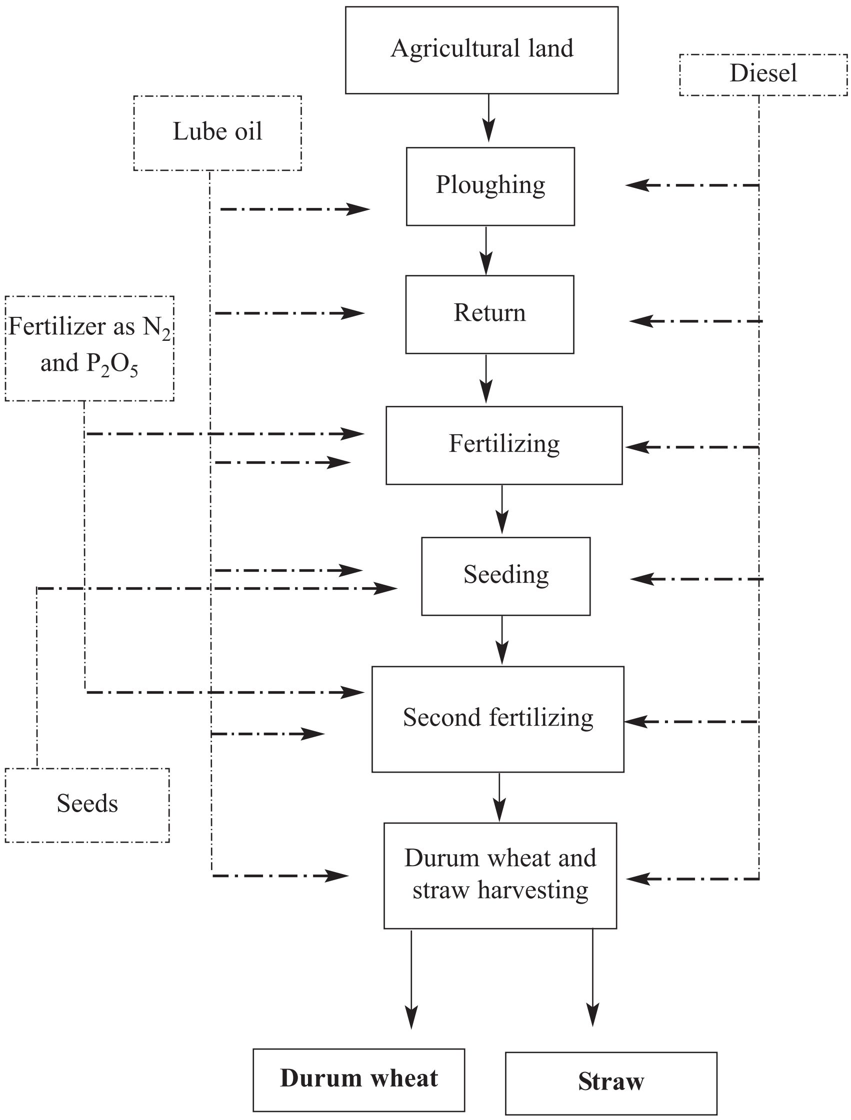

Fig. 2 - Durum wheat production flow chart.
Source: Personal Elaboration

Semolina industrial production

In this case the reference functional unit is 1 kg of semolina obtained by the durum wheat milling. Figure 3 shows the phases related with this productive cycle, while Table 4 reports the input and output data which refer to the production of 1 kg of semolina. It has been considered that, from the durum wheat, the milling yield is semolina for the 64% while the remaining 26% is formed by other output: flours, brans, corns, waste.

TABLE 3

INPUT AND OUTPUT FOR THE CULTIVATION OF 1 HA OF SOIL

Input	Quantity	Output	Quantity
Soil	1 ha	Durum wheat	3,000 kg
Durum wheat Seeds	200 kg	Straw	2,400 kg
Diesel Oil	123.1 kg	Emissions into the air:	
Lubrificating Oil	3 kg	NH_3	10 kg
Nitrogen Fertilizers (N_2)	100 kg	N_2O	1.2 kg
Phosphate Fertilizers (P_2O_5)	150 kg	NO_2	3 kg
Weed-Killings (2,4 D)	5 kg	Emissions into the water	
Transport semi resseller → soil	12.7 km	NO_3-	96 kg
		$PO_4{}^{3-}$	0.11 kg

Source: Personal Elaboration

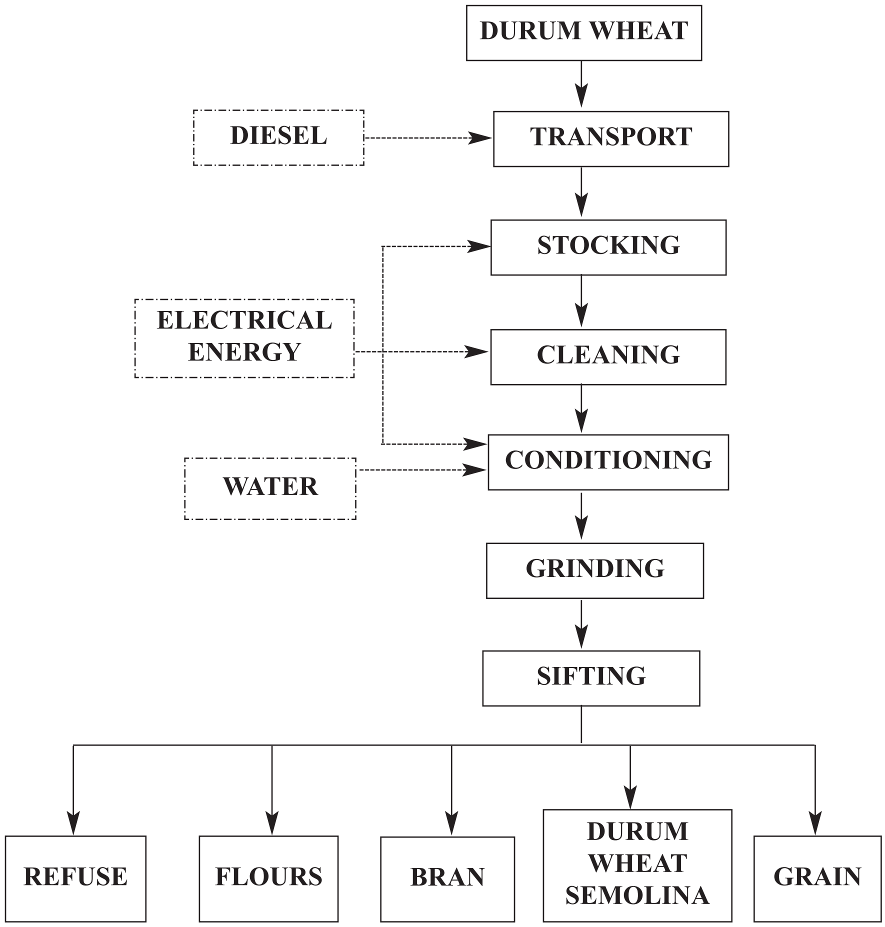

Fig. 3 - Durum wheat semolina production flow chart.
Source: Personal Elaboration

TABLE 4

INPUT AND OUTPUT FOR THE PRODUCTION OF 1 KG OF SEMOLINA

Input	Quantity	Output	Quantity
Wheat transport → mill	70 km	Durum-wheat semolina	1kg
Durum wheat	1.56 kg		
Electricity	0.083 kWh		
Water	0.015 kg		
Natural Gas	0.008 MJ		

Source: Personal Elaboration

Industrial production and dry pasta packaging

The dried pasta production phase is the core of this study. The data are derived from the measurements done inside the plant during the productive cycle and they have been elaborated in order to fit the quantities to the chosen functional unit which corresponds in this case to 1 kg of dried pasta. In Figure 4 it has been represented the different phases connected with the productive cycle in question, while in Table 5 it has been reported the input and output quantities necessary for the industrial production of the dried pasta.

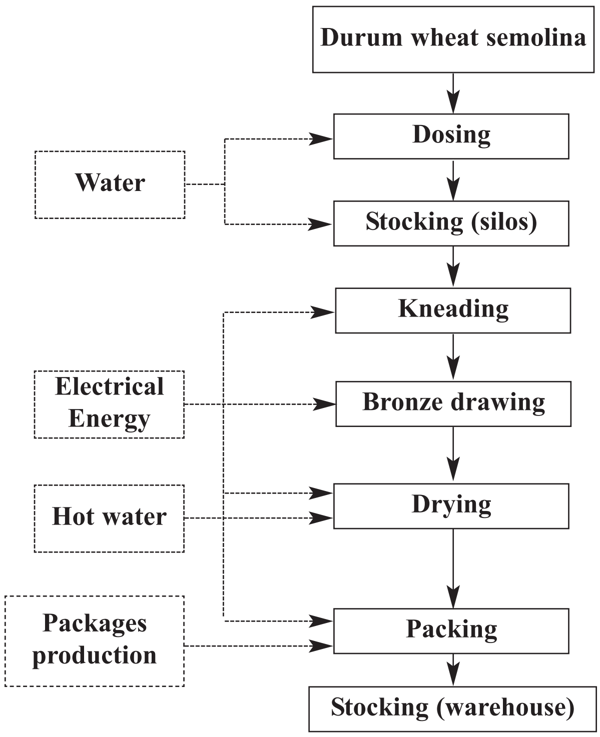

Fig. 4 - Pasta production flow chart.
Source: Personal elaboration

TABLE 5

INPUT AND OUTPUT FOR THE PRODUCTION AND THE PACKAGING OF 1 KG OF PASTA

Input	Quantity	Output	Quantity
Transport to the mill→ pasta factory	60 km	Dry Pasta	1kg
Polypropylene transport(PP)	1,600 km	Heat energy	570.89 Kcal
Coal Transport	1,500 km	Broken pasta waste	0.06 kg
Transport to the pasta factory → GDO	50 km		
Semolina	1.06 kg		
Electricity	0.226 kWh		
Water	0.384 kg		
Fuel oil (BTZ)	0.05 kg		
PP	0.0105 kg		
Carton	0.0165 kg		

Source: Personal Elaboration

Pasta domestic consumption, closure and packaging

Analyzing the pasta cooking phase, it has been followed the cooking instructions carried by the books belonging to the specific litterature and it has been supposed the recycling as the end life of the primary packaging.

In Figure 5 it has been reported the corresponding flowchart while the Table 6 reports the input and output expect for (among the input) the pasta condiments.

Fig. 5 - Pasta consumption and recycling flowchart
Source: Personal Elaboration

TABLE 6

**INPUT AND OUTPUT FOR THE PASTA CONSUMPTION (1 kg)
CLOSURE AND PACKAGING**

Input	Quantity	Output	Quantity
Water	10 kg	PP	10 gr
NaCl	100 gr		
Methane	10.653 MJ		
PP	10 gr		

Source: Personal Elaboration

Conclusions

A life cycle inventory connected to the collected data has to offer reliability guarantees in order to compare the results of different inventories and to obtain just one method to built the LCA model.

The control of this reliability is an important preliminary phase which allows the time optimization for the following steps of the study. Following the instructions here proposed, the inventory application allows to point out clearly the raw materials and the energetic resourcesnecessary for the productive process facilitating the quantification of the resources expected during the following step of the Life Cycle Impact Assessment. This orderly approach of the LCI is more detailed than the one proposed by literature and represents a simple, creative and schematic instrument able to quantify the environmental data; an aware method based on the reality of any productive process and adaptable to any firm different for size and product compartment.

Moreover, this model allows a collection of information about the actual situation of the firm using a visual language of the productive process and representing a valid support for internal decisions about processes, products and activities promoting a continuous improvement process.

The correct application of the material fluxes analysis applied to the single phase of the productive processes as it is here proposed, allows also an efficient development and management of the quantities involved into the economic activities because the establishment of a database related to any step of the productive process is a source of important information. So, not only does this study specify a new and simple homogeneous approach to realize the LCI phase but it also greatly contributes towards the standardization of the methodology related to the materials flow analysis.

Received January 31, 2011
Accepted April 4, 2011

REFERENCES

(1) D. ANDREIS, E. CUSINATO, “La certificazione RINA per il Life Cycle Assessment”, *De Qualitate, 1999*, 51-55.

(2) G. PARASCANDOLO, G. LAGIOIA, “Material flow analysis come filosofia di analisi”, *Ambiente Risorse e Salute 200*6, No 11, 11-19.

(3) M.T. CLASADONTE, A. MATARAZZO, “Input-Output material flow analysis applied to microelectronic devices”, *Journal of Commodity Science, Technology and Quality 2010*, 49 (III), 151-171.

(4) B. NOTARNICOLA, G. M. NICOLETTI, “Analisi del ciclo di vita della pasta e del cuscus”, *Tecnica Molitoria 2001*, 19-27.

(5) B. NOTARNICOLA, I. MONGELLI, G. TASSIELLI, G.M. NICOLETTI, “Environmental Input-Output Analysis and Hybrid Approaches to improve the set up of pasta life Cycle Inventory”, *Journal of Commodity Science, Technology and Quality 2004*, 43(III), 59-86.

(6) AA.VV., *Rational use of energy in the pasta manufacturing sector*, ENEA, National Center for Alternative Energy Department of Energy, 1997.

(7) G. MONDELLI, “La pasta è servita!”, *Tecnologie Alimentari 1995*, 1, 70-78.

(8) D.P.R. 9 febbraio 2001 n° 187 “Regolamento per la revisione della normativa sulla produzione e commercializzazione di sfarinati e paste alimentari”, pubblicata nella G.U.R.I. 22 maggio 2001 n° 117.

(9) M.G. D'EGIDIO, M.A. PAGANO, “Pasta and couscous: basic food of mediterranean tradition”, *Tecnica molitoria International 2010*, 105-114.