

# **VALORIZATION OF FOOD WASTE TO POLYMERS**

Project Report submitted in fulfillment of major project of  
**BACHELORS OF TECHNOLOGY IN BIOTECHNOLOGY**

*by*

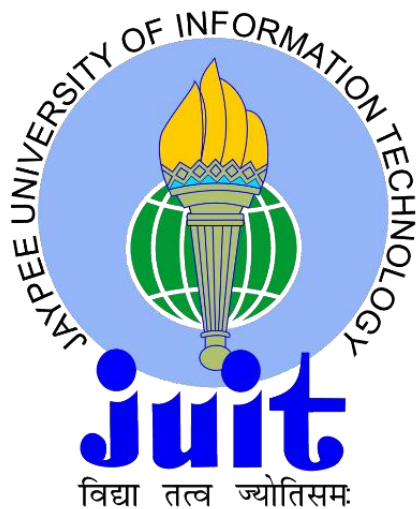
**VASUDEV SINGH (171802)**

*and*

**SUGAM SINGH (171812)**

*Under the Supervision of*

**DR. GARLAPATI VIJAY KUMAR**



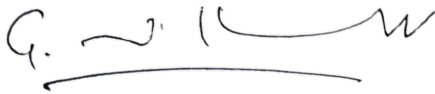
**DEPARTMENT OF BIOTECHNOLOGY AND BIOINFORMATICS**

**JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY**

**WAKNAGHAT, SOLAN (H.P)**

## **SUPERVISOR'S CERTIFICATE**

This is to certify that the major project work titled “Valorization of Food Waste to Polymers” submitted by **Vasudev Singh (171802)** and **Sugam Singh (171812)** during their 8th semester in May 2021 in fulfillment for the major project in Biotechnology of Jaypee University of Information Technology, Solan has been carried out under my supervision. This work has not been submitted partially or wholly to any other University or Institute for the award of any degree or appreciation.



(Signature of Supervisor)

**Name of Supervisor**-Dr. Garlapati Vijay Kumar

**Designation:** Associate Professor

Department of Biotechnology and Bioinformatics

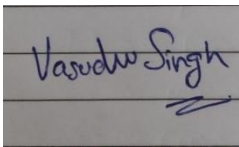
Jaypee University of Information Technology

Waknaghat, Distt-Solan, H.P. – 173 234

**Date** : 25th May,2021

## **DECLARATION**

I hereby declare that the major project work entitled “*Valorization of Food Waste to Polymers*” has been solely submitted to the Department of Biotechnology and Bioinformatics, Jaypee University of Information Technology, Waknaghat in due of the literature review and research work we have done under the major project in guidance of our supervisor **DR. GARLAPATI VIJAY KUMAR**



Vasudev Singh (171802)



Sugam Singh (171812)

Department of Biotechnology and Bioinformatics  
Jaypee University of Information Technology, Solan  
Waknaghat.

Date: 25th May,2021

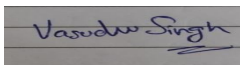
## ACKNOWLEDGEMENTS

We take this opportunity to express our first and foremost gratitude to our “DEPARTMENT OF BIOTECHNOLOGY AND BIOINFORMATICS” for the confidence bestowed upon us and entrusting our project title “*Valorization of Food Waste to Polymers*”.

At this juncture, with proud privilege and profound sense of gratitude we feel honored in expressing our deepest appreciation to **Dr. Garlapati Vijay Kumar**, for being a lot more than just a supervisor and going beyond the call of duty in our guidance, support, advice, and motivation throughout. He has been the source of inspiration to come what may, these issues cannot bring you down. Sincere thanks for his insightful advice, motivating suggestions, invaluable guidance, help and support in successful completion of this major project and also for his constant encouragement and advice throughout our minor project work.

Special thanks to our parents for their infinite patience and understanding and project partners for the constant support and most importantly God, who in his mysterious ways, always made things work out in the end.

In gratitude,



Vasudev Singh (171802)



Sugam Singh (171812)

## **TABLE OF CONTENTS**

SUPERVISOR'S CERTIFICATE	1
DECLARATION	2
ACKNOWLEDGEMENTS	3
TABLE OF CONTENTS	4-5
LIST OF TABLES	6
LIST OF FIGURES	6
ABSTRACT	7
INTRODUCTION	8-9
REVIEW OF LITERATURE	10-30
REVIEW OF FOOD WASTE.	
PLANT BASED FOOD WASTE	
<i>Potato Waste</i>	
<i>Corn Stover</i>	
<i>Mango Seed</i>	
<i>Citrus fruit waste</i>	
<i>Grape Waste</i>	
<i>Pumpkin Seed</i>	
<i>Sugar Bagasse</i>	
<i>Coffee Waste</i>	
<i>Banana Waste</i>	
<i>Avocado Seed</i>	
<i>Carrot Waste</i>	
<i>Peanut Husk</i>	

*Cereals Straw*

ANIMAL BASED FOOD WASTE

OBJECTIVES: 30-35

METHODOLOGY 31-35

BIOMASS SOURCE

*Starch*

*Cellulose*

*Chitin*

INDUSTRIAL BIOTECHNOLOGY

BIODEGRADATION OF POLYMERS

*Enzymatic Degradation*

*Non-Enzymatic Degradation*

CONCLUSION 36

REFERENCES 37-44

## **LIST OF TABLES**

Table 1 Substances found in Industrial food wastes in wt.%	11
Table 2 Substances found in Industrial food wastes in wt.%	12
Table 3 World's corn Production	17
Table 4 Chemical composition of corn Stover	18
Table 5 Chemical composition Mango almond	19
Table 6 Main grape producer	20
Table 7 World production of Pumpkin	21
Table 8 World Production of Sugar Bagasse	22
Table 9 Coffee Producers	23
Table 10 Banana production of the world	24
Table 11 Avocado production around the world	25
Table 12 Cereal producer around the world	28

## **LIST OF FIGURES**

Figure 1 Structure of Corn Stover	18
Figure 2 Industrial meat and by-product pathway	29

## **ABSTRACT**

The food squander created every year is roughly. There are artificial stocks which might get redirected to substance creation as a result of the oil value rises, inflicting no competition over land use and giving new abundance commencing open doors to food-delivering nations. It presumptively realigns the fashionable and farming areas of public economies. Food squander creation scales with the planet as requests for materials. This audit expands upon past milestone papers in compound Reviews that notice biomass in compound creation. It studies the current worldwide food-squander and shows but it's additionally used at intervals the age of hydrophobic polymers.

**Key words:** Biomass, compound synthesis, garbage , hydrophobic compound , biopolymer, inexperienced chemistry.



## **INTRODUCTION**

The term Valorization implies diverting previous food waste to either food items, feed items, or changing it over to or extricating food or feed fixings taking into consideration

a) A satisfactory supply of such streams (their strength of robustness, quality, and arrangement).

b) A satisfactory market importance of the intercession (mechanically achievable, financially reasonable, administratively consistent, and naturally practical).

This is getting more basic for the quickly developing worldwide populace which thus, is requesting more assets to ensure food security. A fragile harmony between expanded food creation and in general insignificant effect on the climate must be set up for an economical turn of events. A spin-off of this test the United Nations in 2015 embraced definite destinations in its “Maintainable Development Goals (SDG)” to scale back edible misfortune and lavish the world over to zero.5 per capita at every the shopper and dispersion focuses and therefore, food misfortunes with the creation chain by 2030.

Curiously, yet, the waste administration of food below the support of the Food and Agricultural Organization (FAO) is effectively driving in setting the definitional system of FLW. It alludes to food deprivation as, “food delivered for human utilization weren't edible for humans.” It went farther to characterize food deprivation as ;the decline among the overall or price of food,” whereas food squander is treated as a section of food deprivation that's alluded to as “the removal or non-edible utilization of food that was expected for utilization with the complete food creation and dispersion chain, that is, from creation to buyer”. whereas food squander is Associate in Nursing unexampled and distinct piece of food deprivation as a result of the reasons

for food squander and its preventative systems unit of measurement distinctive from those of food losses.

The amount of food deprivation and dissipation all round the world was placed at “~33% of food planned for utilization” (FAO, 2011). This was additionally separated per space round the globe and per capita, food squanders at the client level as 98-115 kg/year in North-America and Europe and “6–11 kg/year in geographic area and South/Southeast Asia” (FAO, 2011). In alternative exploration did by American state Laurentiis et al. (2018), that assessed food deprivation and squander inferable from creation up to definite utilization stage, it absolutely was resolved that nearly “180 kilogram for every individual annually of food is wasted yearly in Europe alone” Isah et al., 2019. An unprecedented extent of this loss is thanks to the patron level: “a little or no on top of 100 kilogram for every individual annually is formed at the client level of which seventy six kilogram is ascribed to singular homes and twenty five kilogram for cafés and food business.” Thus, the use of singular homes is exceptionally concerned with food deprivation and squandering. In China, “natural squander” was deeply ensnared and restricted to the use of vegetables, nuts, and new organic merchandise. These discoveries infer that automation and gathering development within the norm of life might prompt expanded utilization of merchandise of the soil, and thus , “high proportion of natural waste.” A comparable example was seen in Australia regarding leafy foods wherever it absolutely was involved, jointly reason for food deprivation and squander as high as 286 tons for each year (Zhang et al., 2010; Ghosh et al., 2017). many food deprivation and squander happens at the dissemination and purpose of human utilization

## **REVIEW OF LITERATURE**

### **REVIEW OF FOOD WASTE.**

Food squander sums annually. (Firn et al.,2009) because the innovation of food-handling creates, the pre-consumer food losses can generally diminish but within the created nations, buyer food squander can generally be a lot of outstanding. at this time giant numbers of those squanders square measure uneconomically utilised and square measure oftentimes discarded within the neighborhood climate, inflicting contamination problems. The agro-mechanical squanders that square measure accessible in huge sums incorporate among others, mash and citrus skin (mandarin/tangerine,orange,lemon, grapefruit, lime), seed squander ( grape ,mango, pumpkin), skin (banana and potato), espresso, nut husk, straw,also,sugar pulp. These squanders contain high substances of natural matter and, as found in Table one to boot, 2, they are loaded in fiber,fat,detritus,protein associate degreed sugars which can be used in an extremely few auxiliary applications.there's a worldwide examination effort to explore new useful employment opportunities.

Table 1 Material contained in industrial food waste in wt.%(Sanchez et al.,2013)

	Citrus Peel								
	Peanut Husk	Potato	Mango Seed	Sugar Bagasse	Grapefruit	Lemons	Lime	Orange	Mandarin
<b>Fibres</b>	26.2	2.40	3.96	--	11.9	14.9	14.4	--	--
<b>Lignin</b>	--	--	--	24.8	--	--	--	7.5 ± 0.6	8.6 ± 0.8
<b>Hemicellulose</b>	18.33	--	--	--	--	--	--	11.0 ± 1.1	6.0 ± 0.6
<b>Moisture</b>	--	--	40.5	--	8.2	10.6	10.1	--	--
<b>Protein</b>	7.39	10.2	1.43	0.5	4.9	9.3	9.7	9.1 ± 0.4	7.5 ± 0.2
<b>Sugar</b>	--	0.7	--	--	--	--	--	9.6 ± 0.2	10.1 ± 0.5
<b>Ash</b>	7.79	--	--	--	4.2	5.2	5.1	2.6 ± 0.1	5.1 ± 0.2
<b>Fatty Acids</b>	--	0.40	4.92	--	--	--	--	4.0 ± 0.2	1.6 ± 0.1
<b>Starch</b>	--	67.5	--	--	--	--	--	--	--
<b>Cellulose</b>	22.5	--	48.19	--	27.8	--	--	37.1 ± 3.1	22.6 ± 2.2
<b>Pectin</b>	--	--	--	0.7	--	--	--	23.0 ± 2.1	16.0 ± 1.2
<b>Lipids</b>	--	0.06	--	--	--	--	--	--	--
<b>Ether Extract</b>	6.31	--	0.83	3.9	1.1	2.8	2.9	--	--

<b>Nitrogen Free Extract</b>	52.4	--	--	--	69.6	67.8	67.9	--	--
------------------------------	------	----	----	----	------	------	------	----	----

Table 2 Material contained in Industrial food wastes in wt.%(Sanchez et al.,2013)

	Coffee						Carrot		
	Value of Pulp	Value of Husk	Value of Avocado Seed	Value of Wheat Straw	Value of Banana Peel	Value of Corn Stover	Value of Pomace	Value of Peel	Value of Leaf
<b>Cellulose</b>	48	57.89	33.12 ± 2.77	--	59.56	27.78 ± 2.82	19.35	31.0 ± 0.89	52.75 ± 0.71
<b>Carbohydrates</b>	--	--	--	28.0 ± 0.597	--	--	--	--	--
<b>Lipids</b>	--	--	1.9 ± 0.34	--	--	32.0 ± 2.68	1.1 ± 0.12	1.5 ± 0.15	--
<b>Starch</b>	--	--	--	--	--	--	--	--	--
<b>Pectin</b>	00	00	00	029.3 ± 0.69	00	00	00	00	00
<b>Protein</b>	00	00	056.0 ± 2.698	00	00	00	00	00	07.2 ± 0.15
<b>Moisture</b>	08	09.28	02.0 ± 0.694	07.8 ± 2.25	07.98	--	08.4 ± 0.25	09.7 ± 0.32	015.2 ± 0.54

<b>Fibres</b>	1.99	9	--	--	10.692	--	--	--	--
<b>Lignin</b>	--	--	--	$4.2 \pm 1.37$	--	$11.0 \pm 1.85$	--	--	--
<b>Fatty Acids</b>	19	--	$5.69 \pm 1.69$	$69.6 \pm 6.9$	7.7	--	$69.5 \pm 1.5$	$48.69 \pm 0.4$	$13.0 \pm 0.69$
<b>Ether Extract</b>	--	--	--	--	--	--	--	--	$2.75 \pm 0.1$
<b>Ash</b>	--	--	$1.9 \pm 0.27$	--	13.44	--	$7.78 \pm 0.01$	$10.3 \pm 0.34$	$10.57 \pm 0.3$
<b>Hemicellulose</b>	--	15.8	--	--	--	$7.69 \pm 1.89$	--	--	--
<b>Sugar</b>	--	--	--	--	--	--	--	--	--

The most ancient current uses area units as low cost steers feed or harvest manure, however completely different applications utilize food squanders as property wellsprings of gelatins, characteristic strands, oils, also, as a culture mode for parasites. They serves as a feed stocks for methane and biofuels production through physico-chemical and biological approaches. The food squander biomass quality may well be organized by the foremost vital accessible section, notwithstanding this scientific categorization leads to disarray since it's typically the lower yield things that have esteem and may well be sourced from varied species across various classifications. In addition, Associate in Nursing order obsessed on most elevated current utilization of biomass things can straightaway get obsolete. then we've a bent to first have confidence in the primary food squander assets one by one, inspecting their constitution, accessibility and current employment. The biomass-based wastes serves as a feedstock for new venturing business of new hydrophobic polymer chain (Fox et al., 2013). The biomass-based wastes can originate from the rural agricultural residues through post-harvest operations and considered to be environ-threat therefore the most ancient current uses as low cost steers feed or harvest manure, however completely different applications utilize food squanders as property wellsprings of gelatins, characteristic strands, oils, also, as a parasite dwelling homes.

Additionally, Associate in Nursing order smitten by most elevated current utilization of biomass things can straightaway get obsolete. then we've a bent to first admit the primary food squander assets one by one, inspecting the composition and accessibility (Fox et al., 2013). Food waste can be collectable as rural, postharvest, handling activities which usually uncontaminated hence it can be used to as substrate for industrial commodities production. Some authors like pteridophyte et al. utilize the term "food misfortunes" to portray pre-buyer squander consequently saving the expression "squander" with its orderly value judgement for native or buyer squander. The extent of mechanical what's extra, shopper squander shift with food kind. For instance, the Sixteen temperament issue form of the beginning creation of oats can be a pre-customer misfortune

and an extra 12-tone music is lost by the shopper overall. These extents shift topographically, the extra made countries having a bent to possess higher shopper misfortune and lower pre-customer misfortunes. For roots and tubers, then again, the pre shopper misfortune is ordinal of beginning creation and buyer misfortune merely six Gregorian calendar months 1944 by and large. For oilseeds and tubers pre-customer misfortunes another time rule at 2 hundredth whereas the client loses merely a try of on the underlying creation. it'll for the foremost 0.5 be expected that shopper squanders are too debased for auxiliary cycles apart from natural process.it may be employed in optional cycles like matter creation. Some authors like pteridophyte et al. utilize the term "food misfortunes" to portray pre-buyer squander consequently saving the expression "squander" with its orderly value judgement for native or buyer squander. The extent of mechanical what's extra, shopper squander shift with food kind. For instance, the Sixteen temperament issue form of the beginning creation of oats can be a pre-customer misfortune and an extra 12-tone music is lost by the shopper overall. These extents shift topographically, the extra made countries having a bent to possess higher shopper misfortune and lower pre-customer misfortunes. For roots and tubers, then again, the pre shopper misfortune is ordinal of beginning creation and buyer misfortune merely six Gregorian calendar months 1944 by and large. For oilseeds and tubers pre-customer misfortunes another time rule at 2 hundredth whereas the client loses merely a try of on the underlying creation. it'll for the foremost 0.5 be expected that shopper squanders are too debased for auxiliary cycles apart from chemical processes.



## **PLANT BASED FOOD WASTE**

### ***Potato Waste***

Potato (*Solanum tuberosum* L.) is one of the food stuff majorly in various countries (FAOSTAT, 2008). Overall, 25% of potato plant constitutes under wastage which may be in the form of plant matter and potato peel. China is presently the most effective potato maker at seventy 2 Tg once a year and right around a third of all potato units reaped in China and Russia. Starch is that the elementary and at sixty eight visible dry weight and utilizations for starch in polymers and as a forerunner to chemical compound subsidiaries is portrayed. Potato squander is likewise a wellspring of polyphenols that unit found predominantly inside the submerged. The polyphenolic and chlorogenic isomers fractions of potato tuber and its energy coefficient over cereal grains, the potato waste can serve as a substrates for a myriad products. In one approach of biomethanogenesis, the potato waste can be used as a substrate for biomethane production through the sequential steps hydrolysis, fermentation, acetogenesis and methanogenesis. Potato waste also serves as raw material for Xanthan, a food thickening agent, which is presently producing from sugars. Polylactic corrosive (PLA) is also one of the non-oily product from potato wastes (Bilanovic et al., 2010)

### ***Corn Stover***

Corn stover is another waste from Corn which is the major food-based crop of many countries (Table.3).Hub, shell, leaves, sheath and center, and sheath are the five sections of corn stover (Fig. 1). Reap is the only edible part, the rest is considered as food waste which accounts for 696 Tg of corn waste generated per year. The chemical composition of corn Stover was tabulated in Table 4. This could be the foremost plentiful lignocellulose property quality at intervals the globe because of its substance creation and conjointly the large amount created

every year around the world. As found in Table four, seventieth of the corn fodder is made out of ligno-cellulose relating to 487 Tg. the essential application for corn stovers is as manure however new freedoms for its utilization square measure arising, among them analysis on catalyst reaction and strong state maturation (Hongzhang et al.,2011) also, as a property hotspot for ethyl group alcohol production(Liao et al.,2011) utilizing *Pichia stipitis*,(Agbogbo et al.,2008) lignocellulolytic microbe (Zambare et al.,2011) or with microbial enzymes (Ryu et al.,2011). The another noteworthy product from corn stover is the biopolymer.

*Table 3 World's corn Production(Sanchez et al.,2013)*

<b>Country</b>	<b>Production/Tg</b>
India	16.7
Ukraine	10.5
Argentina	13.1
South Africa	12.1
France	15.3
USA	333.0
Indonesia	17.6
Brazil	51.2
Mexico	20.1
China	164.1
World	818.8

Table 4 Chemical composition of corn Stover(Sanchez et al.,2013)

Part of Plants	Weight Ratio (%)	Cellulose (%)	Hemicellulose (%)	Lignin (%)	Ash (%)	Acid insoluble Ash (%)
Node	15.4	33.3 ± 4.9	32.2 ± 3.2	10.1 ± 1.8	4.9 ± 1.1	0.5 ± 0.2
Core	22.9	28.9 ± 3.9	32.2 ± 2.4	12.5 ± 1.5	5.4 ± 1.3	0.5 ± 0.1
Leaf	32.0	26.2 ± 2.3	33.9 ± 1.9	9.3 ± 1.4	11.6 ± 1.5	1.6 ± 0.6
Shell	9.4	36.7 ± 3.2	27.5 ± 2.2	14.2 ± 1.0	4.6 ± 0.2	0.5 ± 0.2
Whole	100	27.8 ± 2.8	32.0 ± 2.6	11.0 ± 1.8	7.8 ± 1.6	0.9 ± 0.3

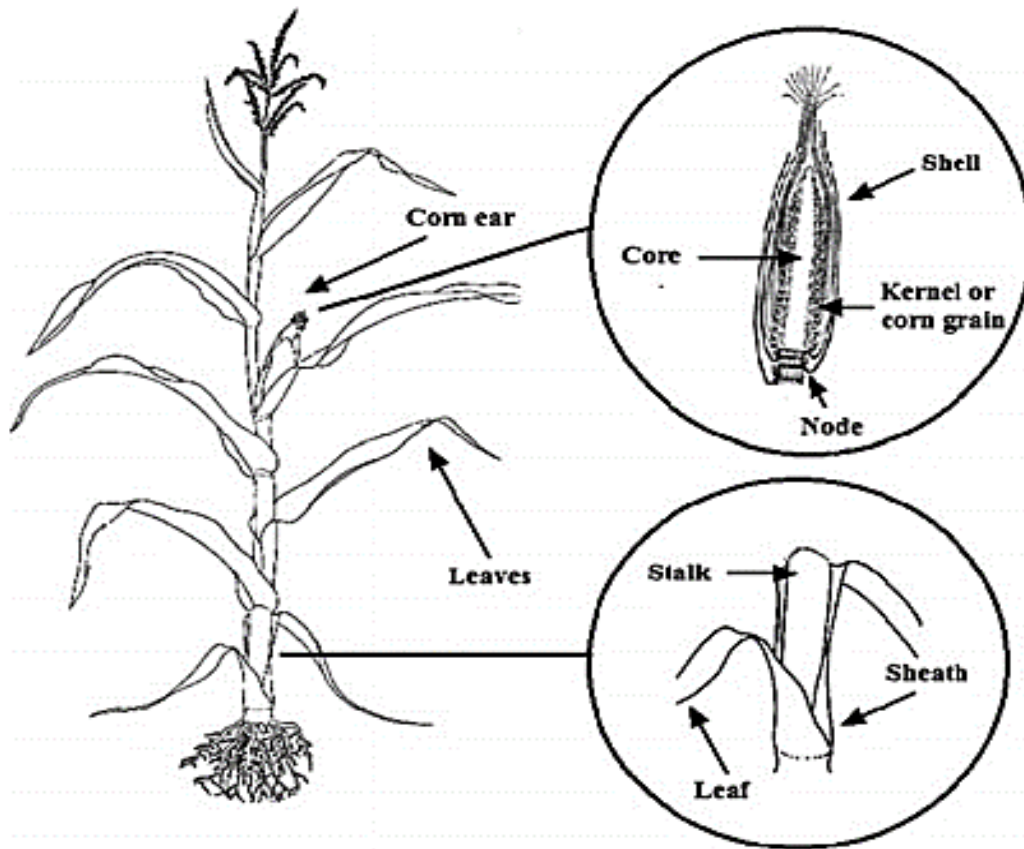


Figure 1 Structure of Corn Stover(Sanchez et al.,2013)

Polyhydroxyalkanoates (PHA) is made from corn grains even so there are endeavors to supply it in mix with corn fodder.(Dale et al.,2005) Another

methodology is that the substance natural process of the lignocellulosic materials at intervals the corn fodder, that's regarding seventy one (Table 4) of its absolute structure, utilizing alkene carbonate and additionally glycol as soluble and element corrosive as impetus for the planning of polyols. The lignocellulosic part of corn stover serves a raw material for polyols production towards subsequent biopolymers, radical acids and cyclic anhydrides production (Fei et al.,2006; Tipeng et al.,2008)

### ***Mango Seed***

Mango (*Mangifera indica*) is another tropical organic product of southern Asia. Overall, the seven south Asian nations are the world-baskets for the mango's supply chain in that India leads with the 39% share.

The strip and almond are waste parts of the mango and accounts for major mango waste which accounts for 15.7 Tg of annual yield. The composition of mango waste is mainly starch, fiber and fat (Table 5). The mango waste serves as a raw material for production of gelatin and acetic acid. The lipid fraction of mango waste comprises 52-56% of unsaturated fatty acids. The mango seed oil also have use in confectionary and dessert shops and also used as a substitute of cocoa butter (Kittiphoom et al.,2012; Nilani et al.,2010).

*Table 5 Chemical composition Mango almond(Sanchez et al.,2013)*

<b>Constituent</b>	<b>Amount %</b>
Carbohydrates	48.19
Fiber	3.96
Ash	0.83
Protein	1.43
Moisture	40.50
Fatty acids	4.92

### ***Citrus fruit waste***

Citrus wastes comprise waste from lemon (*Citrus limon*)/lime (*Citrus aurantifolia*), mandarins/tangerines (*Citrus nobilis*), orange (*Citrus sinensis*), grapefruit (*Citrus heaven*). Most citrus strip squanders are used for cattle feed and so the remainder is organized, creating an enormous quantity of traditional buildup waste.(Oluremi et al.,2007) The citrus waste used a maturation agents for enzyme production (Mamma et al.,2008) and as a colour ingredient (Chowdhury et al.,2008). The citrus (Mandarin) wastes were also reported for bioethanol production (Boluda-Aguilar et al.,2010). The usage of citrus wastes for gelatin production is one of the well-known business which have the mutiple applications in pharma and food industries. (Cho et al.,2003).

### ***Grape Waste***

The annual grape waste accounts for 15 Tg and the various countries of grape waste generation was tabulated in Table 6. Usually, around 30 weight units grape waste generated in in 100 L of wine production (Arvanitoyannis et al.,2006).

*Table 6 Main grape producer(Sanchez et al.,2013)*

Country	Production/Tg
EU-27	2.00
Turkey	2.00
Chile	1.03
Brazil	1.30
China	5.62
World	15.08

The seed oil of grape (10-20%) is a rich source of unsaturated linoleic acid (69–78%, w/w) which serves a better feedstock for biodiesel production. (Fern´andez et al.,2010). The tochopherol, polyphenol, proanthocyanidins of

grape seeds makes the valuable substrate with clinical significance. The polyphenolic content of grape skins high varies with the grape variety, is one of the better candidates for cancer treatment. Rather than various food squanders, an honest scope of ventures as of currently profit by grape squander as well as treating the soil, dietary enhancements, gas creation for warming functions, drug additional substances, and creature feedstuffs. It will consequently be contended that with this broad waste usage program effectively in progress, grape squander does not offer a solid and one amongst a brief likelihood for obtaining compound forerunners for numerous employment.

### ***Pumpkin Seed***

The pumpkin seeds the waste material from pumpkin accounts for 42 Tg annual yield and the foremost players in this business was summarized in Table 7. The unsaturated fatty acids of pumpkin seeds makes the pumpkin waste as a suitable substrate for bioenergy and biofuel industry with the improved physico-chemical properties of the end-use FAME's (Sanchez et al.,2013).

Table 7. World production of Pumpkin (*Sanchez et al.,2013*)

<b>Country</b>	<b>Production/Tg</b>
Ukraine	0.567
Egypt	0.75
Russian Federation	1.234
USA	0.758
China	6.59
World	21.25

### ***Sugar Bagasse***

Sugar Baggase is the waste from sugar cane industries (*Saccharum L.*) which typically used for production of sugars and grain alcohols, accounts for 130 Tg annual yield, dominant by India and Brazil (Table 8).

*Table 8 World Production of Sugar pulp (Sanchez et al.,2013)*

<b>Country</b>	<b>Manufacturing/Tg</b>
India	25.700
Mexico	5.454
Brazil	39.402
Thailand	6.877
China	11.726
World	130.437

The composition of sugar pulps accounts for the presence of 39% glucan and 22% xylan which serve as a raw material for paper and biofuel industries. It's mostly created out of compound (20–30%), polyose (40–45%), and hemicelluloses (30–35%). (Cardona et al.,2010) The limiting advance is that the debasement of polyose and hemicelluloses into sugars for ethyl radical alcohol creation is tortuous, energy-devouring, and contains a high price. The creation of ethyl radical alcohol from sugar pulp may be a heap of puzzling likewise as five cycles—biomass pre-treatment, polyose reaction, maturation of hexoses and pentoses, partition and emanating treatment (Cardona et al.,2010).

The biomass pretreatment depends on the solubilization and detachment of the segments needed (polysaccharides and carbs) for his or her additional treatment. The ensuing reaction breaks the chemical element obligations of the various atoms into their sugar segments, that square measure then aged into ethyl alcohol. (Demirbas et al.,2005) the importance of the ethyl alcohol course is that ethyl alcohol will endure a corrosive catalyzed parchedness to alkene, which can enter foursquare into a regular substance live plant. It may even be modified over into synthetic resin and used inside the union of vinyl chloride and for the creation of vinyl polymers and so on.

**Coffee Waste**

Globe low (Coffee Asp.) creation surpasses eight.4 Tg and there area unit 2 principle assortments, coffee tree and coffee tree. Brazil and Vietnam area unit the principle manufacturers dominate fifty three of world absolute creation (Table 9).

*Table 9 Coffee Producers (Sanchez et al.,2013)*

<b>Country</b>	<b>Manufacturing/Tg</b>
India	0.287
Uganda	0.195
Vietnam	1.124
Ethiopia	0.256
Indonesia	0.589
Guatemala	0.244
Peru	0.247
Brazil	3.323
Colombia	0.545
Mexico	0.289
World	8.387

The mechanical interaction to segregate java powder consists of eliminating the shell conjointly, adhesive piece of the cherries by either a wet or dry interaction, every delivering squanders with numerous synthesis. Endocarp, mesocarp, and pericarp from the dried organic product address hr of absolute weight, that is, 5 Tg/year. Coffee husk and mash compound arrangements have appeared albeit remarkably, these shift with plant, development conditions, and harvest. The deposits even have a vital level of alkaloid that limits their ensuing use whereas tannins hinder its utilization as cows feed due to counter-dietary impacts. Arrangement medicines and feed scale back the live off against healthful substances like polyphenols, tannins, and alkaloid (Rojas et al.,2002).



Coffee wastes can also be used as a substrate for production of proteins, microbial enzymes, alkaloids and food flavours along with the biogas and compost production (Pandey et al., 2000). The foremost recent applications incorporate the employment as strands for the creation of molecule boards (Bekalo et al., 2010) and as a supply for the mixture of SiO<sub>2</sub> nanoparticles. (Espíndola-Gonzalez et al., 2010)

### ***Banana Waste***

Probably the foremost notable Banana (*Musa sapientum*) is a variety of even accepted tropical organic product at intervals the globe and it's accessible consistently. The strip addresses ordinal of the banana fruit producing yearly around twenty 2 Tg of strips, quite a bit of that's native waste. The four primary makers unit of measurement Asian countries, Brazil, Ecuador, and China (Table 10) world organization, manufacture twenty seven Tg of bananas annually, being primarily 1/2 the yield and so manufacture 10.9 Tg of potential banana squanders (Mohapatra et al., 2010).

*Table 10 Banana production of the world (Sanchez et al., 2013)*

<b>Country</b>	<b>Production/Tg</b>
India	11
Indonesia	3.2
Philippines	3.6
Brazil	6.34
Ecuador	5.2
China	4.87
World	55.2

The debasement of starch and hemicelluloses by chemicals clarifies the late stage increment of sugar the overall compound organization of banana strips has appeared. The high substance of supermolecule (7.9%) and carbs (59.5%),

create it acceptable for parasite development and thus the high a vicinity of unsaturated fats (11.6%) shows it alright might even be utilized as associate degree elective wellspring of energy and presumably for biopolymers (Emaga et al.,2008 It usually utilized as a substrate for microfungus biomass production (Essien et al.,2005). From the biomethanation of banana strip, it's likewise conceivable to accumulate alkane by maturation utilizing flocculating yeast to supply unceasing fermentation alcohol production (Annadurai et al.,2002).

### ***Avocado Seed***

The product is from a native Mexican plant Avocado (*Persea Americana*) and essentially developed on heat and humidities. As per FAO51 the globe creation is around three.9 Tg annually wherever seventy six of absolutely the creation is strained by ten nations (Table 11). because it started in Mexico, this nation is the greatest maker with thirty second of world yield.

*Table 11 Avocado production around the world (Sanchez et al.,2013)*

<b>Country</b>	<b>Production/Tg</b>
Guatemala	0.098
Brazil	0.144
Dominican Republic	0.188
Indonesia	0.266
USA	0.277
Peru	0.166
Colombia	0.177
Chile	0.33
Mexico	1.234
China	0.101
World	3.856

The avocado natural product involves a boring inexperienced strip, inexperienced sleek mash, and a colossal seed that addresses 10-22% of completely the load contingent upon the species, implying that it contributes conceivably zero.85 Tg of waste. The seed is typically created out of damp and sugars, whereas the leftover 100 percent is lipids, proteins, remains, and fiber. The unsaturated fat structure of the avocado seed has appeared. It contains twenty seven unsaturated fats wherever seventeen square measure soaked (32% of absolute unsaturated fats), seven square measure monounsaturated (21%), and 3 square measure unsaturated unsaturated fats (47%). Exploration on avocado seed removal has zeroed in essentially on clinical and corrective applications. These keep in mind reads for the antimicrobial potential, skin and hair vaporised uses, for internal organ scleroprotein solubility, skin collagen-metabolism, and consequences for malady (Werman et al.,1998) Clearly additional intensive applications for unsaturated fats from avocado seed concentrate might exist memory their arrangement for chemical action.

### ***Carrot Waste***

Worldwide the second most thought vegetable The carrot ,*Daucus carota* was the potato for once. Carrot food squander consists of strips, the pomace left once juice creation, and leaves from gathering. Around 40–30% of carrot mash is delivered once the extraction of juice, exploit a high expected absolute world creation of result. The leaf encompasses an important amount of unrefined macromolecule and carbs, whereas the pomace contains quite an hour of fiber. Lipids and dirt area unit out there in comparable sums in all of the carrot side-effects. The side-effects of being browsed as crude materials for the creation of cell reinforcements. The carotenoids centralizations of  $\alpha$ -carotene,  $\beta$  – carotene and xanthophyll and inside the carrots pomace area unit fifty one, 6, and 36 ppm, severally. Likewise with the big variety of various food squanders, carrot leaf is largely aware of supplementing cows' food. Pomace and strip ar used as chance RACOD (Rapidly Acidifying Chemical number eight Request) provide of natural acids from microbial-production, as a wellspring of soluble fiber

hydrolyzate from accelerator production (yoon et al.,2005) and for the expulsion of number twenty four from chemical compound solutions.(Bhatti et al.,2010) The starch is used for the creation of PLA.(Jamshidian et al.,2010)

### ***Peanut Husk***

Enormous accumulated Peanut ,*Arachis hypogaea* L. is used in numerous social orders. The all throughout the planet formation of nutty in 2011, came to thirty four Tg.51 The grain sets up regarding half-hour, showing that ten Tg of total developments are created as husks. The 5 rule conveyance of title countries are China (14.6 Tg) India (6 Tg),USA(1.8 Tg), and Federal Republic of Nigeria (1.6 Tg). The composition fluctuates on the compound piece of nut husk. The burning of nut husks has offered a way to have an effect on numerous reusing plans. Nut husk also used as a substrates for fragrances, tones, chlorine, and organics substances and thus the additional third-dimensional is truly a wellspring of chemical element for power gadgets in an exceedingly few countries Chang et al.,2013). A chemical transformation for the formation of limitless chemical elements from nutshells is accessible. Nut shells ar moreover used for the maintenance of hurtful metal particles which subsequent used in waste water treatment (Asubiojoa et al.,2009). In assessment with pine wood, a typical copper remover in trade, nut husk disposes of ninety eight of copper particles from wastewaters whereas pine wood takes four hundred and forty yards. Nut shell waste is truly created out of fiber and is used as a facilitator in chemical compound composites whereas the oil obtained from the seed is commonly polymerized.

### ***Cereals Straw***

The overall creation of oats was a pair of.6 Pg According to the UN agency in 2011. This arrangement consolidates the formation of paddy ,wheat, maize, rice, popcorn, grain, rye, sorghum, , oats, millets, buckwheat, triticale, quinoa, fonio, bird food, mixed grains, and minority grains. The highest producer countries show up in Table 12. China is the crucial creator with two hundredth of the world's creation, followed by the USA and Asian countries with fifteen August

1945 and St Martin's Day, severally. These three countries end up forty second of traditional creation.

*Table 12 Cereal producer around the world (Sanchez et al.,2013)*

<b>Country</b>	<b>Production/Tg</b>
India	285.5
Ukraine	56.3
Argentina	50.2
France	65.7
Indonesia	83.4
Brazil	77.6
Russia	91.8
USA	386.8
Bangladesh	52.6
China	520.9
World	2587

The cereal yield stores resulting in get-together deals 50-75% of the laborious and quick creation. This shows that at any rate two.6 Pg of stores are created resulting in social events. A part of this development is left on the globe to diminish its crumbling and as waste matter as a result of it reincorporates common matter at intervals the dirt. it's what is more used for the formation of waxes by carbon dioxide extraction<sup>128</sup> for his or her usage in up specialists, sparkles, or the covering business, and as a biofuel in energy plants wherever it's supported to make high squeeze issue steam that is utilized to drive a rotary engine to make power, the use of the language plastic material to make strawboards, as fire-resistant of wood, and their use at intervals the advance trade.(King et al.,2006) they are conjointly used as, particularly for polymers,strongholds for numerous materials.

## Animal Based Food Waste

According to the FAO, the animal based waste comprises of 0.6 Pg China is the highest producer of animal- based food waste (Table 12). China is the crucial creator with 2 hundredth of the world's creation, followed by USA and Bharat with fifteen August 1945 and 11 November, severally. These three countries end up forty second of typical creation.

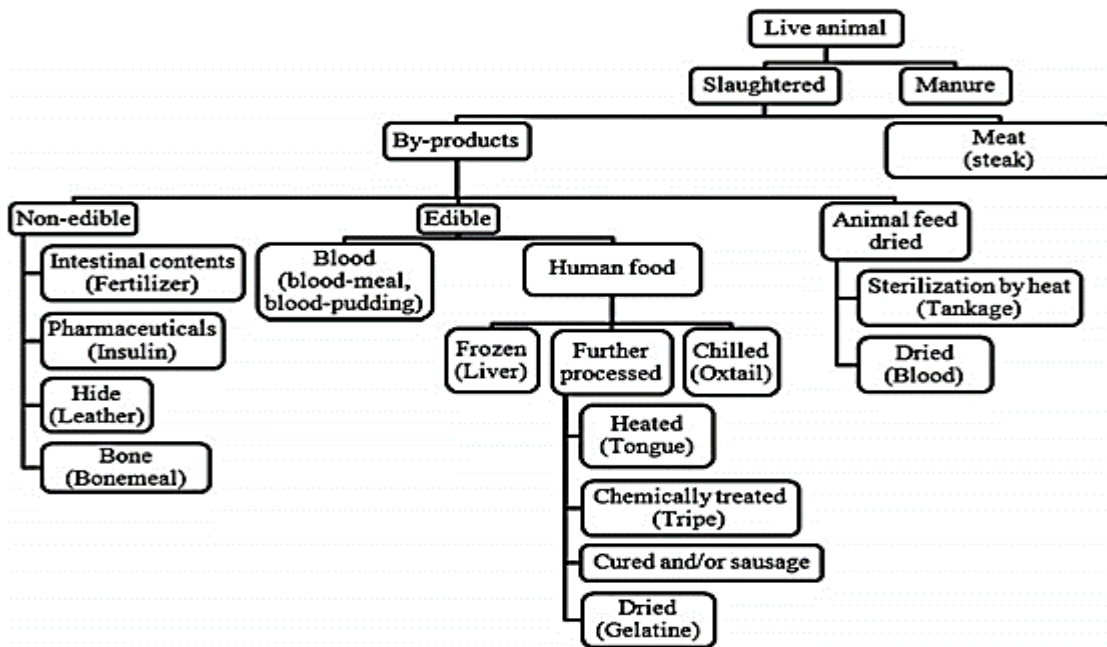


Figure 2 Industrial meat and by-product pathway (Sanchez et al.,2013)

Some unsavoury outcomes square measure treated for animal feed, waste material or macromolecule primarily based pastes. some tissue square measure used to create composite bone-cum-protein meals or individual things like bone-dinner, meat-dining expertise, and blood-supper. The complete quantity of waste is 10–15% of the live weight butchered (LWK) animal (Verheijen et al.,2013). In 2011, the general meat creation, in line with executive department, reached 244 Tg wherever forty second contrasted with pork, thirty fifth to poultry, and twenty third to beef.135 about twenty five Tg of sophistication three meat waste is created yearly among the globe. One application is the use of fat and oils for the assembly of biofuels. Triacylglycerols 3 long-chain unsaturated fats square

measure typically hydrolyzed or transesterified to acids or esters and alcohol. The esters square measure typically used as biodiesel once the alcohol is removed.(Feddern et al.,2012) different waste that is pursued for its ill-treatment is that the tufts which can be used for the creation of perishable thermoplastic films anyway get chemical change together with alkyl group salt.

By virtue of fish, the shellfish contains typically half-hour scroungers likewise, seventieth molluscs. Shellfish taking care of waste comprises four-hundredth exoskeletons (shell) whereas the invertebrate handling squander includes sixty fifth shells.138 In 2010, 20.8 Tg of invertebrate to boot, 11.8 Tg of shellfish were gotten, making 18.2 Tg of shell squander. This waste contains typically 100 percent of polyose on dry weight.(Thirunavukkarasu et al.,2011)

## **OBJECTIVES**

The objectives of the research are as follows

- Learning the proof of concept.
- Make a look into the possible methodologies.
- Characterization approach for produced polymers.

# **METHODOLOGY**

## **BIOMASS SOURCE**

The underlying 3 categories of rough material area unit starches, celluloses, and polysaccharide that represent the overall heading of polysaccharides, sugars made public by the event of monosaccharide stores through organic compound or hemiacetal linkages. they will furthermore be found as short saccharide progressions or compound intermittent units related to alternative biopolymers. square measure|they're} unit biopolymers that are removed directly as rough materials from plants and animals. Living creatures use polysaccharides for energy storing and underlying segments. the big agent macromolecules throughout this house unit of measurement polyose fiber, polyose film, and starch granules, and on they make-up around twenty 2 to thirty seventh of waste resources although they are referred to as unadapted polymers, they overall need to have a mass or surface compound modification, principally on the radical social events of their spine structure for his or her usage as biopolymers. The mass modification relates to the game came upon subordinates, of that chitosan can be a model, whereas surface modification incorporates similitude and reduction of hydrophilicity of normal strands through valency associations between the surface and conjointly the organization of the fibers. The modification of trademark polysaccharides has primarily turned around decreasing hydrophilicity (hydrophobization) by reducing the surface energy or by making AN adequate surface morphology to induce a water contact purpose quite ninety.

## **Starch**

Starch is made from provincial plants, usually from rice, maize, potatoes and wheat as deliquescent crystallites with estimates going from one to a hundred a



hundred. It seems like garbage , regardless, primarily in potato and to a lesser extent mango seed Starch-rich in amylose is supported in many cycles since its one-dimensionality guarantees higher stream properties and a development in extending and strength. Starch strength is broken when: (I) it's warm at 150°C wherever the glycoside joins begin to interrupt , (II) at 250°C visible of the breakdown of the event , and (III) at low temperatures once the retrogradation of starch happens Starch square measure typically used in its standard style, mixed or as a filler for, bury alia, the which means of tablets and cases, for clinical prosthetic device, or to reinforce paper execution. to be utilized in its typical construction, it must be modified to beat the defenseless heat, shear, and damaging strength equally as high rates and levels of retrogradation.

### *Cellulose*

Cellulose could also be a straight chemical compound with continuation units of anhydrous-D'Glucopyranose (cellobiose) wherever every compound contains 3 hydroxyl radical gatherings. It is a considerably glasslike and high nuclear weight biopolymer. polyose is delineated by its helpless dissolvability thanks to the sturdy intra-and between sub-nuclear atomic number 1 bonds within and among the individual chains. The detectable morphology of polyose is dependably wanting like strands. polyose fibers square measure used as strongholds, superseding fiber in composite materials with thermoplastics or thermosetting chemical compound networks. they supply the advantages of a decreasing in thickness and worth , lower fiber damaged region on handling instrumentality, the general openness of lignocellulosic strands, reusing openings, or repetition for energy recovery; methods that can't be applied to fiber polyose debasement square measure typically refined by proteins free from parasites, organisms, and protozoans that turn the oxidation reactions of

polyose, or lower nuclear weight oligomers sent from the protein reaction of polyose.

### ***Chitin***

Chitin might be a substance found in crustacean and bug frame, and may likewise be found in mushrooms and yeasts. Since polysaccharide has Associate in Nursing obstinate character and extremely helpless dissolvability, its immediate uses as Associate in Nursing chemical compound material unit of measurement square measure restricted. all the same, it's conjointly synthetically adjusted by incomplete basic N-deacetylation at high temperatures that prove the connected essential amino capability. Chitosan, the N-deacetylated results of polysaccharide, is maybe acknowledged once the number of deacetylation permits its status in acidic media. With an ordinal degree of chemical action, the polysaccharide chains become tolerably soluble, shaping stable totals throughout that the N-acetyl groups unit of measurement unpredictably taken. At the aim once it's on high of her it gets insoluble and secures primary ability. The subsidiary chitosan is to a degree one issue contrary to chitin; as a result of its inflexible semi clear structure, solid H holding, and free compact amino groups, it's soluble in somewhat acidic watery arrangements and insoluble in water and antacid media. The macromolecule polyosease is in charge of the debasement of polysaccharide whereas chitosanase and lysozymes corrupt chitosan.

### **Industrial Biotechnology**

White biotechnology could also be a term used for the distinction in property assets into new mixtures by joint development and protein cycles. Applied to the district of polymers, it consolidates polymers which are able to be sent in development measures or by compound chemical process mistreatment substrates created by a maturing cycle. The foremost outstanding models are the acyclic polyesters PHA and PLA. acyclic polyesters area unit parceled out into 2 essential gatherings in keeping with their holding technique for the constituent

monomers. One affair is that the poly(alkylene dicarboxylate) is coalesced by polycondensation reactions of diols (HO-R-OH) and radical acids (HOOC-R-COOH). The ensuing gathering contains the polyhydroxyalkanoates that are unit printed by reiterating units of radical acids (HO-R-COOH). PLA is sent by the compound development of potable corrosives obtained by maturing whereas PHA comes from microorganism cycles. Each biopolymer uses starch feedstocks for his or her creation. These area units are typically obtained from food wastes like nut husks, occasional wastes, banana strips, avocado seed, carrot waste, and oat husks.

## **BIODEGRADATION OF POLYMERS**

Biodegradation of polymers square measure typically pictured as a result of the molecule degradation of solid compound material into results, as AN example , water, CO<sub>2</sub> , minerals, oligomers, monomers, or midway mixtures throughout a native living space achieving the inadequacy of the mechanical, hidden, and substance responsibility of the principal mass chemical compound. The biodegradability of a chemical compound and consequently its ultimate outcome creation depends upon the compound structure of the mass material. it's going to usually be less dependent on the crude materials used for the creation of the chemical compound. The pathways by that biodegradation of traditional and built compound substances square measure typically accomplished are: The use of microorganisms that square measure divided into 2 groups: plant digestion below aerobic conditions and microorganism digestion which can be aerobic or anaerobic;

- The Enzymatic degradation
- The Non-Enzymatic degradation

### ***Enzymatic Degradation***

Enzymatic Degradation alludes to Biological reaction. Organic reaction, by and large, is performed by compound debasement measures. Their square measures 3 distinct catalysts that play out this response:- Hydroxylase catalyst, oxidoreductase catalyst, enzyme catalyst. Hydroxylase Enzymes foursquare consolidate gas within the substrate, oxidoreductase Enzymes imbed the whole gas atom, enzyme Enzymes utilize the gas particle as a chemical element acceptor making binary compound and a  $H_2O_2$ .

### ***Non-Enzymatic Degradation***

Non-Enzymatic debasement alludes to artificial chemical reactions. Substance chemical reaction may be a mass debasement live. It's caused once the chemical reaction is accomplished by the doorway of water into the mass compound delivering a decrease within the atomic load of the compound balance. On the off probability that this harmony is upset, an internal contact action corruption cycle begins. On account of acyclic polyesters created by means that of the carboxyl and hydroxyl group finish bunch side-effects. This contact action accelerates the inner debasement contrasted thereupon on a superficial level and might deliver Associate in Nursing empty out structure with a bimodal relative atomic mass dissemination. bimodal alludes to Associate in Nursing external layer with high sub-atomic weight Associate in Nursing an inner layer of lower sub-atomic weight.

## CONCLUSIONS

- ❖ Three factors are likely to displace the polymer and composite materials market towards biomass resources and away from mineral oil feedstock. They are: (i) the upward drift in mineral oil price, (ii) regulatory interventions intended to address climate change, and (iii) consumer preference for “eco-products.”
- ❖ The main sources which could be deployed in biopolymer production are potato waste, mango seed, citrus peel, coffee waste, straw, sugar bagasse, pumpkin seed, banana peel, avocado seed, corn stover, carrot waste, and peanut husk.
- ❖ These types of food waste are the most viable and they are produced, processed and commonly used in the majority of countries in the world, even though the quantity varies according to the region, Human Development Index of the country, and consumer social behavior.
- ❖ The most **important** applications of **bioprocess-engineering** research and development related to agriculture and food involve production of agricultural chemicals for control of animal and plant diseases, growth-stimulating agents for improved yield, and biological insecticides and herbicides.
- ❖ To be prepared for the biological manufacturing systems of the future, it is important to identify the fields of science.
- ❖ Bioprocess engineering is concerned with translating biological science into biologically based manufacturing.

## **REFERENCES**

1. Sanchez-Vazquez, S. A., H. C. Hailes, and J. R. G. Evans. "Hydrophobic polymers from food waste: resources and synthesis." *Polymer Reviews* 53, no. 4 (2013): 627-694.
2. Pleissner, Daniel, and Carol Sze Ki Lin. "Valorisation of food waste in biotechnological processes." *Sustainable chemical processes* 1, no. 1(2013): 21.
3. Firn, Richard D., and Clive G. Jones. "A Darwinian view of metabolism: molecular properties determine fitness." *Journal of Experimental Botany* 60, no. 3 (2009): 719-726.
4. Hoekstra, R. "International Year of the Potato." *Biodiversity Newsletter for Europe* 36, no. 6 (2008).
5. Furst-McNess company. Commodity nutrient profile, potato processing waste, use and application. [http://www.mcness.com/sites/default/files/file attach/PotatoWasteUSE03.pdf](http://www.mcness.com/sites/default/files/file_attach/PotatoWasteUSE03.pdf) (last accessed April 23, 2013)
6. Greenbiz news. Potato Power for Homes, Factories on McD's New Best Practices List. <http://www.greenbiz.com/news/2010/05/04/potato-power-homes-factories-on-mcdonalds-newbest-practices-list> (last accessed April 23, 2013).
7. Thirty thousand tonnes of potato waste converted into renewable energy. [http://www.freshplaza.com/news detail.asp?id=54469](http://www.freshplaza.com/news_detail.asp?id=54469) (last accessed April 23, 2013.)

8. Bilanovic, Dragoljub D., Samuel Hunter Malloy, and Petra Remeta. "Solid or semi-solid state fermentation of xanthan on potato or potato waste." U.S. Patent 7,727,747, issued June 1, 2010.
9. Production., Food and Agriculture Organization of the United Nations (FAOSTAT) and United State Department of Agriculture (USDA)" in the "Foreign Agricultural Service" <http://faostat.fao.org>. (last accessed April 23, 2013)
10. Hongzhang, Chen, Li Hongqiang, and Liu Liying. "The inhomogeneity of corn stover and its effects on bioconversion." *biomass and bioenergy* 35, no. 5 (2011): 1940-1945.
11. Liao, Wenjie, Reinout Heijungs, and Gjalt Huppes. "Is bioethanol a sustainable energy source? An energy-, exergy-, and emergy-based thermodynamic system analysis." *Renewable Energy* 36, no. 12 (2011): 3479-3487.
12. Agbogbo, Frank K., Frank D. Haagensen, David Milam, and Kevin S. Wenger. "Fermentation of acid-pretreated corn stover to ethanol without detoxification using *Pichia stipitis*." In *Biotechnology for Fuels and Chemicals*, pp. 53-58. Humana Press, 2007.
13. Ryu, Seunghyun, and Muhammad Nazmul Karim. "A whole cell biocatalyst for cellulosic ethanol production from dilute acid-pretreated corn stover hydrolyzates." *Applied microbiology and biotechnology* 91, no. 3 (2011): 529-542.
14. Zambare, Vasudeo P., Aditya Bhalla, Kasiviswanath Muthukumarappan, Rajesh K. Sani, and Lew P. Christopher. "Bioprocessing of agricultural residues to ethanol utilizing a cellulolytic extremophile." *Extremophiles* 15, no. 5 (2011): 611.

15. Kim, Seungdo, and Bruce Dale. "Life cycle assessment study of biopolymers (Polyhydroxyalkanoates)-Derived from No-Tilled Corn (11 pp)." *The International Journal of Life Cycle Assessment* 10, no. 3 (2005): 200-210.
16. Yu, Fei, Yuhuan Liu, Xuejun Pan, Xiangyang Lin, Chengmei Liu, Paul Chen, and Roger Ruan. "Liquefaction of corn stover and preparation of polyester from the liquefied polyol." In *Twenty-Seventh Symposium on Biotechnology for Fuels and Chemicals*, pp. 574-585. Humana Press, 2006.
17. Wang, Tipeng, Lianhui Zhang, Dong Li, Jun Yin, Sha Wu, and Zhihui Mao. "Mechanical properties of polyurethane foams prepared from liquefied corn stover with PAPI." *Bioresource technology* 99, no. 7 (2008): 2265-2268.
18. Kittiphoom, S. "Utilization of mango seed." *International food research journal* 19, no. 4 (2012).
19. Nilani, P., P. Raveesha, N. B. R. N. Kasthuribai, and B. Duraiswamy. "Formulation and Evaluation of Polysaccharide Based Biopolymer—an Ecofriendly Alternative for Synthetic Polymer." *Journal of Pharmaceutical Sciences and Research* 2, no. 3 (2010): 178-184.
20. Hosni, Karim, Nesrine Zahed, Raouf Chrif, Ines Abid, Wafa Medfei, Monem Kallel, Nadia Ben Brahim, and Houcine Sebei. "Composition of peel essential oils from four selected Tunisian Citrus species: Evidence for the genotypic influence." *Food Chemistry* 123, no. 4 (2010): 1098-1104.
21. Oluremi, O. I. A., I. A. Andrew, and J. Ngi. "Evaluation of the nutritive potential of the peels of some citrus fruit varieties as feedingstuffs in livestock production." *Pakistan Journal of Nutrition* (2007).



22. Mamma, Diomi, Elisavet Kourtoglou, and Paul Christakopoulos. "Fungal multienzyme production on industrial by-products of the citrus-processing industry." *Bioresource technology* 99, no. 7 (2008): 2373-2383.
23. Chowdhury, Sachchidananda D., Begum M. Hassin, Shubash C. Das, Md H. Rashid, and Abu JM Ferdaus. "Evaluation of marigold flower and orange skin as sources of xanthophyll pigment for the improvement of egg yolk color." *The Journal of Poultry Science* 45, no. 4 (2008): 265-272.
24. Boluda-Aguilar, María, Lidia García-Vidal, Fayiny del Pilar González-Castañeda, and Antonio López-Gómez. "Mandarin peel wastes pretreatment with steam explosion for bioethanol production." *Bioresource technology* 101, no. 10 (2010): 3506-3513.
25. Cho, Chang-Won, Do-Youn Lee, and Chan-Wha Kim. "Concentration and purification of soluble pectin from mandarin peels using a crossflow microfiltration system." *Carbohydrate Polymers* 54, no. 1 (2003): 21-26.
26. Mundial, Elementos de Coyuntura Vitivinícola. "Organisation Internationale de la Vigne et du Vin." *Paris. Francia* (2008).
27. Porter, Professors Michael, Hirotaka Takeuchi, Maria Baibakova, Matthew Guilford, Jennifer Lee, Rami Sarafa, and Marius Weigand. "The French Wine Cluster." *Harvard Business School* (2013).
28. Private comment from Robert Tinlot, ex-president and honorary general manager and director of the "Office International de la Vigne et du Vin" (OIV), president of the Amorim Academy and present honorary head of Chateau Changyu AFIP Global.

29. Arvanitoyannis, Ioannis S., Demetrios Ladas, and Athanasios Mavromatis. "Potential uses and applications of treated wine waste: a review." *International Journal of Food Science & Technology* 41, no. 5 (2006): 475-487.
30. Fernández, Carmen María, María Jesús Ramos, Ángel Pérez, and Juan Francisco Rodríguez. "Production of biodiesel from winery waste: extraction, refining and transesterification of grape seed oil." *Bioresource technology* 101, no. 18 (2010): 7019-7024.
31. Hamman, Evan, and Felicity Deane. "The control of nutrient run-off from agricultural areas: Insights into governance from Australia's sugarcane industry and the Great Barrier Reef." *TEL* 7 (2018): 451.
32. Almazan, O., L. Gonzalez, and L. Galvez. "The sugar cane, its by-products and co-products." In *Proceedings of the Third Annual Meeting of Agricultural Scientists, Réduit, Mauritius, 17-18 November 1998*. Food and Agricultural Research Council, 1999.
33. Cardona, C. A., J. A. Quintero, and I. C. Paz. "Production of bioethanol from sugarcane bagasse: status and perspectives." *Bioresource technology* 101, no. 13 (2010): 4754-4766.
34. DEMİRBAŞ, AYHAN. "Bioethanol from cellulosic materials: a renewable motor fuel from biomass." *Energy sources* 27, no. 4 (2005): 327-337.
35. International Coffee Organization. Methods for coffee extraction. [http://www.ico.org/field\\_processing.asp](http://www.ico.org/field_processing.asp) (last accessed April 23, 2013)
36. Rojas, JB Ulloa, J. A. J. Verreth, J. H. Van Weerd, and E. A. Huisman. "Effect of different chemical treatments on nutritional and

- antinutritional properties of coffee pulp." *Animal Feed Science and Technology* 99, no. 1-4 (2002): 195-204.
37. Pandey, Ashok, Carlos R. Soccol, Poonam Nigam, Debora Brand, Radjiskumar Mohan, and Sevastianos Roussos. "Biotechnological potential of coffee pulp and coffee husk for bioprocesses." *Biochemical Engineering Journal* 6, no. 2 (2000): 153-162.
  38. Bekalo, Samson Ayele, and Hans-Wolf Reinhardt. "Fibers of coffee husks and hulls for the production of particleboard." *Materials and structures* 43, no. 8 (2010): 1049-1060.
  39. Espíndola-Gonzalez, A., A. L. Martínez-Hernández, C. Angeles-Chávez, V. M. Castano, and C. Velasco-Santos. "Novel crystalline SiO<sub>2</sub> nanoparticles via annelids bioprocessing of agro-industrial wastes." *Nanoscale research letters* 5, no. 9 (2010): 1408-1417.
  40. Emaga, Thomas Happi, Christelle Robert, Sébastien N. Ronkart, Bernard Wathelet, and Michel Paquot. "Dietary fibre components and pectin chemical features of peels during ripening in banana and plantain varieties." *Bioresource Technology* 99, no. 10 (2008): 4346-4354.
  41. Essien, J. P., E. J. Akpan, and E. P. Essien. "Studies on mould growth and biomass production using waste banana peel." *Bioresource Technology* 96, no. 13 (2005): 1451-1456.
  42. Bardiya, Nirmala, Deepak Somayaji, and Sunil Khanna. "Biomethanation of banana peel and pineapple waste." *Bioresource technology* 58, no. 1 (1996): 73-76.
  43. Annadurai, G., Ruey-Shin Juang, and D. J. Lee. "Adsorption of heavy metals from water using banana and orange peels." *Water science and technology* 47, no. 1 (2003): 185-190.

44. Gómez López, Vicente Manuel. "Characterization of avocado (*Persea americana* Mill.) varieties of very low oil content." *Journal of Agricultural and Food Chemistry* 46, no. 9 (1998): 3643-3647.
45. Rodríguez-Carpena, Javier-Germán, David Morcuende, María-Jesús Andrade, Petri Kylli, and Mario Estévez. "Avocado (*Persea americana* Mill.) phenolics, in vitro antioxidant and antimicrobial activities, and inhibition of lipid and protein oxidation in porcine patties." *Journal of agricultural and food chemistry* 59, no. 10 (2011): 5625-5635.
46. Mueller, Reinhard, Kurt Seidel, Anke Kaczich, Detlef Hollenberg, and Iduna Matzik. "Skin and hair aerosol foam preparations containing an alkyl polyglycoside and vegetable oil." U.S. Patent 6,045,779, issued April 4, 2000.
47. Mueller, Reinhard, Kurt Seidel, Anke Kaczich, Detlef Hollenberg, and Iduna Matzik. "Skin and hair aerosol foam preparations containing an alkyl polyglycoside and vegetable oil." U.S. Patent 6,045,779, issued April 4, 2000.
48. Werman, M. J., S. Mokady, M. E. Ntmni, and I. Neeman. "The effect of various avocado oils on skin collagen metabolism." *Connective tissue research* 26, no. 1-2 (1991): 1-10.
49. Yoon, Kyung Young, Myeonghwa Cha, Seung Ryeul Shin, and Kwang Soo Kim. "Enzymatic production of a soluble-fibre hydrolyzate from carrot pomace and its sugar composition." *Food Chemistry* 92, no. 1 (2005): 151-157.
50. Bhatti, Haq Nawaz, Abdul Waheed Nasir, and Muhammad Asif Hanif. "Efficacy of *Daucus carota* L. waste biomass for the removal of chromium from aqueous solutions." *Desalination* 253, no. 1-3 (2010): 78-87.

51. Jamshidian, Majid, Elmira Arab Tehrani, Muhammad Imran, Muriel Jacquot, and Stéphane Desobry. "Poly-lactic acid: production, applications, nanocomposites, and release studies." *Comprehensive reviews in food science and food safety* 9, no. 5 (2010): 552-571.
52. Chang, E. Peanut shells, corn stalks: China's alternative to coal? CNN World. <http://articles.cnn.com/2009-12-06/world/china.alternative.energy.coal.chinese-governmentboilers-low-carbon?s=PM:WORLD> (last accessed April 23, 2013).
53. Bieak, Nicole, and Brian R. George. "Utilization of peanut shell fibers in nonwoven erosion control materials." *International Nonwovens Journal* 4 (2003): 1558925003os-1200414.
54. Bauder, J. Cereal crop residues and plant nutrients. Montana State University Communications Services. <http://www.montana.edu/cpa/news/wwwpb-archives/ag/baudr230.html> (last accessed April 23, 2013)
55. King, Bruce, and Mark Aschheim. "Design of straw bale buildings: the state of the art." (2006).
56. Stoytcheva, Margarita, and Gisela Montero, eds. *Biodiesel: feedstocks and processing technologies*. BoD—Books on Demand, 2011.
57. Thirunavukkarasu, N., K. Dhinamala, and R. Moses Inbaraj. "Production of chitin from two marine stomatopods *Oratosquilla* spp.(Crustacea)." *Journal of Chemical and Pharmaceutical Research* 3, no. 1 (2011): 353-359.