

## New proposal for integrated production of sugar and biofuels from sugar beet

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The problems related to the traditional technology of sugar-beet processing have become so important that the beet sector in Europe, and particularly in Italy, has been shocked. If we want to produce sugar beet in the future it will be necessary to decrease the production costs by a simplification of the technology, together with a decrease in the problems related to the energy and water consumptions, the elimination of the solid, liquid and gaseous wastes. It is necessary to evaluate correctly the complexity and the size of the plants, the transportation costs, the quality of the beet, the diversification of the final products and the utilization of by-products.

We have tried in the past to give our contribution to solving these problems but we have found difficulties in convincing the beet sugar world to drastically modify the traditional technology. The problems are so important that an European Project (TOSSIE – TOward Sustainable Sugar Industry In Europe – [www.tossie.pw.plock.pl](http://www.tossie.pw.plock.pl)), started in March 2006, having the main object of disseminating the results of the research obtained in the last decades.

We proposed different solutions including the elimination of calco-carbonic purification process, the utilization of membrane technology and suggesting different processing schemes. Now we would like to propose another possible solution with the elimination of the diffusion process and a balanced production, besides the crystallized sugar, of biofuels.

Preliminary results obtained in the laboratory and in a pilot plant will be presented and discussed.

### 1. Introduction

The drastic decisions adopted by European Union with the aim of restructuring the beet sugar sector in Europe are well known both to the sugar companies and the farmers. The effects of these decisions, in particular concerning the Mediterranean countries where the quality of the beet is lower, caused a drastic decrease of the “sugar quota” and the closing of an important number of sugar factories. As an example, we can mention that in Italy, during the 2005 sugar beet campaign, 19 sugar factories were in operation while, during the 2006 beet campaign, only 6 of them worked regularly. Besides the forced decrease in the production of crystallized sugar beet in Europe, there is a continuous increase in attention to biofuels (bioethanol, biobutanol, biodiesel, biomethane, biohydrogen). In fact, using biotechnological processes, it is possible to utilize agricultural products as renewable raw material for solving both the problems related to the exhaustibility of the mineral oil and the environmental protection. The

competition played by the cane, both concerning the production of crystallized sugar and bioethanol (Amorim, 2006; Knight, 2006; Andrietta et al., 2007), is a reality which cannot be ignored and which undoubtedly has, as strong points, both lower environmental pollution and the possibility of using the bagasse as a source of energy and electricity.

The possibility of saving, in the future, the production of the beet in Europe (important also for the agronomic necessity of a correct rotation of the agricultural cultivations), is strictly correlated with the reduction in production costs, the decreasing in the consumption of energy and water, the solving of the ecological and environmental problems, the simplification of the plants, the limitation of transportation costs, the correct utilization of by-products, the application of biotechnologies, in particular for the production of biofuels (Corre, 2006). We started 20 years ago studying these problems and in 1998 we presented the first results of our research and our proposals to this conference (Vaccari et al., 1998). In the following years we updated our proposals on the basis of the results of our work (Vaccari et al., 1999, 2000, 2001, 2002, 2003, Grabowski et al, 2001). The sugar companies looked at these proposals with curiosity but without taking them in due consideration taking into account that drastic changes in the technology need investments not considered indispensable and, in any case, having high risk. Now the situation has become very worrying and in some countries there is a risk that the beet cultivation will disappear. With the aim of finding a solution to these problems and to alert the sugar companies to take into consideration the results of the recent researches, the European Union financed the TOSSIE project (TOward Sustainable Sugar Industry in Europe) whose objectives are clearly documented in the proper website: <http://www.tossie.pw.plock.pl>. Interesting suggestions have been presented at the recent Symposium organized by Andrew Van Hook Association: "Innovation and environment protection for a sustainable sugar industry" (Creodoz, 2007; Theoleyre, 2007; Hempelmann, 2007).

## 2. Previous proposals

The proposals mentioned above represent drastic changes in the traditional technology for the production of sugar from beet. These proposals have been summarized in a presentation made at the workshop organized by TOSSIE Project in Ferrara last January and now available in the website mentioned above. In that presentation a chronicle of the proposals suggested in the past has been made. The backbone of these proposal is the elimination of the traditional calco-carbonic purification process which is mainly responsible for the various technological and environmental problems mentioned above. The possibility of processing beets without the traditional treatment with milk of lime can be achieved only if we utilize innovative technologies for the sugar industry such as concentration at low temperature, crystallization by cooling, membrane treatments and chromatographic separation processes. Without entering in the details of the reasons for these proposals widely documented in literature, we summarize in the following (Figure 1) the basic schemes remembering that some of them have been patented (European Patents 9610548.6-2114 and 99108020.1-2114).

The continuous increase of interest in biofuels suggests some modifications of the schemes mentioned above following the criteria, already widely utilized in Brazil as far as cane processing is concerned, of a balanced production of crystallized sugar and bioethanol (Figure 2). Such modifications, not only make the process easier by

removing the recycling of the sugar but completely solve the problem of the exhaustion of the molasses which depends on the quality of the beet.

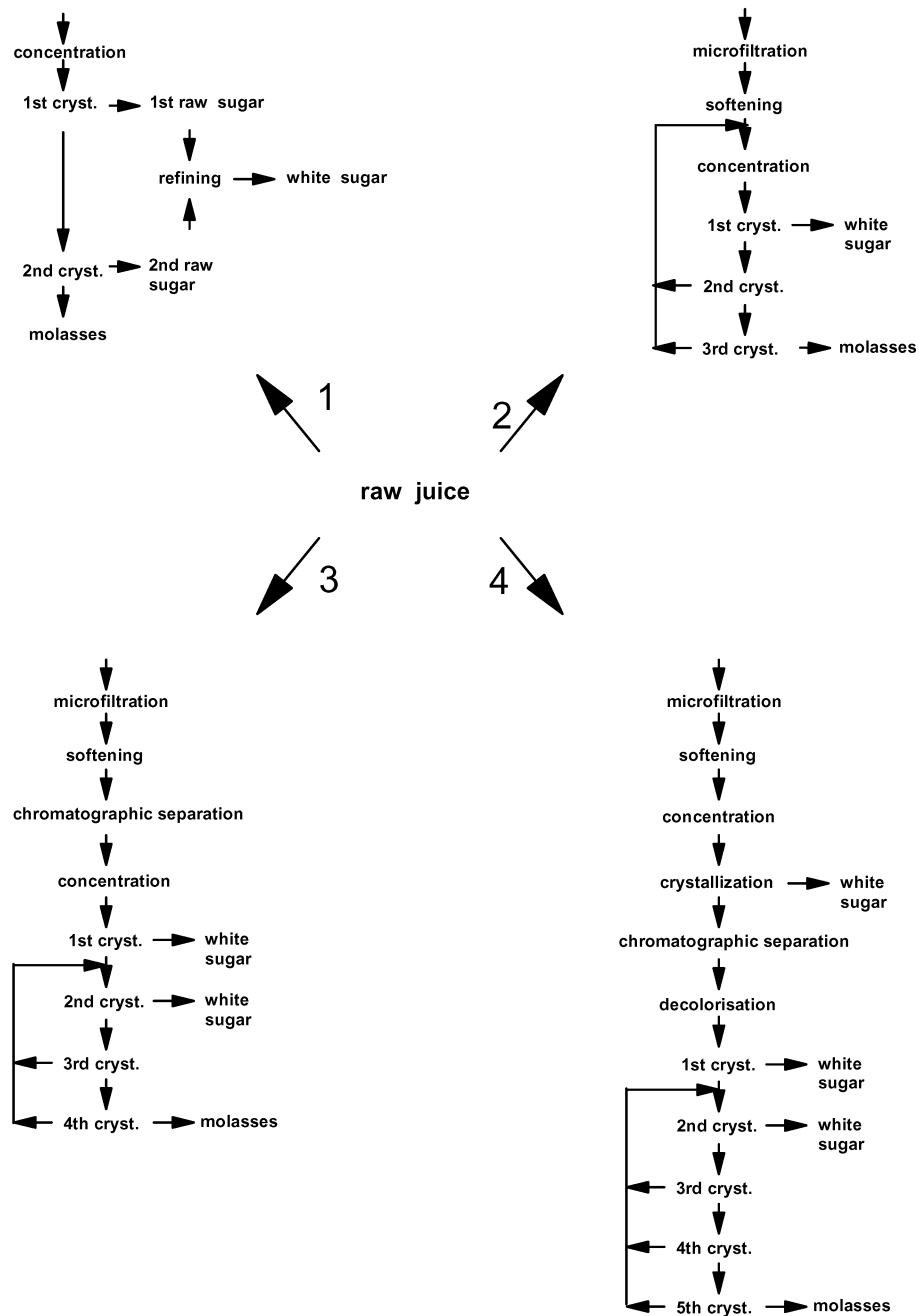


Figure 1 – Schemes summarizing the previous proposals

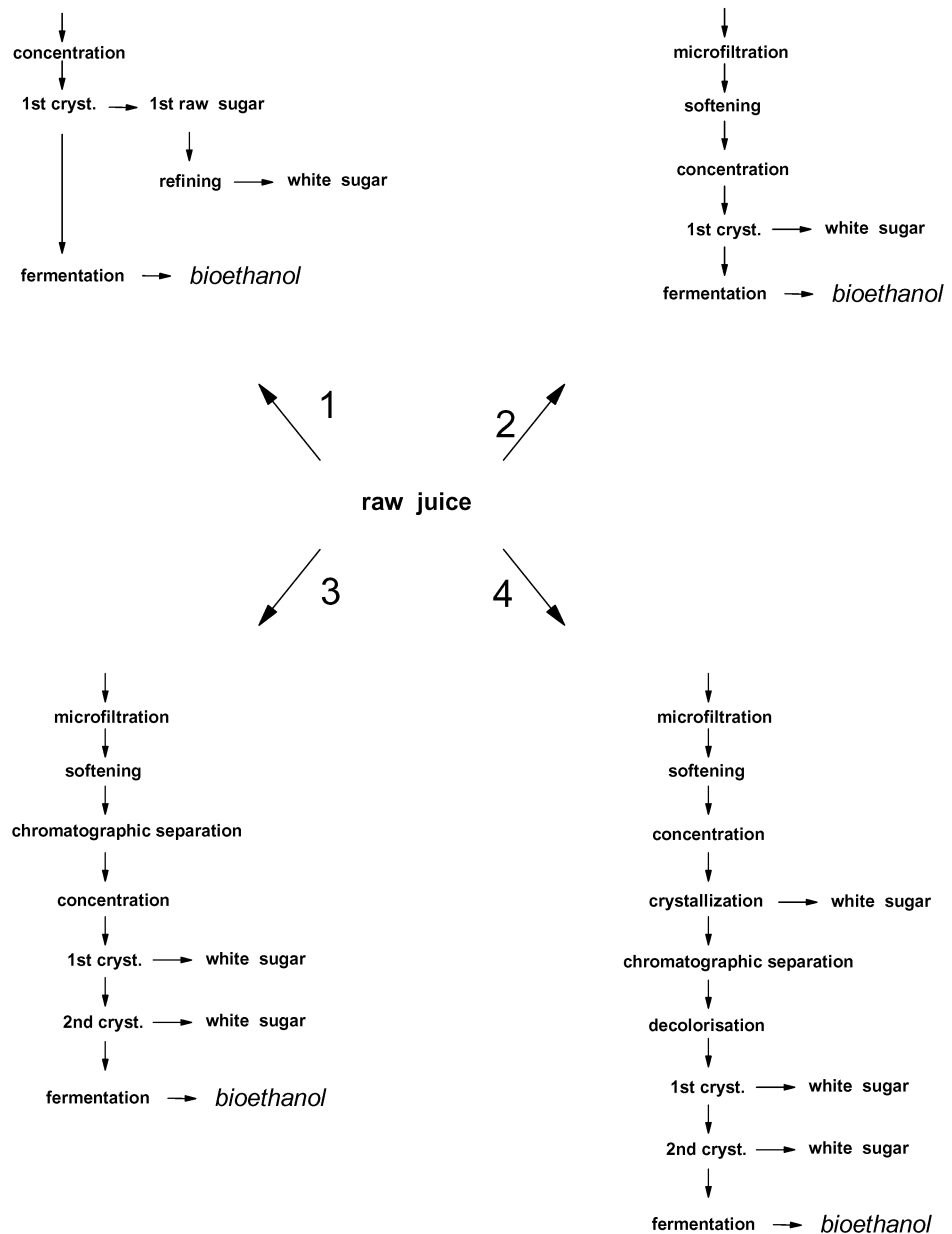


Figure 2 – Modification of the schemes of Figure 1 with the insertion of bioethanol production.

### 3. New proposal

We are convinced that the simplification of the plants, joined to the search for independence from fossil fuels, could play a basic role in the future of European sugar beet production. Following this line, we evaluated the possibility of removing not only the calco-carbonic purification process but also the diffusion process following the

scheme depicted in Figure 3. The roots, after grinding, are simply squeezed producing the “raw pressed juice” which, after concentration at low temperature (low pressure) could be crystallized by cooling. The raw sugar produced could be refined while the run-off syrup could be utilized in alcoholic fermentation processes to produce bioethanol. The pressed roots, which have not been submitted to any thermal treatment, have a dry substance content which is sufficiently high for burning, with the aim of producing steam to be used in the concentration of both the pressed juice to be crystallized and the vinasses produced in the distillation process. For completing the cycle of utilization of the raw matter, we can hypothesize squeezing of the leaves with the aim of obtaining a solid fraction to be burned and a liquid fraction which, mixed and concentrated together with the vinasses, could give a fertilizer.

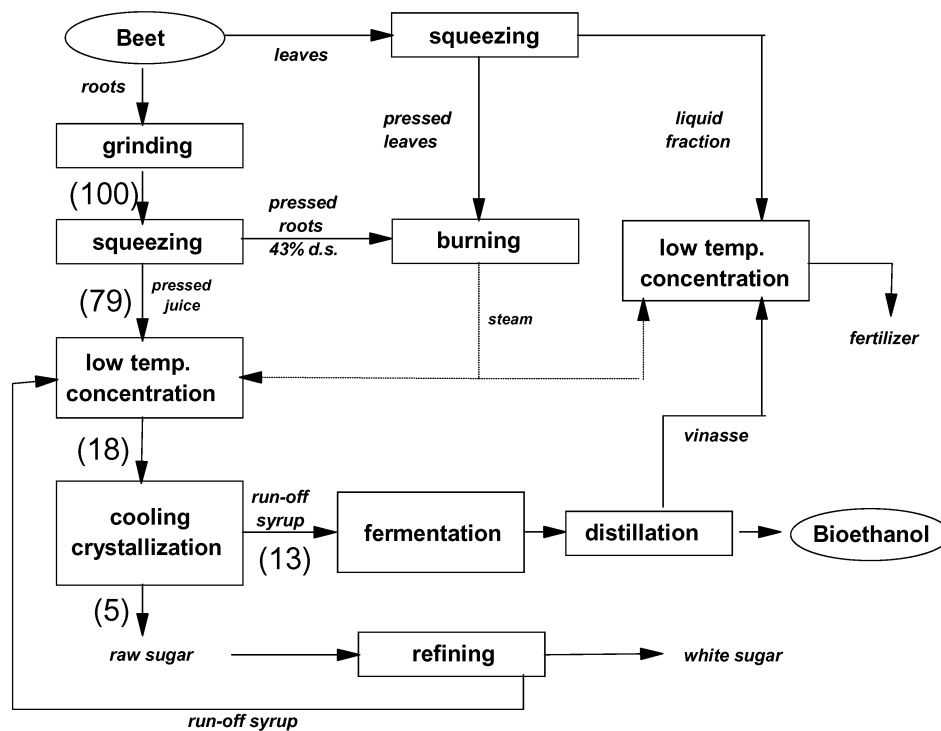


Figure 3 – New proposal concerning the replacement of the diffusion with the squeezing

Table 1 – Analytical data obtained in the laboratory tests

	Pressed juice	Conc. pressed juice	Run-off syrup	Sugar
° Brix	18.5	80.0	73.38	
Polarisation	16.65	72.0	62.62	99.9
Purity quotient	90.0	90.0	85.3	
pH	6.75	6.57	6.73	
Invert Sugar %	0.28	1.0	2.1	0.09
Ash %				0.08

We made some preliminary tests, both in the laboratory and in a small pilot plant, to verify the scheme we have proposed, and some figures concerning the mass balance are quoted in brackets in the Figure 3. In Table 1 some analytical results are summarized. Fermentability tests carried out on the run-off syrup of the crystallization test showed good results.

#### 4. Conclusions

Although we have made only preliminary tests, we judged the results sufficiently interesting for filing a patent (Italian Patent PD2006A000227). We are now assembling a larger pilot plant able to process 100 kg of beet per hour and we trust that it could be a first step for setting up an industrial plant.

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