Trends for an Industrial Utilisation of Olive Mill Wastes

by Umberto Tomati, Emanuela Galli and Pompilio Rapanà

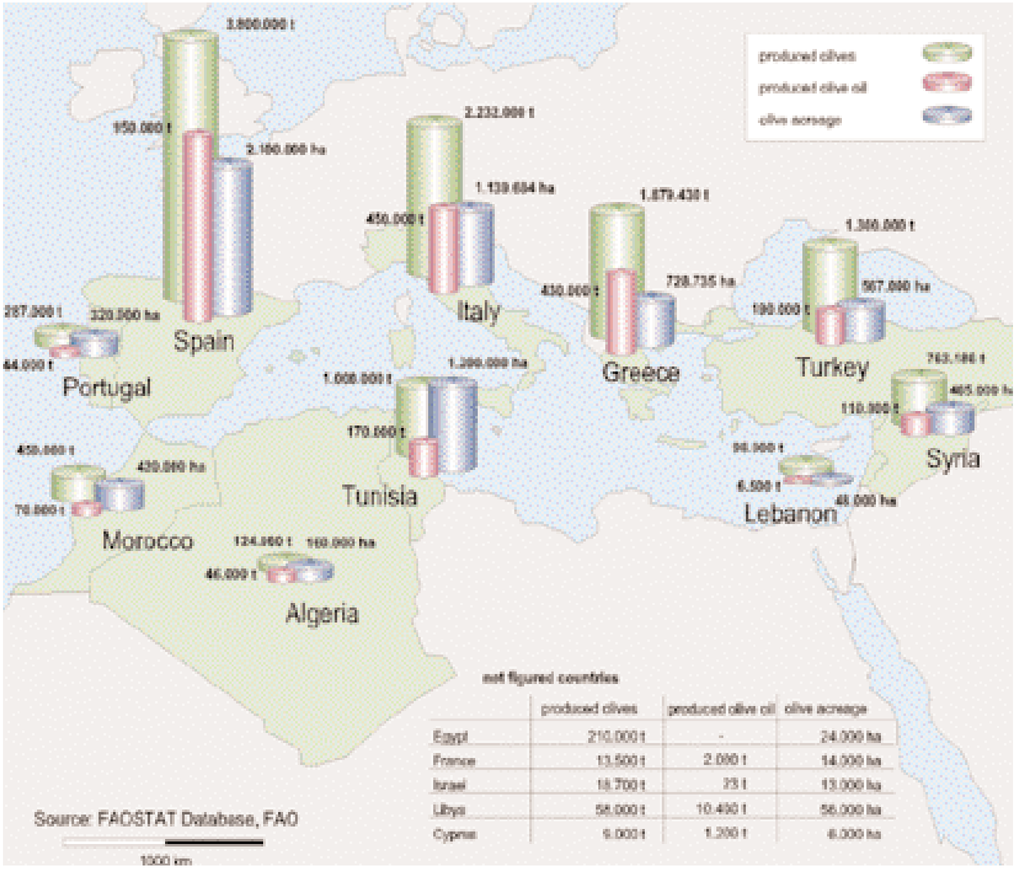

Figure 1 - Olives and olive oil production in the Mediterranean area in 1998

Olive mill wastes can be recycled as a soil conditioner and as a starting material to obtain high value products. Land application and composting are the most suitable technologies. Setting machines for spreading wastes, milling technologies for reducing waste volumes, and composting plants are relevant industrial applications. The recovery and production of high value compounds is another interesting industrial application. Polyphenols can be extracted and used as substitute of synthetic antioxidants. Microbial biomasses can be used to obtain enzymes and polysaccharides.

The worldwide olive oil production is estimated in about 2 million tons per year, 78% of which are produced in the European Union. Other main producers are Tunisia (170,000 tons), Turkey (190,000 tons), Syria (110,000 tons) and Morocco (70,000 tons). More than 95% of the world's olives are harvested in the Mediterranean region; the highest yield is achieved in Spain, Italy and Greece (Table 1 and Figure 1). Consequently, the most of liquid and solid waste (OMW) yearly resulting from olive industry is produced in the Mediterranean area (Table 1). More than 30 million m^3 of liquid and solid wastes are produced in the short harvesting season lasting about 100 days [1]. Actually, nobody knows the amount of wastes produced, and surely their production is underestimated. The quantity of wastes is mainly related with the type of the extraction process; their quality is influenced by the type of extraction process, cultivar, area of cultivation, use of pesticides and fertilisers, harvesting time, stage of maturity, climate/weather conditions.

Wastes produced by the olive mill industry can be either considered as a polluting stream or a resource to be recycled [2]. If considered polluting wastes, they must undergo depuration

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Table 1 - Mean data of production (ton/year) [1]

	UE	*Other*	*World*
Olive yield	7,700,000	2,000,000	9,700,000
Olive oil	1,450,000	375,000	1,825,000
Wastes	5,800,000	1,500,000	7,300,000

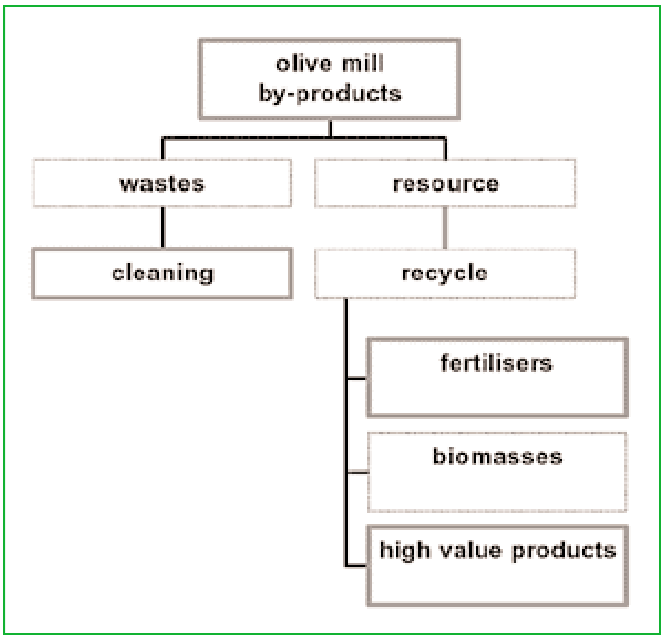


Figure 2 - Olive oil by-products: wastes or resource

before their release in the environment; if considered as a resource, they can be usefully recycled as a soil conditioner and/or as a starting material to obtain high value products (Figure 2). Land application and composting are the technologies that can mainly be proposed to solve the problem, due to the huge quantity of wastes yearly produced. This double aspect of olive wastes generates antagonism among the various political groups, mainly agriculture and environment ones, because their different point of view on this topic.

The national research programme: "Recycling the wastes of the agro-industrial system - Subproject olive mill wastes"

The possibility of using OMW as a resource has been deeply studied by the National Council of Research through the national research programme: "Recycling the wastes of the agro-industrial system" [2-4]. The main aims of this interdisciplinary programme were:
- evaluating the problems posed by olive milling industry;
- proposing suitable solutions for the various territorial contexts;
- demonstrating the possibility of using olive mill wastes as a potentially reusable resource;
- avoiding environmental pollution.

To gather the most of information, the programme was structured in four main topics:

Topic 4.1.1.: Review of the existing situation with regard to the production, characterisation and spreading of olive mill wastes; extracting technologies and operating plants, aimed at (Scheme 1):
- providing a census about all the aspect of oil industry (i.e. number of olive mills, typology and potentiality, oil and waste production);
- defining suitable strategies aimed at waste managing;
- providing useful information to Agencies (i.e. regions) involved in drawing up disposal plans.

Topic 4.1.2.: Determination of the hydro-pedomorphological, climatic and agronomic aspects concerning the spreading of wastes, aimed at (Scheme 2):
- acquiring information and preparing maps for a correct agronomic use of wastes;
- developing suitable technologies for the waste spreading;
- providing information for a better regulation on olive mill waste disposal.

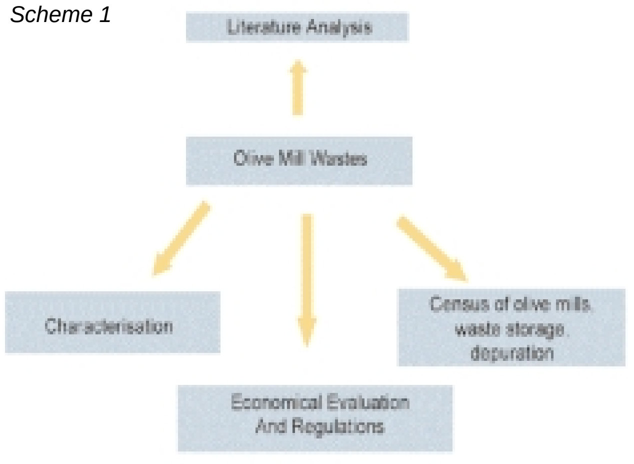
Topic 4.1.3.: Biostabilisation of olive mill waste and use of the compost, aimed at (Scheme 3):
- developing suitable technologies for waste biostabilisation
- producing "quality" soil conditioners.

Topic 4.1.4.: Olive mill waste recycle as raw material for high added value compound recovery, aimed at (Scheme 4):
- proposing technologies for high value compounds extraction/biosynthesis.

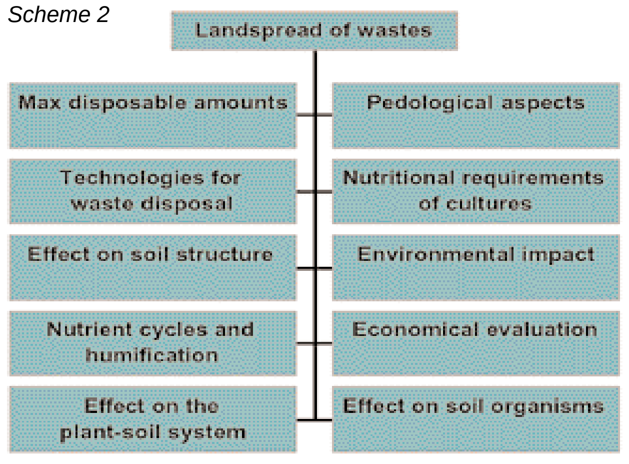
Trends for industrial applications

The studies carried out in the project made evident the possibility of using olive wastes as a substrate for biomass production and direct recovery of phenolic compounds. Information

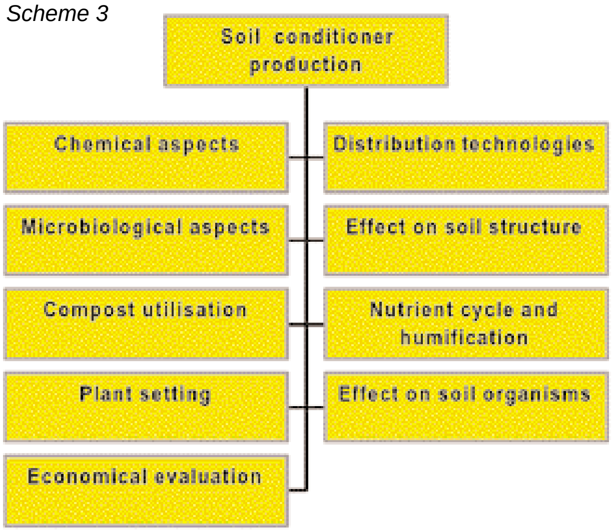
Scheme 1



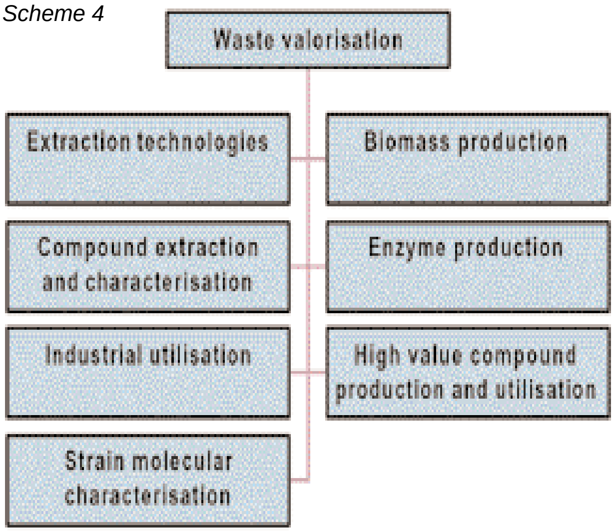
Scheme 2



Scheme 3



Scheme 4



permitted to define strategies, processes and technologies able to manage OMW for their agronomical use as well as a starting material for the production of high value compounds.

Agronomic use

Improving technologies for waste land spread and waste production and biotransformation - Because of their composition, OMW can be considered as a soil conditioner. Therefore, the existing laws allow waste land spread (40 or 80 m^3 ha^{-1}). Moreover, wastes can be distributed within 30 days from their production. Since OMW are produced during the rainy winter season, the right agronomical use of OMW depends on the possibility of having ad hoc speading machines able to distribute homogenously the wastes even on wet grounds. Then, because of the limited quantities permitted, the remained amounts could undergo stabilisa-tion. Besides, having in mind the huge quantities of wastes produced, technologies able to reduce waste production are very suitable to face the environmental problem posed by olive mill industry. Answering to these three points, the project set:
- a prototype of an *ad hoc* waste water spreading machine (Soc. Verdegiglio Macchine Agricole) able to operate in olive groves, conforming to the law. Based on soil characteristics, a software permits to regulate the speed and evaluate the right amount of waste to spread [5, 6] (Figure 3);

Table 2 - Olive composition* (%)

Constituents	*Pulp*	*Stone*	*Seed*
Water	50-60	9.3	30
Oil	15-30	0.7	27.3
Constituents containing nitrogen	2-5	3.4	10.2
Sugar	3-7.5	41	26.6
Cellulose	3-6	38	1.9
Minerals	1-2	4.1	1.5
Polyphenols (aromatic substances)	2-2.25	0.1	0.5-1
Others	-	3.4	2.4

* Values in percent by weight

Figure 3 - Prototype of the waste water spreading machine

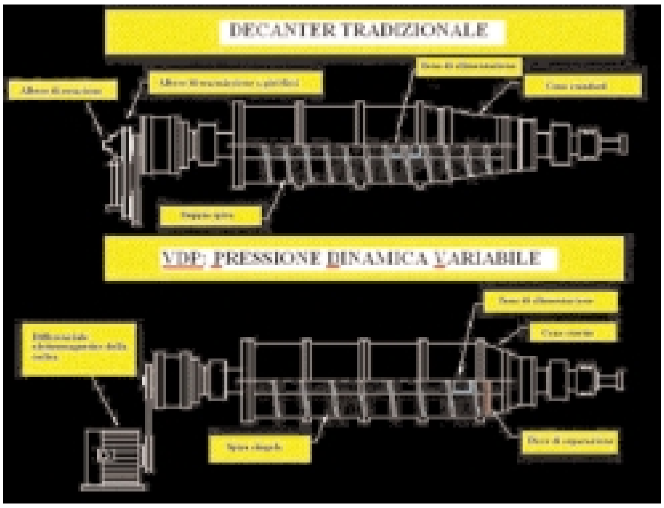


Figure 4 - Multipurpose decanter VDP (variable differential pressure)

Figure 5 - Composting plant

- a multipurpose decanter VDP (variable differential pressure) (Alfa Laval) that permits to improve oil quality strongly reducing waste stream [7] (Figure 4);
- a computerised composting plant (TpA di Vincenzo Nuzzo) that permits, in a pre-industrial scale, to obtain a very high quality compost [8-10] (Figure 5).

Organic conditioner production - To improve and restore soil fertility, agriculture requires stabilised organic matter. Technologies for compost production from many typologies of organic wastes are set, and compost benefit on soil fertility has been deeply stressed. In spite of that, farmers are reluctant to use commercial composts since they do not fit the standard parameters for the agricultural exploitation [11-14]. Starting from OMW, a high quality compost was obtained, free of genotoxicity and showing antiparasitic activity. Soil conditioners having a high antiparasitic activity can also be obtained from algal biomasses [15-17].

OMW as a starting material for the production of high value compounds

Phenol extraction and use as antioxidants

To preserve flavour, colour and avoid vitamin degradation as well as to prolong shelf life, food industry requires antioxidants. Butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) are the synthetic antioxidants most frequently used to preserve food. These substances, that are powerful inhibitors of lipid peroxidation in food matrices, can be toxic when used at high concentration. OMW are rich in phenols showing a powerful antioxidant activity and therefore, they can be regarded as a cheap and suitable source of natural non toxic antioxidants in food industry. The antioxidant activity of monomeric and polymeric compounds has been object of investigation, and there is evidence that such compounds can be recovered from OMW for their use as food preservative [18-22].

Production of fungal biomasses as a starting material for enzymes, polysaccharides and other high value products

Because of their composition, OMW are a suitable substrate that enhance the growth of mycelial biomasses.

Cosmetic and pharmaceutical use - Many classes of polysaccharides, in particular chitin, chitosan and β-glucans, can be extracted from the cell walls of mushroom mycelia. Deacetylated chitin and chitosans are components widely used for cosmetic and pharmaceutical preparations. It is worthy of note that mushroom chitin is characterised by a much lower acetylation grade in comparison to shrimp chitin that is the most important source for chitin and chitosan production. Chitosans are industrially obtained by chitin deacetylation, so, starting from chitin with a low acetylation grade, it is possible to improve chitosan quality. β-glucans are a heterogeneous class of glucose-derived polysaccharides containing β-1,3 and β-1,6 linkages. They display an immunomodulating ca-

Table 3 - Chemical physical characteristics of olive mill wastewaters

	Pressure extraction process			*Continuous extraction process*		
	Min	*Average*	*Max*	*Min*	*Average*	*Max*
pH	5.1	5.4	5.8	4.7	5.4	5.5
Water %	79.85	86.4	91.7	90.4	93.5	96.5
Organic compounds %	7.22	12.0	18.3	2.6	5.2	8.0
Lipids %	0.02	0.5	1.0	0.5	1.3	2.3
Nitrogen compounds %	1.2	1.8	2.4	0.17	0.3	0.4
Sugars %	2.0	4.5	8.0	0.5	1.5	2.6
Organic acids %	0.5	0.9	1.5	-	trace	-
Polyalcohols %	1.0	1.1	1.5	0.9	1.1	1.4
Pectins, tannins %	1.3	1.5	1.7	0.23	0.37	0.5
Glycosides %	-	trace	-	-	trace	-
Polyphenols %	1.2	1.7	2.4	0.3	0.63	0.8
Minerals at 550 °C	1.0	1.5	1.7	0.2	0.4	0.5
P_2O_5 (%)	0.14	0.21	0.23	0.03	0.06	0.07
CO_2 (%)	0.2	0.3	0.35	0.04	0.08	0.1
SO_3, SiO_2, FeO, MgO (%)	0.06	0.09	0.10	trace	0.02	0.03
CaO (%)	0.06	0.09	0.10	0.01	0.02	0.03
K_2O (%)	0.47	0.71	0.81	0.11	0.19	0.24
Na_2O (%)	0.07	0.1	0.11	0.01	0.03	0.03
Suspended solids %	0.08	0.1	0.15	0.7	0.9	1.1
Dry matter at 105 °C	8.3	13.6	20.15	3.5	6.5	9.6
COD (g/l)	54.1	208.0	318.0	28.9	49.5	79.1
BOD_5(g/l)	19.2	90.2	134.8	17.0	28.7	41.2

pacity resulting in antitumor, antibacterial, antiviral and anticoagulatory activity and could be extracted from selected and/or genetically modified mushroom strains [23].

Removal and recovery of heavy metals - The role of polysaccharides in adsorbing heavy metals has been ascertained from long time. Based on the results obtained in the project, the use of mycelial biomass of many basidiomycetes immobilised on inert supports, i.e. polyvinylalcohol, can be suggested as a cleaning tool to complete the removal of heavy metals remained in industrial streams after the usual treatments. Metal recovery can be then achieved [24, 25].

Enzyme production - Polyphenoloxidases have been economically obtained in solid state and liquid fermentation using selected fungal strains grown on OMW. The enzyme complexes can be suitably used in the paper industry [26-29].

Conclusions

Many studies have been performed to solve the problem of environmental protection, offering contributions to both agricultural and industrial sectors. It is time of diffusing appropriate and innovative processes able to permit the complete utilisation of OMW as a suitable resource to be recovered. The new technologies should be provided by appropriate internet devices; so there is the need to create a portal as a reference point for researchers, industries and other people involved in this field. This is the trend that will be pursued as a future development of the project.

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