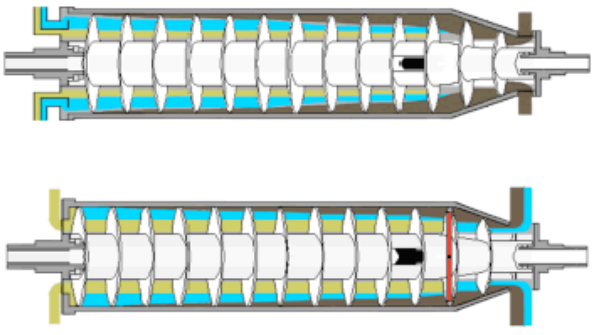
THE EVOLUTION OF THE SYSTEM OF OLIVE OIL EXTRACTION FROM THREE PHASES TO TWO PHASES

The heart of the continuous extraction system lies in the horizontal decanter, where the crushed and liquefied paste undergoes centrifugal action.
The principal characteristics of the three-phase extraction system are, for every one hundred kilos of olives processed, the addition of about 35-55 lt. of hot water into the decanter and the production of solid waste (pomace) with 50% humidity and approximately 90-110 lt. of vegetation water.

The most pressing problem of the three-phase centrifugal extraction system consists of the production of great quantities of waste water and the difficulties encountered in disposing of them. The vegetation water, in fact, is highly acid and toxic for plants, owing to its chemical composition. Therefore, before it is used in fertigation and sprayed on fields, certain agricultural and legislative issues must be considered.
Environmental and economic requirements led, during the early '90s, to the perfection of a new-generation centrifugal extraction system, that was capable of eliminating the issues associated with vegetation water.
This type of extraction, known as the "two phase" or "integral method", makes it possible to eliminate the use of process water, so indispensable in the three-phase system, with the double advantage of limiting the use of natural resources (water) and eliminating the production of waste water, whose disposal adds considerably to the running costs of olive mills.

In two-phase extraction, the horizontal centrifuge is designed to have only two exits, so that the vegetation water is expelled together with the solid waste (pomace) while the oil is expelled from the other end. From here, via the vibro-filter compartment, the oil mixture is channelled into a single vertical centrifuge. Therefore the only by-product that is obtained is a very wet pomace (with about 65% water content).



The principal feature of this system is the oil is extracted from the olive paste without the addition of water. Only if the olives happen to be too dry is 5% of water added, to reach the correct water content.

The addition of process water in the three-phase system results in more oil being lost in the pomace, therefore a lower extractive yield, the production of large quantities of vegetation water to be disposed of with consequent issues of both economic and environmental nature and a lower quality of production, mainly linked to the lower content of polyphenols in the oil obtained.

If process water is not added, on the other hand, a better quality of oil is obtained with lower environmental impact (thanks to the lesser quantity of vegetation water produced) and lower investment and operating costs, the latter due to reduced consumption of water and energy.

	CORATINA CULTIVAR		OGLIAROLA CULTIVAR	
	TWO PHASE	THREE PHASE	TWO PHASE	THREE PHASE
3.4 - DHPEA	0.9	0.6	0.7	0.5
p - HPEA	3.7	2.3	3.3	4.2
3.4 – DHPEA - EDA	522.2	427.2	30.1	18.5
p – HPEA – EDA	78.2	67.3	21.0	22.4
3.4 - DHPEA - EA	351.7	244.9	68.0	52.0
Lignans	38.4	35.6	48.0	46.7
POLYPHENOLS	673	585	304	263

Variation of the phenolic content of the oil in relation to the system of extraction used. Data is shown as mg/kg of oil as an average of three independent samplings, while the period of induction is expressed in hours and indicates the stability of the product over time (*Servili et al., 2003*)

The table below shows the positive and negative aspects of both systems compared.

3 phases	- humidity in the pomace (+ value)	+ vegetation water produced
		- polyphenols in the oil
		+ costs (investments and running costs)
2 phases	No vegetation water	+ humidity in the pomace (value of pomace=0)
	-environmental impact	
	+ oil (reduced loss)	
	+ polyphenols in the oil	
	-costs (investments and running costs)	

As far as the by-products of the extraction are concerned, the modern two-phase centrifugal plants produce a very wet pomace compared with the pomace from the 3-phase method.

	PRESSURE*	THREE PHASES	TWO PHASES
VEGETATION WATER	40.0	90.0	0.0
Oil	0.2	0.3	0.0
Dry matter	4.5	3.7	0.0
VIRGIN POMACE	35.0	55.0	80.0
Oil	2.6	2.2	2.0
Dry matter	22.6	24.2	26.0
Water	9.8	28.6	52.0
Humidity	28.0	52.0	65.0
T O T A L B Y - PRODUCTS	75.0	145.0	80.0
Oil	2.8	2.5	2.0
Dry matter	27.1	27.9	26.0
Water	45.1	114.6	52.0

(Average quantities of by-products per 100 kg of olives processed in relation to the system of extraction adopted)

The vegetation waters are made up of the olive water content (about 40-50% of the olive's weight), the water used for washing the olives (about 5% of their weight), the water used for cleaning the extraction plant (also equal to about 5% of the weight of the olives processed) and the dilution water used in the case where a three-phase system of extraction is used (about 30-50% of the weight of the olives).

Parameters	Pressure	Three-phase decanter	2.5-phase decanter
pH	4.5-5.7	4.5-6.0	4.5-6.0
Dry matter (%)	8-20	4-15	7-18
Organic substance (%)	6-16	3-12	3-14
Oil content (%)	0.2-0.8	0.6-2.0	0.6-2.0
C.O.D. ($g/O_2/L$)	60-200	50-170	50-180
Phenols (g/L)	2-10	2-10	2-10
Ash (%)	2-4	1-3	2-4
Nitrogen (%)	0.10-0.15	0.05-0.10	0.10-0.15
Phosphorus (%)	0.05-0.10	0.02-0.06	0.05-0.10
Potassium (%)	0.2-0.4	0.1-0.2	0.2-0.4

(Characteristics of vegetation waters in relation to various systems of production, *Di Giovacchino L.,2004*)

In Italy the most widespread procedure for using vegetation water is to spray it on fields. This is the most common method although, owing to the geomorphological features of the territory, it is not always easy or economical to find, in the vicinity of the olive mills, areas suitable for spraying in compliance with the requirements of current legislation.

The pomace is made up of the solid parts of the fruit (skin, pulp, seed and kernel). It does not contain heavy metals, toxic pollutants or pathogenic organisms and, being made of organic matter of unfermented vegetable origin, its composition is similar to that of a plant fertiliser.

Parameters	Pressure	3-phase decanter	2.5-phase decanter	2-phase decanter
Humidity (%)	22-35	45-55	55-62	65-75
Oil (% of crude pomace)	6-8	3.5-4.5	3.5-4.5	3.0-4.0
Fibre (%)	20-35	15-25	12-20	10-15
Kernel (%)	30-45	20-28	15-20	12-18
Ash (%)	3-4	2-4	3-4	3-4
Nitrogen (mg/100gr)	250-350	200-300	200- 300	250-350
Phosphorus (mg/100gr)	40-60	30-40	35-45	40-50
Potassium (mg/100gr)	150-200	100-150	100-180	150-250
Total phenols (mg/100gr)	200-300	200-300	250-350	400-600

(Characteristics of virgin pomace in relation to the various systems of production, *Di Giovacchino L., 2004*)

In the past, owing to its fat content, pomace represented a source of income for the olive-miller, who sold it to pomace plants where the residual oil was extracted using solvents. The oil obtained was subsequently processed and then marketed as "olive pomace oil".
There is currently an inversion of this trend. Extracting residual oil from pomace is no longer a remunerative activity for the miller, for whom this operation is worthwhile only for pressed pomace, as the amount he receives for 3-phase pomace only covers the transport costs. Nor is it remunerative for the pomace mill – indeed pomace oil is no longer the main product for the pomace mill, but a by-product, while the principal product is now biomass.

Consequently those working in this sector are showing growing interest towards alternative systems of disposal and exploitation of this product.
The case is quite different for the wet pomace that is produced by the modern two-phase centrifugal plants, which have become popular starting in the Nineties.
There is a great difference in water content between the wet pomace that is produced by the two-phase system and the pomace produced by the traditional 3-phase system and very different potential uses.

First and foremost, because of its high water content, the extraction of the residual oil becomes difficult and costly, requiring a preliminary drying process or the use of centrifugal equipment. The pomace mills, increasingly, are refusing to take this pomace. In recent years, the problem has become more serious because of a reduction in consumption – and therefore of commercial value – of pomace oil.

In the 2-phase process, the wet pomace is treated following a procedure that has been developed over the years and which has shown itself to be the best solution for optimum exploitation of the potential of this material, from an environmental point-of-view, as well as from that of recovery and added value.

After a period of storage in tanks specially designed for this type of material, which enable a loss of 8-10% of the humidity, the wet pomace undergoes a process to remove the kernels.

The kernel can be easily separated using a simple centrifuge, giving 12-15% of dry kernel, which can be re-used in the mill or sold as fuel, and the pulp.

The pulp free of kernels has a residual humidity of between 62% and 65% and is spread on the fields, exploiting its excellent qualities as a fertiliser. Unlike the vegetation waters, the wet pomace does not filter into the soil leaving concentrations of macro-elements that damage the crops. Nor does it give off a bad smell, because the large amount of water it contains creates conditions lacking in oxygen, which prevents fermentation.