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Food Processing Wastes: Characteristics, Treatments and Utilization Review

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Abstract. Food industrial wastes from various industries contains substances which, due to their corrosive or toxic effects, cause damage to the sewage network, adversely affect the central sewagepurificationplants, reduce the self-purification of rivers and have an unfavorable effect upon the living conditions for the organisms in these waters. These substances (i.e., alkalis, acids, chlorides, solids and salts) contained in the industrial effluents can be removed by physical, biological and chemical means or at least their concentrations reduced to an acceptable level.

Key words: Food, waste, water, processing.

Introduction

For many food processing plants, a large fraction of the solid waste produced by the plant comes from separation of the desired food constituents from undesired ones in the early stages of processing. Undesirable constituents include tramp material (soil and extraneous plant material); spoiled food stocks; and fruit and vegetable trimmings, peel, pits, seeds, and pulp. In some food processing plants, caustic peeling is used to remove skins from soft fruit and vegetables such as tomatoes.This operation produces a highly alkaline or salty solid waste, depending on whether the alkalinity is neutralized. High-moisture solid waste materials can also be generated by water cleanup and reuse operations in which the dissolved or suspended solids are concentrated and separated from wastewater streams (Anon., 1997).

Waste application to land and feeding of wastes to livestock are two viable alternatives for waste management. These alternatives are especially desirable when the wastes are from the food processing industry because of low levels of priority pollutants. In fact, for appeal to farmers and others, these wastes might be labeled "agricultural processing wastes." (Brown *et al*., 1989).

Neither land application nor feeding of wastes to animals is particularly unique. Page *et al*. (1987) summarized the overall subject of sludge application to land. Likewise, Beszedits (1981)has discussed the feeding of sludge to animals.

Pomace constitutes a major part of the wastes from fresh fruit processing for wine, juice and soft beverage production, and accounts for 25% of the volume of the raw material processed (Nawirska and Kwasniewska, 2005).

Disposal of solid wastes to domestic sewers is becoming less favorable because of increased sewer rates and the reluctance of municipal sewage treatment plants to accept these waste streams, which have high biological oxygen demand (BOD) and, in some cases, high salt content. The practice of land-filling is becoming less favorable due to the generation of foul odors as communities expand and reside in proximity to food processing plants. Leaching of undesirable constituents such as salts, soluble organicsinto the soil and groundwater is also an important concern where the groundwater is used by communities or migrates into nearby streams. Currently, solid wastes disposed by land-filling or composting are minimally treated using dewatering screens, centrifugal screens or strainers to separate liquids from the solids(Anon., 1997). In the case of solids from juice extractors and sorting operations to remove blemished or spoiled fruits and vegetables, the solid waste is not treated before disposal. Similarly, low moisture content solid wastes that are potentially suitable as fuel or for incineration undergo minimal processing, such as size reduction and minimal drying(Anon., 1997).

Solid wastes sent to a sewer undergo comminution and are mixed with water or other liquid waste streams to produce acceptable flow properties and biological oxygen demand (BOD) loading. Some solid wastes disposed of as animal feeds are not further treated, but are fed (with silage) to local livestock, particularly dairy and beef cattle. Solid wastes from orange juice processors and distilleries can be dried and sold as livestock feed (Anon., 1997).

Characteristics of the food wastes

- High moisture content.
- High ferment ability.
- Nutrient status is good.
- Food wastes generally have lower content of inert contaminants such as stones
- Food wastes may increase other impurities such as plastics
- The output may have a higher salt content

In general, food processing wastes industry have the following characteristics (Litchfield, 1987):

- Large amounts of organic materials such as proteins, carbohydrates and lipids.
- Varying amounts of suspended solids depending on the source.
- High biochemical oxygen demand (BOD) or chemical oxygen demand (COD).

Types of food processing wastes

Food processing can be divided into four major sectors including fruit and vegetables; meat, poultry, and seafood; beverage and bottling; and dairy operations. All of these sectors consume huge amount of water for processing food. A considerable part of these waters are potential wastewaters to be treated for safe disposal to the environment.

There are many types of food processing wastes, such wastes are divided into two categories: wastewater (liquid wastes) and solid wastes and, in many cases, produce added value products.

1. Wastewater:

The food processing industry utilizes water to meet its individual day-to-day needs. Fifty percent of the water used in the fruit and vegetable sector is for washing and rinsing. Likewise, dairies utilize water as cleaning agent for process machinery. Water is the primary ingredient in products for the beverage and fermentation sector, and so, by increasing the amount of water used in the food processing, wastewater increased.

Characteristics of food-processing wastewater:

Food processing wastewater can be characterized as:

1. nontoxic, because it contains few hazardous compounds, with the exception of some toxic cleaning products.
2. Wastewater from food processing plants is organic.

3. Another contaminant of food processing wastewaters, particularly from meat, poultry, and seafood processing, is pathogenic organisms.

Ammar (2000) tabulated the physical, chemical and microbiological characteristics of wastewater from canning and chocolate plants as presented in Table (1).

The data presented in table (1) show that there are many differences between the characteristics of raw canning wastewater and raw chocolate wastewater.

From the mentioned characteristics, it could be noticed that canning waste water had acidity, chlorides, hardness, BOD, COD, SS, turbidity, total count and coliform group levels higher than those recorded for raw chocolate wastewater which it contained TDS and pH values were greater than those recorded for canning wastewater, so the treatment processes for each wastewater should be different and consequently the used chemicals and their doses should differ to produce effluents less dangerous and/or more safe into the sewage system.

Table (1). Physical, chemical and microbiological characteristics of some processing wastewater samples (Ammar, 2000).

Parameters	**Canning wastewater**	**Chocolate wastewater**
Total dissolved solids mg/L	780	1120
Conductivity m.S/cm*	1.116	1.601
PH	5.34	11.62
Acidity mg /L	72.675	Nil
Total hardness mg/L	600	250
Chlorides mg/L	92.47	9.99
BOD mg/L	362.5	345
COD mg/L	460	425
Suspended solids mg/L	4260	0.964
Turbidity NTU**	80	60
Alkalinity mg $CaCO_3$/L	Nil	489
Total count cfu/ml***	20,000	5000
Coliform group cfu/ml	9000	<30

*m.S/cm: milli Siemens/ centimeter, **NTU=NephelometricTurbidity Unit, ***cfu/ml: colony forming units/ milliliter.

Food processing wash water Wash water from such processes as vegetables and fruits processing; canning; slaughtering; baking, etc. Wash water results from food processing can be treated and reused. Clean in Place(CIP)water used for cleaning machines before or after processing. Preferably, cleaning in place water is reusing after treatment.

Slaughterhouse wastewater

It could be benefit to treat the slaughterhouse waste, it contains a lot of ingredients i.e., blood, fat, protein, hair…etc.

Fish and meat processing wastes contain a lot of organic solids i.e., blood, fat, protein.

Kitchen wastewater Kitchen waste contains different types of solids, fats, oils, grease, surfactants, acids, and microbes.

Bakery wastewater

The bakery wastewater also have baking organic solids and cleaning water.

Ammar (2006) reported the characteristics of baking processing effluents (BPE) and poultry slaughtering effluents (PSE) as presented in Table (2).

Results in Table (2) revealed that BPE and PSE effluents contained high levels of total dissolved solids (TDS) 1397 and 1035 mg/l, respectively. On the other hand, suspended solids (SS) in BPE and PSE were 1160 and 660 mg/l, respectively. Results also showed that, BPE and PSE exhibited high chemical oxygen demand (COD) values, being 8001 and 1240 mg/l, respectively. Turbidity measurement of BPE and PSE, 59 and 30 NTU (nephelometric turbidity unit) respectively.

Table (2) .Baking processing (BPE) and poultry slaughtering (PSE) effluents characteristics (Ammar, 2006).

Specification	Description	
	BPE	PSE
pH	5.8	7.2
Turbidity, NTU*	59.0	30.0
TDS[a], mg/l	1397.0	1035.0
SS**, mg/l	1160.0	660.0
COD[n], mg/l	8001.0	1240.0

*NTU=NephelometricTurbidity Unit, [a] TDS = Total Dissolved Solids,

** SS = Suspended Solids, [n] COD = Chemical Oxygen Demand.

2- Solid wastes:

Solid wastes include both organic and packaging waste. Organic waste, that is, the rinds, seeds, kernels, skin, and bones from raw materials, results from processing operations. Inorganic wastes typically include excessive packaging items that are, plastic, glass, and metal. Organic wastes are finding ever-increasing markets for resale, and companies are slowly switching to more biodegradable and recyclable products for packaging.

The proximate percent and composition of food processing solid wastes

Food processing wastes have been characterized on a unit basis by goinginto the plant and determining waste loads and flow rates at each step of the processing operation and relating each step to the total waste load. Table (3) summarizes the proximate percent of some food processing wastes.

Table (3). Proximate percent of some food processing wastes.

Food processing waste	%	Author(s)
Mango peels	7 – 24	Berardini, et al., 2005
Mango kernel	9 – 40	Berardini, et al., 2005
Carrot	20	World bank group, 1998
Broccoli	20	World bank group, 1998
Corn	4	World bank group, 1998
Peas	4	World bank group, 1998
Peaches	18	World bank group, 1998
Strawberries	6	World bank group, 1998
Shrimp	40 – 45	Ammar, 2006

Data in Table (4) show the proximate composition, on a dry-weight basis, of protein, fat and ash in the various by-product solids recovered with the aid of chitosan as a coagulating agent (Bough and Landes, 1978).

Table (4). Proximate composition of coagulated solids recovered from food processing waste effluents by coagulation with Chitosan (Bough and Landes, 1978).

Effluent	Solids composition %		
	Protein	Fat	Ash
Vegetable activated sludge	28	1	20
Poultry chiller	36	54	1
Poultry scalder	68	1	15
Egg washer waste	44	38	4
Meat packing	41	17	11
Meat processing and curing	14	-	-
Fruit cake	13	-	2
Cheese whey	75	0.2	10

Fruit and Vegetable processing:

Wastewater resulted from the fruit and vegetable food processing is high in suspended solids, and organic sugars and starches and may contain residual pesticides. Solid wastes include organic materials (i.e., rinds, seeds, kernels and skins) is handled by conventional biological treatment or composting.

Meat, Poultry, and Seafood:

The solid wastes resulted from meat, poultry, and seafood industries are high in protein and nitrogen content. They are excellent sources for recycled fish feed and pet food. Skeleton remains from meat processing are converted into bonemeal, which is an excellent source of phosphorus for fertilizers. Fats, oils, and greases (FOG) waste (typically from industrial fisheries) is used as a base raw material in the cosmetics industry.The simplemethod for removal of solid waste has been its use in animal feed, cosmetics, and fertilizers.

Dairy:

In general, dairy wastewater is pure milk raw material mixed with water.These wastewater from pasteurization or sterilization processes. Another wastewater source of the dairy processing is from equipment and tank-cleaning. These wastewaters containwaste milk and sanitary cleaners and are one of the principal waste constituents of dairy wastewater. Milk waste forms corrosive lactic and formic acids.Approximately 90% of a dairy's wastewater load is milk.

Food processing wastes treatment

Wastewater:

Wastewatertreatment could be carried out by using different physical methods (i.e., sedimentation ,grit removal, conditioning, floatation and thickening), chemical methods (i.e., chemical precipitation) and biological treatment methods, i.e., aerobic processes (trickling filters, activated sludge treatment,lagoons and spray irrigation) and anaerobic processes (contact process and sludge digestion).

Solid wastes:

Current use of food processing solid waste can be summarized as follows:

1. The production of high-value food by-products.
2. Disposal (by sewer or landfilling) a zero-value-added waste (a negative-value).
3. The next level of use for these materials is as animal feed.
4. Fuel value is the next lower use.
5. A low-value use is for composting or land application with limited soil amendment value.

Incineration

Incineration and use as a fuel are options in certain cases, but such uses are limited to those solid wastes that have relatively low water content and can be further dried with ease. The moisture content of suitable fuels is about 10% or less.

Animal feed

Feeding food by-products directly to livestock allows for former wastes to be useful again. In addition, the quantity of liquid and solid waste is reduced when by-products are fed to livestock rather than being disposed of in landfills or wastewater treatment plants.

Factors affecting the disposal of solid wastes as animal feed including:

1. The cost of shipping or transporting,
2. The purification during storage and transport, and
3. The presence of undesirable constituents such as alkaline or salt.

Dewatering

New dewatering schemes are needed to make food processing solid wastes more economical to handle for many applications. Common dewatering processes use a variety of mechanical means such as screw presses, belt presses, vacuum filters, etc. Separations involving other mechanical forces, such as ultrasonic and non-mechanical forces such as electric or magnetic fields, have been used in a few specialized sectors (Anon., 1997).

Electro-osmotic dewatering

There are definite potential benefits in combining multiple dewatering fields. The use of pressurized dewatering in the presence of an electric field is referred to as electro-osmotic dewatering. Using this system separation results were reported with three types of food wastes: apple pomace, brewer's spent grain, and fresh vegetable waste. Increases in dry solids content (up to 70% in the case of the fresh vegetables) in the product were achieved in all cases by coupling the electric field effect with the pressure effect. Energy consumption, per kilogram of water removed, was considerably less when compared with thermal drying (Orsat, *et al.,* 1996).

Electroacoustic dewatering

This technology improves the performance of mechanical dewatering machines by superimposing electric and ultrasonic fields. It has been coupled with belt driers and screw presses to replace thermal dewatering. Results using a belt press with electroacoustic dewatering (EAD) were very positive. Apple juice yields were increased from 75% up to 90%. Similarly, corn fiber was dewatered to 47% solids, compared 35% achieved with a screw press. Tests with orange pulp in a screw press EAD unit showed a positive, but small effect of the EAD. The results suggest that EAD is mechanically adaptable for screw presses, but has better potential to enhance the performance of lower-speed, tapered screw designs (Anon., 1997).

By-products recovery

New food products are always under development within the food processing industry, and these efforts should focus on use of the solid waste streams. For example, freeze-dried wheat water soluble recovered from a byproduct stream of a gluten-starch washing plant could be substituted for 10% of the egg whites in an angel food cake formula (Maziya-Dixon, *et al*., 1994).

A large number of specific new products have been identified and are being developed to use byproduct streams in new ways. In the case of cassava, a root crop widely used in developing countries, the fibrous residue is being investigated for a range of products including starch recovery and derivative high-glucose or high-fructose syrup, confectioner's syrup, ethanol, and growth medium for single cell protein (SCP), enzyme production, in addition to more traditional uses as animal feed, fertilizer, and biogas production (Ghildyal and Lonsane, 1990).

New types of seed oil have been identified as potential products. Apple (and Kiwi) seed oil recovery has been evaluated in New Zealand and found to be a potential money earner. These specialty oils would be used in cosmetics, but their recovery requires the development and implementation of the seed recovery systems first (Kennedy, 1994).

Solid waste reduction

Companies will continue to look at ways to reduce solid waste generation, use less or reusable packaging, and use biodegradable packing products. Excessive packaging has been reduced and recyclable products such as aluminum, glass, and high density poly ethylene(HDPE) are expected to continue being used to a wider degree in packaging situations.

Composting of food processing wastes

Composting, a very old biologically based technology, could be applied to wastewater sludge treatment. However, over the last several decades, it has not gained significant attention, because of the lack of a scientifically based knowledge for its application.

The basic principles in composting and the Solid State Bioconversion (SSB) are similar. However, in recent years, researchers have focused their attention on applying the SSB approach to optimize the composting process for the treatment of wastewater sludge. For an efficient degradation of wastewater sludge and wood waste, fungi and microorganisms' associations should be selected and then, for adjusted metabolic activities and microbial growth, the C:N ratio should be found. Microorganisms can degrade the organic carbon present in the composting substrate only when they have enough nitrogen sources for growth. In the case of nitrogen deficiency (the C:N ratio is too high), the composting process is inhibited. The availability of organic carbon is also crucial. Thus, taking into account the fact that the organic carbon obtained in fine disperse wood waste will be more rapidly utilized by microorganisms than that of coarsely shredded wood, specially adapted microbial associations can be applied in order to optimize the C:N ratio upon composting the waste of different dispersity, Figure 1. shows the conversion of photosynthesized biomass, by-products, waste, including their transformation under thermal conditions (Viesturs *et al*., 2004).

Composting is another option of disposal; however, odor and leaching of soluble constituents are limiting factors. Composted material is valued as a soil amendment or potting soil, but widespread use and marketability are constrained by shipping cost. Composition of the composting feedstock needs to be controlled to obtain the appropriate physical mix to allow the natural composting aerobic bioprocesses to proceed. Examples in the literature show that the full range of food processing wastes can be composted, including fruit and vegetable wastes such as peelings, skins, pomace, cores, leaves, and twigs; fish processing waste such as bones, heads, fins, tails, skin, whole fish and fish offal; meat processing wastes such as paunch contents, blood, fats, intestines, and manure; and grain processing wastes such as chaff, hulls, pods, stems and weeds (Schaub and Leonard, 1996).

Composting has the following benefits(Risse,2003, Schieber, *et al*., 2001):

1. Low transportation costs. The by-products can be composted on site, and the resultinghumus can have a volume and weight reduction of up to 40 percent.

2. Low capital investment. Composting is a batch process that can be done by using either a mound or a window system. In both systems all the by-products are managed to accelerate biological breakdown.

3. Good for seasonal processors. For a company (such as a cannery) that only processes food for several months a year, composting may be a suitable alternative to animal feeding or land filling. Livestock producers may be unwilling to switch to a livestock feed that is only available for a short period.

4. Long shelf life. Humus can be stored without spoiling and applied to enrich the soil as needed.

Viesturs *et al*., (2004) diagramed the conversion of photosynthesized biomass, by-products, waste, including their transformation under thermal conditions (Fig**.**1)**.**

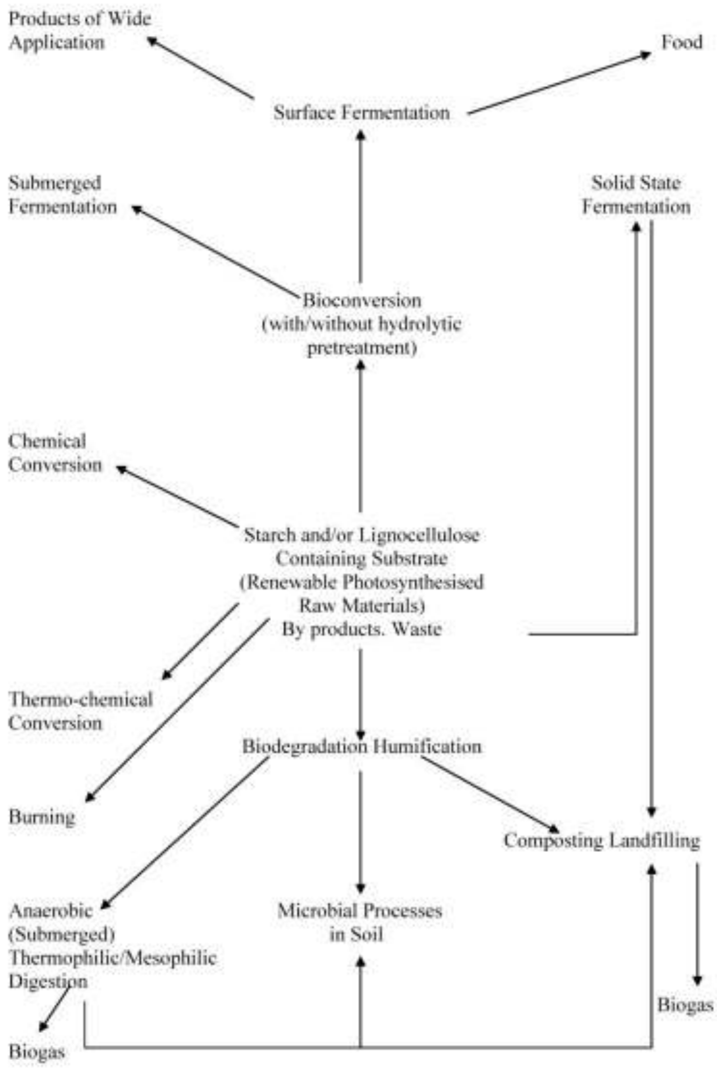

Fig.(1). Flow diagram of the conversion of photosynthesized biomass, by-products, waste, including their transformation under thermal conditions (Viesturs et al., 2004).

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مخلفات التصنيع الغذائي: الخصائص، المعالجة والاستخدامات

بحث مرجعي

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(قدم للنشر ٢٠١٣/٣/٣م، قبل للنشر ٢٠١٣/٦/٥م)

ملخص البحث. إن مخلفات التصنيع الغذائي الناتجة من مختلف الصناعات تحتوي علي بعض المكونات والتي نتيجة لتأثيرها السام أو المسبب للصدأ تسبب تدمير لشبكات الصرف الصحي ولها تأثيرات ضارة علي محطات المعالجة الرئيسية وأيضا تقلل من إمكانية التنقية الذاتية بالأنهار وكذلك تسبب روائح غير مرغوب فيها نتيجة توفر الظروف المناسبة للأحياء الدقيقة الملوثة لها. هذه المكونات (القلويات ، الأحماض، الكلوريدات، الجوامد والأملاح) الموجودة بالمخلفات السائلة يمكن إزالتها بطرق المعالجة المختلفة سواء الطبيعية أو الحيوية أو الكيميائية أو علي الأقل تقليل تركيزها إلي المستويات المقبولة.

الكلمات المفتاحية: الأغذية – المخلفات – الماء – التصنيع