

## Dates Derived Industries

Mohammed M. R. Al-Abid<sup>1</sup>

### Summary

Dates transmutation industries provide opportunities to produce added value products that can be used as ingredients for food, pharmaceutical and chemical industries especially from low quality dates and, thus, boost the economy of date palm cultivation. These industries convert the main component of dates, which is sugar, by mean of physical, chemical, and biotechnological methods to produce assorted ingredients. The current study focuses on the dates derived industries such as production of high fructose syrup (HFCS), crystalline glucose and fructose, polyols, citric acid, ethanol, vinegar and baker's yeast. Furthermore, the study includes useful technical comments on the modifications of similar industry, which manufacture different raw material, to suit the dates extract as feedstock. In addition, a brief overview of the market of each product has been incorporated according to the latest available data. The study emphasises the implementation of the date derived industries through definite recommendations. Accordingly, a novel design is recommended throughout the study in which common units of operation for instance extraction, purification and juice conditioning are integrated in an industry complex to reduce the cost of operation. However, the up to date subject matter of of the study has been prepared by rigorous literature search and personal communications.

**Keywords:** Dates; Transmutation; Sugar; HFCS.

### Introduction

The production of dates, according to the recent FAO statistics in the Arab countries, is about 4332208 metric tons, which accounts to 71.69% of total the international production (FAOSTAT, 2006). However, the date production in many Arab countries faces a wide range of problems, including the predominance of low quality dates and change of the local consumers habits. Thus, the demand for dates has not been matching the increasing production. The current industries, local market, and export can utilize only a reasonable part of the quality dates produced, whereas the main bulk of the low quality fruits are not exploited. As revealed by many publications, the main component of all date cultivars is sugar. Invert sugar is the dominant saccharide type of the Middle East cultivars, while sucrose is the major sugar type of North African, American and some Iraqi cultivars such as Zahdi. The current study focuses on some promising transmutation industries that convert the abundant sugar content of dates to added value products. Concerning the availability of dates as raw material, the investment in such industries bears the elements of success. Moreover, these industries provide job opportunity as well as the required technical expertise. As a result, the sustainability of the date palm cultivation and its socio-economic impact will be given further support.

### Sugar Extraction Stages

There are several date processing steps that can provide the proposed manufacturing with the appropriate juice as raw material. The first step is the date juice extraction and filtration. Since sugar is the main target of the extraction process, any applied technique should be efficient to leach most sugar content of the date. By definition, the extraction efficiency is the ratio of the amount of sugars that are actually obtained, to the actual amount of sugars available in date. Previous results revealed the effectiveness of continuous double stage counter-current technique to extract a

high percent of date sugar. This has minimum loss of residual soluble solids compared to a one-stage system, but maintains the same Brix level in the extracted juice (Al-Abid, 2005). With respect to the factors affecting the performance of the extraction process, the temperature of extraction and the contact time between material and liquid should be considered; increase of both will increase the extraction efficiency. However, the upper limit temperature is considered to be 65°-70° C, to avoid undesired reactions of the juice sugar (Belitz, 2004 and Al-Abid, 2005). In view of the fact that the obtained juice can be utilized as source of sugar assigned for certain application, additional purification steps of the feed by sophisticated ultrafiltration (UF) techniques is essential. Currently, ultrafiltration is exclusively used in the Dibis manufacturing of Saad (UAE) factory. To produce particular products dates' juice should be decolorized and demineralized (juice conditioning) first. The archetypal method to decolorize sugar solutions is based on the utilization of carbon. Other techniques have been applied to decolorize sugar liquors such as the novel applications of aluminum compound based coagulants as decolorizing aids in sugar refining, moving bed decolorization system, and granular activated carbon with pulse-bed (Dow, 2002a and Lurgi, 2004a & 2004b).

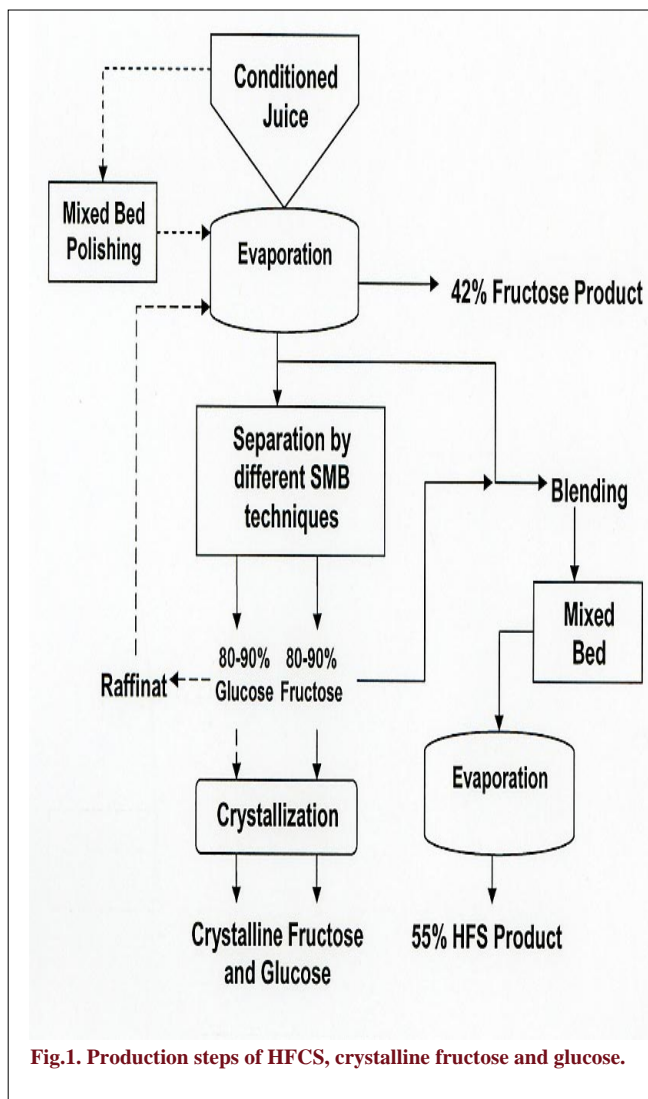
### High Fructose Corn Syrup (HFCS) and Sugars Production

High-Fructose Corn Syrups (HFCS) are now manufactured and used in many countries throughout the world. HFCS is produced from a variety of starch raw materials including corn, rice, tapioca, wheat, cassava, and sugar beet pulp. HFCS is consumed in large quantity in the United States by using corn starch as raw material. Crystalline fructose is now being used in a growing number of food applications. However its production as sweetener represents a small percentage of total fructose. In 2005 USDA estimated HFCS consumption per capita, as 42.2 lbs per year. USDA data reflected that the utilization of HFCS in food and beverage manufacturing and HFCS consumption increased,

<sup>1</sup> Expert of Food Technology, P.O.Box 673, Mena Al-Fahal 116, Sultanate of Oman, Fax: (+968) 893097. E-mail: mmralabid@yahoo.com

where as sugar consumption decreased. In Japan, HFCS provides quarter of the demand for sugar. HFCS vendors buy domestic produced starch at a fixed rate and U.S. produced HFCS increased from 2.2 million tons in 1980 to an average of 9.2 million tons, on dry weight basis, during 2000s. HFCS replaced the most expensive price sugar in a variety of uses (Bray, 2004). The utilization of date's juice as feedstock for the production of HFS is competitive to the units of operation of HFS production from starch, due to the elimination of liquefaction and saccharification steps. The following Flow chart (Fig. 1) summarizes the production steps of the HFS, crystalline fructose, and glucose.

Using chromatographic technique, fructose concentra-



tion can be increased to over 90%. The mechanism of the nearly all applied separation method which is known as ligand exchange chromatography (Paillit, 2000 and Dow, 2002b). However, a variety of types of SMB (Simulated Moving Bed) chromatographic separation techniques are recently introduced as efficient methods for the production of HFCS as well as the separation of fructose and glucose.

Modification of SMB to SSMB (Sequential Simulated Moving Bed) leads to the optimization of the linear velocity in the system in each zone; as well as fractions are extracted under optimal conditions, thus having positive effects on pressure drops and fraction purity. This technology requires a highly sophisticated monitoring control system, when high purities of fractions are needed (Paillit, 2000). The characteristic of Vogelbusch's modified SMB technology is the enclosing of the adsorbent bed in a single vessel. A circulating liquid stream is continuously passed through the sorbent bed in a closed cycle. Through this technique, maximum usage of column capacity and adsorbent resin kinetics could be achieved. Additionally, the proper design of the equipments would be helpful to extend the lifetime of the adsorbent resin, and also to get a uniform cross flow to reduce the analytical needs, since the concentration profile in a steady state and unchanged (Vogelbusch, 2002).

### Polyols Production

Polyols, or sugar alcohols, are not regarded as "sugars" and are regarded as a group of nutritive sweeteners which exhibit reduced caloric values compared to the respective value of most sugars, and this makes them suitable as sweeteners in the so-called light foods. Moreover, sugar alcohols are metabolized independently of insulin and are thus utilized in diabetic food products. Besides their applications in the food industry, sugar alcohol, such as mannitol, is also used in the pharmaceutical industry. In medicine, mannitol is used to decrease cellular edema (excessive accumulation of fluid) and increases the urinary output. Sorbitol is the least expensive crystalline polyol and is used extensively in the liquid form in oral care. It is used as a sweetener, plasticizer, and humectant and as intermediate substance in the manufacturing of vit C. The global market for polyols, i.e. mannitol and sorbitol, is estimated at US\$1.3 billion (€0.98 bn), with total sales volumes of 1397000 metric tons in year 2000. This volume is expected to increase at an average annual growth rate of 2.7 per cent for the next five years to reach 1597000 metric tons. The estimate of total sales will be US\$1.4 billion by year 2005 as the market grows at 1.3 percent, according to a study done by Business Communications Company (Nutra ingredient, 2005).

Production of the polyols can take place through hydrogenation of purified date syrup that contains both glucose and fructose exclusively in approximately equal amounts. Therefore, the hydrogenation will produce sorbitol and mannitol. The common hydrogenation process is performed at high pressure and temperature in the presence of a metal catalyst (i.e. raney nickel) and hydrogen. In this catalytic hydrogenation reaction, only the  $\alpha$ -fructose molecules are hydrogenated into mannitol, whereas the  $\beta$ -fructose molecules are hydrogenated into sorbitol (Von Weymar, 2002). Therefore, when a 50/50 glucose-fructose mixture (i.e. invert sugar) is used as the starting material, at neutral pH, only approximately 25% (w/w) of the initial sugar is hydrogenated into mannitol, whereas 75% is hy-

drogenated and converted into sorbitol. If date HFCS is used as the starting material and the hydrogenation is performed at alkaline pH, higher mannitol yields can be obtained (Schwarz, 1994). The most frequently used catalyst for this process is Raney-type Ni, and usually promoted with Mo due to its excellent settling properties, high activity and low cost price. However, during the hydrogenation of D-glucose to D-sorbitol leaching of nickel occurs through chelating by the produced sorbitol. For food industry, the maximum allowable concentration of Ni is 2 mg/kg. The leaching out of nickel and chelating by sorbitol can be overcome by using of ruthenium as catalysts, since ruthenium is stable against leaching (Hoffer *et al.*, 2003, Schimpf *et al.*, 2005).

The production of microbial mannitol is based on high cell density cultures of slowly growing heterofermentative lactic acid bacteria. The bioconversion of fructose to mannitol was performed in slowly agitated membrane cell-recycle bioreactor equipped with pH and temperature control. Neither aeration nor nitrogen flushing of the bioconversion medium is required, which drastically lowers the investment costs of such a plant due to the re-use of cell biomass in successive bioconversions. The best production strain (*Leuconostoc mesenteroides*) can be converted up to 95% (mol/mol) of fructose consumed into mannitol. Unfortunately, this is only achieved when a significant amount of glucose is co-metabolized by the cells (Von Weymarn, 2002).

### Citric Acid Production

Citric acid is the most important organic acid produced in large quantity by fermentation. Global production of citric acid in 2004 was about 1.4 million tones as estimated in a recent study of the market by Business Communications Co. BCC. The report showed that China accounts for 35-40% of worldwide citric acid production market and is leading the producers of citric acid of North America and Western European markets. Intensive competition with relatively low prices causes many small citric acid manufacturers in North America and Europe to leave the business in the past decade (Soccol *et al.*, 2006). Big producers then benefit to scale up their business economically as a result of this situation. Citric acid is widely used to impart a pleasant, tart flavor to foods and beverages. It also has applications in chemical and pharmaceutical industries (Al-Abid, 2005). The citric acid process is one of the rare examples of industrial fermentation technology where academic discoveries have worked in tandem with industrial know how. Nevertheless, the intimate knowledge about the large-scale fermentation and subsequent recovery processes are still regarded as industrial property. Although, the date juice has been investigated in Iraq as carbohydrate source to produce citric acid the results were kept on the shelves of universities and research institutions (Al-Abid, 2005). For more than 80 years citric has been produced in an industrial scale by the fermentation of carbohydrates, initially and exclusively by *Aspergillus niger*. However, in recent year, citric

acid can be produced by *Candida* yeasts as well, (Kristiansen, 1999). Citric acid production is strongly influenced by the type and concentration of carbon source. The presence of carbohydrates, which are rapidly taken up by microorganisms has been found essential for good production of citric acid. Since divalent metal ions such as zinc, manganese, iron, copper and magnesium have been found to affect citric acid production a rigorous control of the substrate should be accomplished. The submerged technique is widely used for citric acid production. It is estimated that about 80% of world production is obtained by submerged fermentation. This fermentation process is employed in large scale bases requires more sophisticated technique and rigorous control. On the other hand, it presents several advantages such as higher productivity and yields, lower labor costs, and lower contamination risk (Soccol *et al.*, 2006). Liquid surface culture is the classic citric production process and is considered the first industrial manufacture. Surface fermentation is still used in industries for small and medium scale because it requires less effort in operation, installation, and energy cost. The simplest method to produce citric acid is the solid-state fermentation, also known by "Koji" process. It has been an alternative method for using agro-industrial residues. Solid-state culture is characterized by the development of microorganisms in a low-water activity environment on an insoluble material that acts both as physical support and source of nutrients).

### Ethanol Production

In addition to the significance of ethanol as a solvent for many applications, it is considered as one of the renewable energy sources to replace the climbing fossil fuel. In spite of suspicions raised by several researchers, ethanol has long been a cornerstone of some national policies to many countries that depend on foreign oil (Svoboda, 2005). The USA Energy Policy Act of 2005 requires 7.5 billion gallons of ethanol and biodiesel to enter the nation's fuel supply by 2012, providing 5.75 percent of the nation's transportation fuel needs (Moreira, 2005).

Being produced in vast amounts from corn kernels in the United States and from sugarcane in Brazil, ethanol is the most common plant-to-fuel product, or biofuel, currently available. Standard gasoline engines can run on blends of gasoline containing up to 15% ethanol. Flexible-fuel vehicles can use blends with up to 85 percent ethanol. Brazil uses 20-24% ethanol with some engine and fuel system modification and the EU recommends that 5% ethanol to be mixed with petrol will be adopted before 2010. Ethanol burns cleaner and more efficiently than petrol, resulting in less environmental pollution (Thompson, 2005). Ethanol produced from corn starch requires an additional process, however date juice could be almost directly fermented without an additional process. In Iraq dates juice has been the main feedstock for ethanol production for many decades. In fact, the fermentation of dates extract needs the least pre-treatments and gives higher yield compared with the other available sugar sources such as molasses and liquefied and

saccharified starch (Al-Abid, 2005). Thus, the feasibility of the fermentation from date juice is ensured. Moreover, the values of the by products is supporting the revenue of the ethanol industry. Ethanol is produced through biochemical processes based on fermentation using date juice as sugar source. After preparation of a mash with the appropriate concentration of sugars and solids, the sugars are transformed into alcohol by using certain species of yeast, most importantly, *Saccharomyces cerevisiae*, as the catalyst. The biochemical reaction liberates a significant amount of CO<sub>2</sub> and heat. Much of the CO<sub>2</sub> liberated can be captured and converted into marketable products, such as dry ice, liquid CO<sub>2</sub> for soft drinks, fire-fighting foams, filtration products, and various industrial uses. After fermentation, the ethanol is distilled from other by-products, resulting in a level of purity of approximately 95%. A variety of Distillation column design and number are applied to purify ethanol according to the requirements of the end usage (Al-Abid, 2005 and Linas Technology, 2006).

### Vinegar Production

According to Mintel Custom Solutions, the overall non-food products containing vinegar increased by 131% between 2004 and 2005 (Presented in the annual meeting of the Vinegar Institute (VI), 2006). Household products accounted for over 50% of non-food consumption containing vinegar in the sub-category in 2005, which increased by 100% in comparison with 2004. In addition, they reported that non-foods containing vinegar increased significantly in Asia, Pacific and Europe between 2004 and 2005. New reports point out that the vinegar market is projected to reach \$415 million by 2010. This potential growth is attributed to premium and organic tar, "often dressed up in a palette of flavors"; in addition to the health benefits of vinegar (i.e., its ability to limit the rise in glucose levels) (VI, 2006). Recent, studies suggest that vinegar may increase calcium absorption and extraction from foods. Moreover, vinegar is regarded currently as an effective component of environmentally safe disinfectants, deodorizer and cleaner (VI, 2006). The demand for vinegar in GCC countries shows an ascending trend because of the expansion of some food and chemical industries that apply vinegar as ingredient (Al-Abid, 2005).

Nowadays, submerged culture technique is applied for the manufacture of most commercial vinegars of major consumption. It is carried out in a vessel that is heavily oxygenated by air bubbles supplied through an aerator or sparger. Throughout such sparger, it is likely to achieve a linear relationship between the overall acetic acid production and the volumetric oxygen transfer coefficient (kLa) (Fragapane, 1999). With the single stage, vinegar is produced with up to 17.5%. However, the dual stage produces vinegar with an acidity of up to 20.5%. It should be pointed out; that production of vinegar with acidities up to 20% requires particular strains of vinegar bacteria. Recently, the industrial trend is to achieve the acetic degree by a quick acetification process (submerged culture) and the

product is aged in wooden barrels afterwards. The purpose is to produce vinegars with similar quality in a shorter period.

### Baker's Yeast Production

Baker's yeast (*Saccharomyces cerevisiae*), is considered the most intensively cultivated and commercially produced microorganism, and has been extensively used for the production of single-cell protein (SCP) for human and animal consumption, and ethanol (industrial and potable alcohol) from fermentable sugars because of its GRAS (Generally Regarded As Safe) status (Akinyemi *et al.*, 2003). In addition, it is widely used in leavening of dough because of its ability to produce carbon dioxide, aroma and flavor of bread. Today the global baker's yeast industry produces about 2500 kton per annum (Van Hoek and Aristidou, 2003). About 80% of the yeast sold is in the form of either suspended cells (cream yeast) or compressed yeast. The remainder is sold as viable dried yeast. The global yeast market for baking is valued at over \$ 2.5 billion (Australian). The international baker's yeast market is expanding at about 4% per annum as a result of population growth and dietary changes. In many cases the new and expanding markets are not best suited to wet yeast product, due to lack of ideal transport and storage conditions, in comparison to dried yeast which is the best option. Therefore, it is expected that the ratio of wet to dried yeast consumption over the next five years will be changed significantly. Another market opportunity is represented by the yeast required for application in the multi-million dollar frozen dough manufacturing processes that are growing particularly in Europe and North America. The large demand for high quality (drinking) water in downstream processing of commercial baker's yeast (>15 m<sup>3</sup> wash water used per ton yeast produced) provides an environmental and economic incentive for novel fermentation processes on food-grade media (Van Hoek and Aristidou, 2003). The final yeast produced can be used in food applications without the need for downstream processing. A further inducement for sustainable production technology is that, due to improvements in refining of beet and cane sugar and the quality of molasses, the conventional feedstock for baker's yeast production is declining. Thus, the filtered dates extract is an appropriate substitute especially in the major date producing countries that have no beet or cane sugar production.

Several researches focus on the production of baker's yeast from date extracts. These researches were mainly directed to test the suitability of date extracts versus molasses. Good results were obtained and it seems that there is no technological constrain in using date extract except for the water requirements, which is limited in the greater part of these countries. Accordingly, the major challenge is to reconcile the conditions necessary for High Cell Density (HCD) cultivation with the quality requirements for industrial baker's yeast (high dough-leavening power and high storage stability). The first stage of yeast production consists of growing the yeast from the pure yeast culture in a

series of fermentation vessels. The sequence of the main fermentation stages varies among manufacturers. About half of the existing yeast operations are 2-stage processes and the remaining are 4-stage processes. When the 2-stage final fermentation series is used the pure cultivare

stage is followed by the stock and trade fermentations, and when the 4-stage fermentation series is used, the pure culture stage is followed by intermediate, stock, pitch, and trade fermentations.

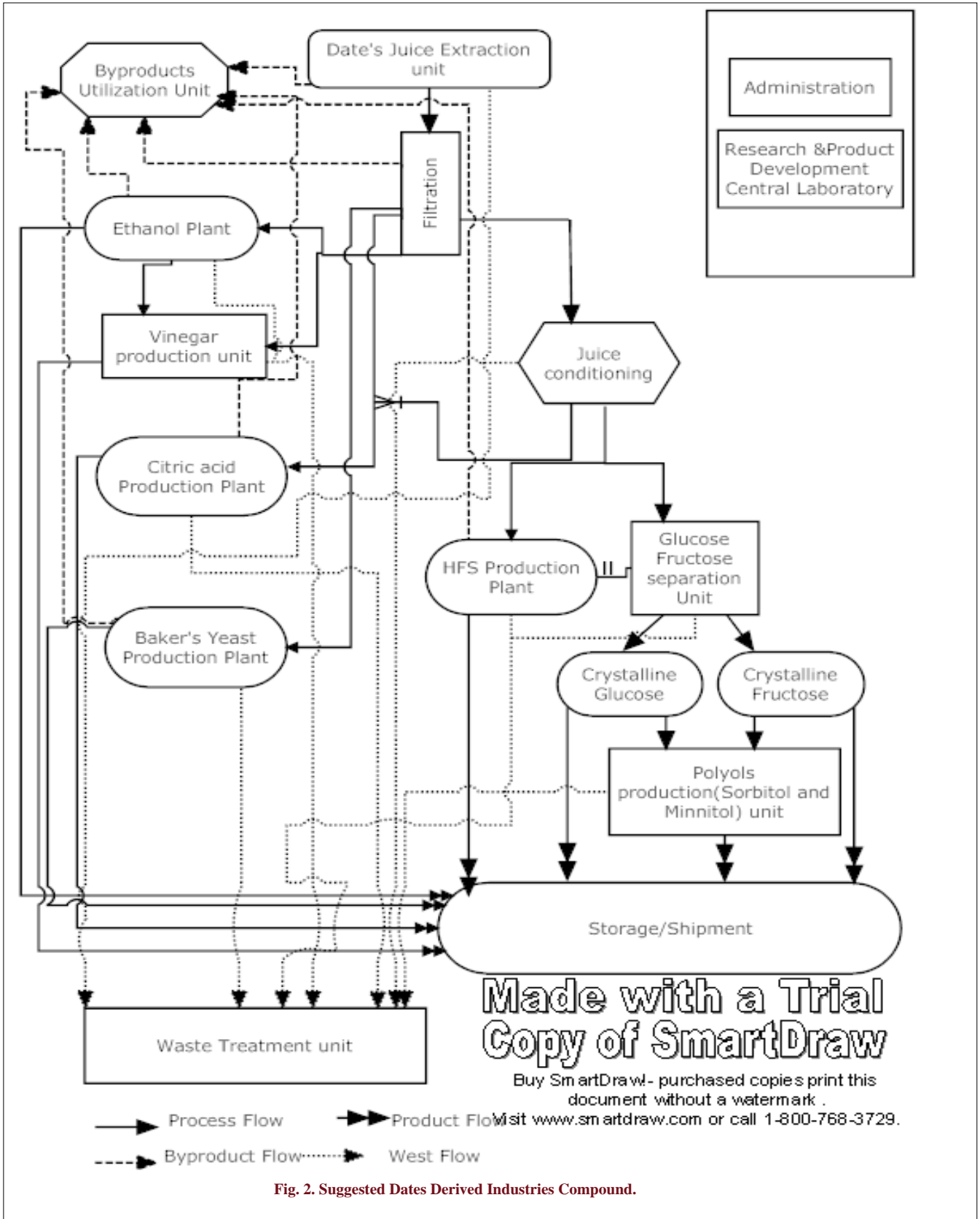


Fig. 2. Suggested Dates Derived Industries Compound.

## Recommended Dates Transmutation Industries

Obviously, some of the units of operation could supply more than the industries, mentioned in this study, with the sugary feedstock. Definitely, the multi usage of some compound units will generally decrease the cost. Thus, the design basis of the proposed industries, as depicted in figure (2), consider the similarities of the raw material requirement, isolation steps and effluent management. Modern process and plant design must reduce the raw material cost, capital investment, plant energy investment, plant energy consumption, inventory in the plant, and the amount of pollutant generated. The proposed project need improved process flexibility, safety and control technology. Process design should be based more on computer modeling, fundamental principles, and molecular simulations than today's semi-empirical approaches. The importance of design is demonstrated by the fact that during process design (about 2% of the total project cost) decisions are made that will fix the major portion of the capital and operating expenses of the final plant. Economic analysis is an important part of the process and plant design, The fixed capital investment of such a project consists of a number of items like purchased equipments, equipment installation, piping, instrumentation and control, electrical utilities, civil engineering and contingencies.

Definitely, the plant capacity/cost relationship is determined for the estimation of total cost, taking into consideration all auxiliaries outside the main process, such as environmental installation and material handling and storage. Other elements of the process economics like the manufacturing cost, profitability and breakeven point should be calculated as well. Prudentially, the economical analyses have to consider all previous parameters for each plant and for the whole compound. In addition, the dates as a novel feedstock for these assorted industries add extra burden on the designer, scientist, engineers and the executive staff. It is therefore important to include the industry compound a research and product development center besides the usual quality control laboratory, which is specified for each product.

## Conclusions

- The dates as raw material with various modifications is quite suitable for the transmutation industry.
- The higher production of particularly low quality dates in most of the Arab countries ensure the supply of the raw material.
- Most of the date transmutation industries utilize the same feedstock as starting material (i.e. filtered or conditioned date juice).
- The market overview of the date derived industry products shows a potential increase.

## Recommendations

- Conduct official feasibility studies of dates transmutation industries by large scale date producing countries to encourage investors.
- Promote researches that develop dates derived industries.
- Start media campaigns to introduce the dates derived industries to the investors community.
- Encourage large-scale production companies to move to dates as raw material through effective marketing policies.

## References

- Akinyemi, O., P.; Betiku, E. and Solomon ,B. O. 2003. Substrate channelling and energetics of *Saccharomyces cerevisiae* DSM 2155 grown on glucose in fed-batch fermentation process, *African J. Biotechn.* 2 (5), 96.
- Al-Abid, M. R. 2005. Dates Derived Industries: Technologies and Economics. Ministry of Agriculture and Fisheries. Oman (in Arabic).
- Belitz, H. D.; Grosh, W. and Schieberle, P. 2004. Food Chemistry. Springer Verlag Berlin Heidelberg, New York, USA.
- Bray. 2004. U. S. Sugar and Sweetener Yearbook series, Tables 50-52. US Dept. Agr. Econ. Res. Serv.
- Dow Ion Exchange Resins. 2002a. HFCS Deashing and Polishing. Reference Manual.
- Dow Ion Exchange Resins. 2002b. Chromatographic Separation of Fructose and Glucose with Dowex Monosphere Resins. Technical Manual.
- FAO STAT. 2006. www.fao.org.
- Fragapane, G.; Robio-Fernandez, H.; Nieto, J. and Salvadore, M. D. 1999. Wine vinegar production using a noncommercial 100L bubble column reactor equipped with anovel type of dynamic Sparger. *Bio-techn. Bioengen.*, 63, (2), 141.
- Hoffer, B., W.; Crezee, E.; Mooijmana, P. R. M.; van Langeveld, A.D.; Kapteijn F. and Moulijn, J.A. 2003. Carbon supported ru catalysts as promising alternative for raney-type Ni in the selective hydrogenation of D-glucose, *Catalysis Today*, 79-80, 35.
- Kristiansen, B. and Matthey, M. 1999. Citric Acid Biotechnology. Taylor & Francis, London Philadelphia.
- Linac Technology. 2006. Introduction in linac distillation technology. www.linac.ru.
- Lurgi Life Science GmbH. 2004a. High Fructose Syrup Production-Process and Economics, Basel-Chemnitz Frankfurt/Main Kuala Lumpur-Memphis-Shanghai.
- Lurgi life science GmbH. 2004b. Starch Saccharification Technology Basel - Chemnitz - Frankfurt/Main - Kuala Lumpur - Memphis - Shanghai.

- Moreira, N. 2005. Growing expectations, new technology could turn fuel into a bumper crop. www.sciencenews.org.
- Nutra ingredient-europ. 2005. www.nutraingredients.com.
- Paillat, D.; Cotillon, M. and Theoleyer, M. 2000. Technology of chromatographic separation in glucose syrup processes. Association AVH-7e Symposium, Mars, Reims, France.
- Schimpf, S.; Kusserow, B.; Mohr, C. and Claus, P. 2005. Deactivation phenomena of catalysts used for the hydrogenation of glucose. Poster, Technische Uniniversität Darmstadt.
- Schwarz, E. 1994. Sugar Alcohols: Mannitol. In Ullman's Encyclopedia of Industrial Chemistry, eds. B. Elvers, S. Hawkins and W. Russey, 5th ed., Vol. A25, VCH, Weinheim 1994, p. 423
- Soccol, C. R. 2006. Citric acid production. Food Techn. Biotechn., 44 (2), 141.
- Svoboda, E. 2005. UC scientist says ethanol uses more energy than it did makes a lot of fossil fuels go into producing the gas substitute. www.sfgate.com.
- The Vinegar Institute (VI). 2006. www.versatilevinegar.org.
- Thompson, R. and Campbell, S. 2005. Preliminary Feasibility of Ethanol Production from Sugar Beet in NE. Tasmania, Australia.
- Van Hoek, P. and Aristidou, A. 2003. Fermentation Gas large-scale, Biotechn. I CEP, Jan., 37.
- Vogelbusch. 2002. Enrichment of high fructose syrup - an example for a new chromatography application. Austria.
- Von Weymar, N. 2002. Process development for mannitol production by lactic acid bacteria. Helsinki Univ. Techn. Dept. Chem. Techn., Techn. Biochem. Report 1, 2002.

## الصناعات التحويلية للتمور

مُحمَّد مُصطفى راضي العبد<sup>1</sup>

### الخلاصة

إن إنتاج مواد ذات قيمة مُضافة من خلال صناعات التمور التحويلية يُمكن استخدامها في الصناعات الغذائية والصيدلانية والكيمياوية وخاصةً عندما تكون مادَّتها الأولية من التمور رديئة النوعية سيُساهم إلى حدٍ كبير في دعم اقتصاديات نخيل التمر. في هذه الصناعات يُحوَّل السُكَّر وهو المُكوِّن الرئيسي في التمور إلى موادٍ أُخرى، بواسطة وسائل فيزيائية-كيمياوية وتقنية حياتية. الدراسة الحالية تستعرض مُعظم صناعات التمور التحويلية كإنتاج الشراب الغني بالفركتوز ومسحوق الفركتوز والكلوكوز والكحولات المُتعدِّدة وحامض الستريك والكحول الاثيلي والخل وخميرة الخبز، بالإضافة إلى المُلاحظات الفنيَّة المُفيدة لتحويل مثل هذه الصناعات لجعلها مُؤاتمة للإنتاج المُعتمد على عصير التمر مع مسح لأحدث المعلومات السوقية المُتوقَّرة لكل مادة يُزَمَع إنتاجها. تُوصي الدراسة بالاهتمام بالصناعات التحويلية ونشرها من خلال توصيات مُحدَّدة وبناءً عليه يُقترح مخطَّط مُبتكر ومُتكامل للصناعات المُشار إليها أعلاه يتم الاستفادة من خلاله من وحدات العمل المُشتركة وذلك لخفض تكاليف الإنتاج كاستخلاص عصير التمر وتنقيته وتكييفه علماً بأنَّ مادة الدراسة أُعدَّت بناءً على أحدث المصادر ذات العلاقة بالإضافة إلى الاتصالات الشخصية.

<sup>1</sup> خبير صناعات غذائية، ص.ب. 973 ميناء الفحل 116 سلطنة عمان، فاكس: 893097 (+968)، بريد إلكتروني: mmralabid@yahoo.com