Ain Shams University

Faculty of Engineering

Design and Production Department

Study of:

"A Study of Potentiality of use of Palm Midrib in Charcoal Production"

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Introduction

- What is Renewable Energy?

  Is the energy that is obtained from a persistent flow of energy occurring in the immediate environment.

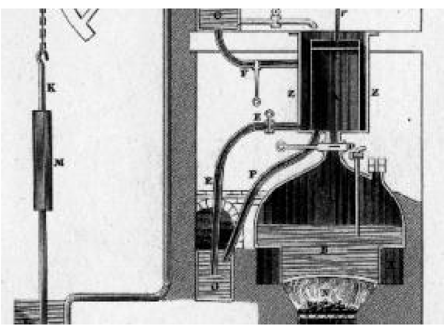
- What is Biomass?

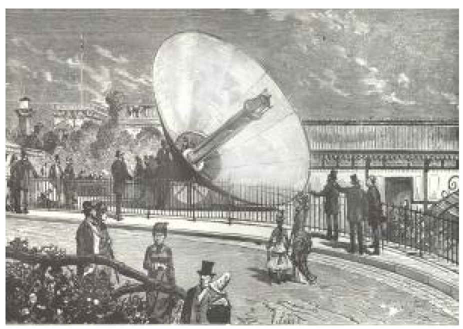
  Plants and Animals including their residues are called Biomass.

- What is Biofuel?

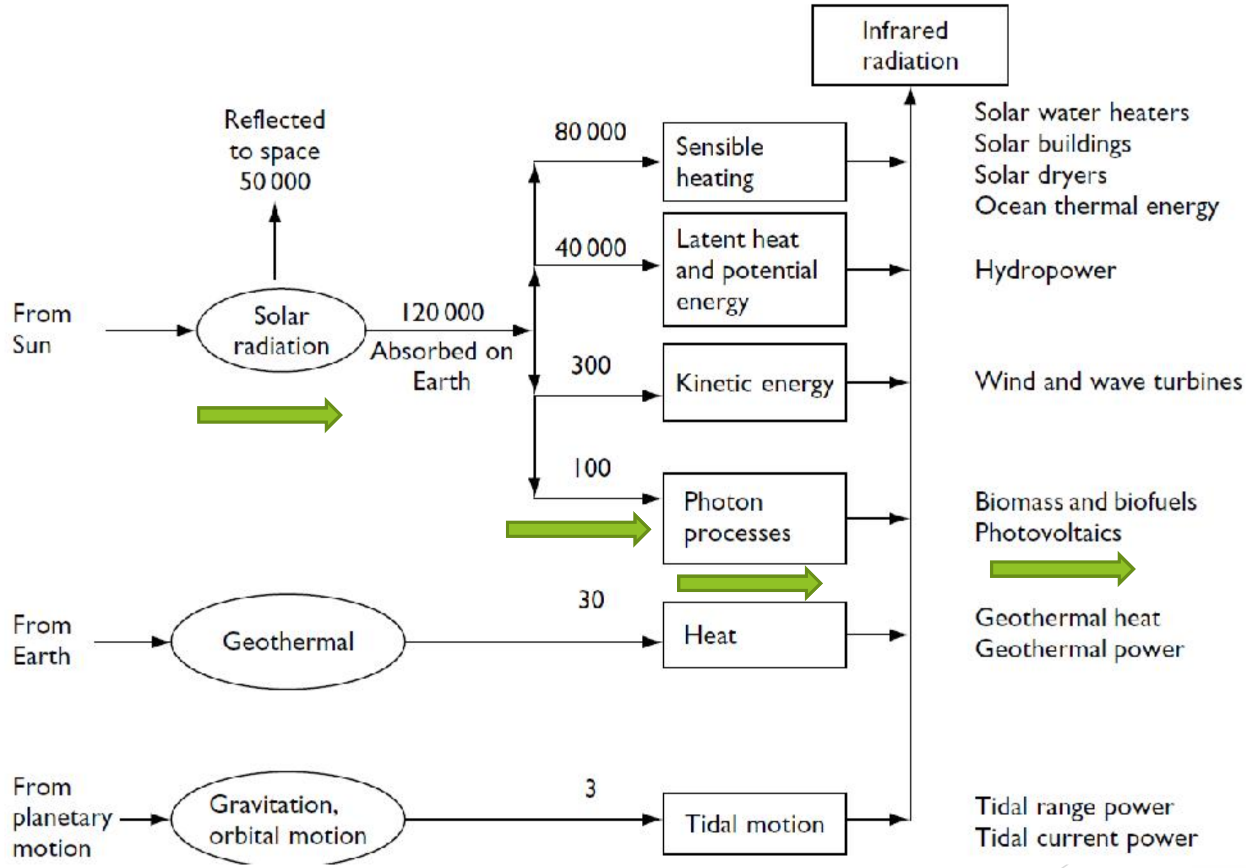
  When chemical reactions are applied to Biomass, it generates methane, methanol, ethyl ester, etc. These called Biofuels.

History of Renewable Energy





The Renewable Energy Map

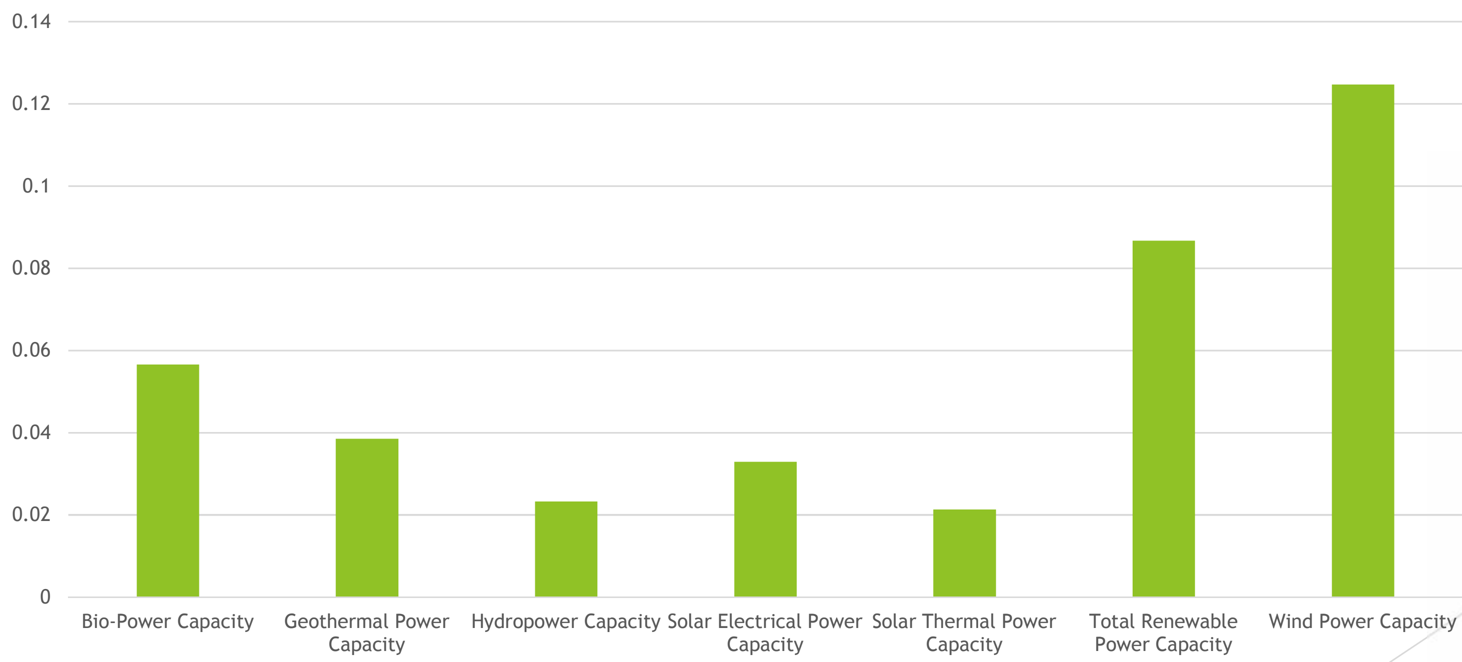


Annual Renewable Energy Report

- The Renewable Energy share of Total World Energy Consumption at 2015 is 19.3%
- The Renewable Energy share of Total World Electrical Energy Production at 2016 is 24.5%

Renewable Energy Source	Unit	Year 2015	Year 2016	Change
Total Renewable Power Capacity	GW	1,856	2,017	+ 8.67 %
Solar Thermal Power Capacity	GW	4.7	4.8	+ 2.13 %
Solar Electrical Power Capacity	GW	228	303	+ 3.29 %
Hydropower Capacity	GW	1,071	1,096	+ 2.33 %
Wind Power Capacity	GW	433	487	+ 12.47 %
Bio-Power Capacity	GW	106	112	+ 5.66 %
Geothermal Power Capacity	GW	13	13.5	+ 3.85 %

Annual Renewable Energy Report



Pyrolysis

- Heating organic materials completely to get solid, liquid or gas materials as fuels is called Pyrolysis process.

OR

- Heating at elevated temperatures, applying a thermochemical decomposition of organic materials in absence of oxygen or restricted air or oxygen flow to make a change in chemical composition and physical phase.

- Type of Pyrolysis:
  - A. Slow Pyrolysis
  - B. Fast Pyrolysis

Heating Rate

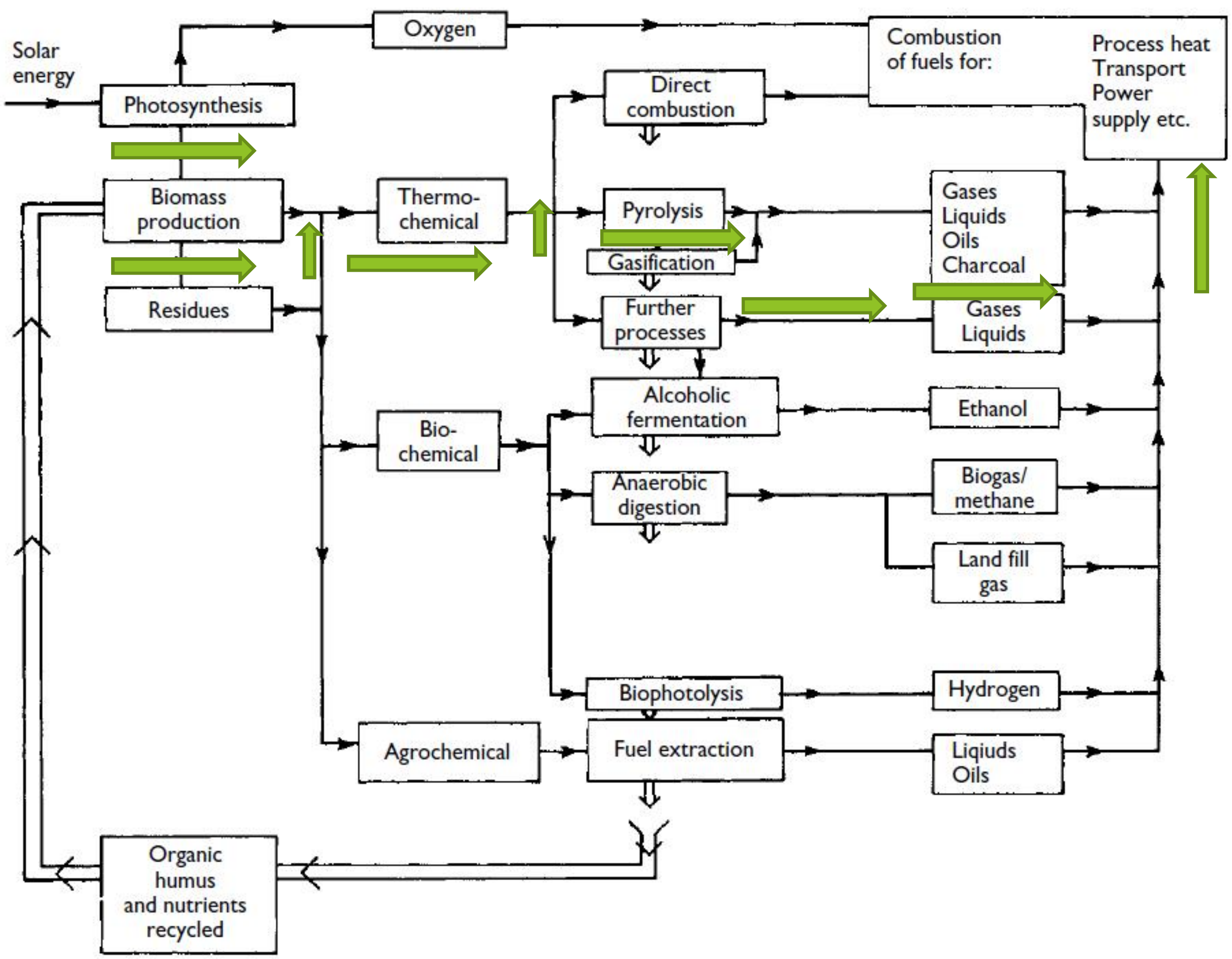
- Slow Heating

  The process of heating is very low approximately 5-7 °C/min , which leads to less liquid material around 30 - 50% of mass. The liquids separate into two phases, a polygynous water and decanted oil. It's considered that when heating any particle larger than 2 mm, it’s a slow pyrolysis.

- Fast Heating

  With a rapid process of heating around 300 °C/min, which is used to obtain high yield of single phase bio-oil around 75% of the mass, around 15% charcoal and it can be achieved when using particles less than 2 mm.

Biofuel Utilization Cycle



Pyrolysis Steps

- At temperatures between 100–120 °C. drying of the input material and moisture goes out.
- At around 275 °C. gases like N_2, CO and CO_2, goes out, also methanol is distilled.
- Around between temperatures of 280 – 350 °C. chemical exothermic reactions occur generating complex mixtures of certain catalysts.
- At more than 350 °C. Charcoal remains and H_2 reacts with CO and goes out in form of tar.

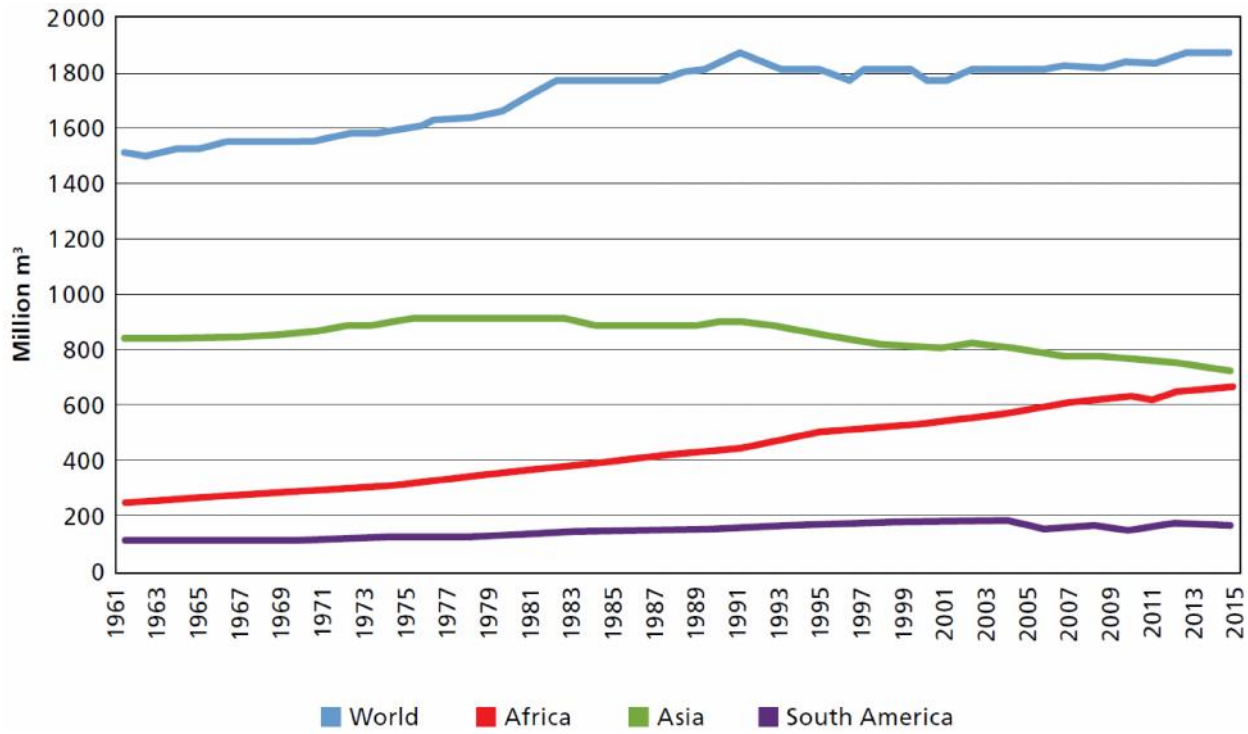
Pyrolysis Output

Yields of 1000 kg of Dry Wood (Approximately)	
Charcoal	300 kg
Gas	140 m^3
Methyl Alcohol	14 L
Acetic Acid	53 L
Esters	8 L
Acetone	3 L
Wood Oil and Light Tar	76 L
Creosote Oil	12 L
Pitch	30 kg

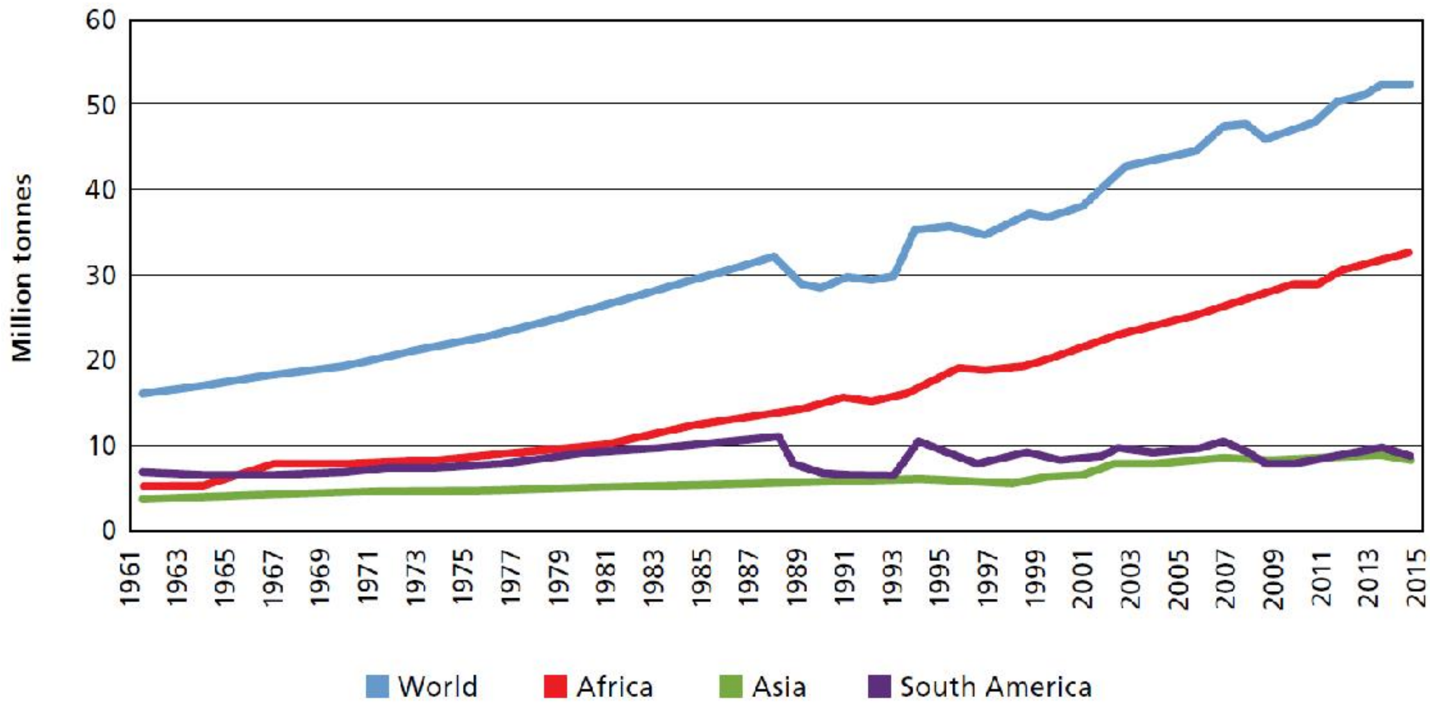
Charcoal

- The black carbon and ash residues which came from animal and vegetation substances by removing water and volatile material during slow heating in absence of oxygen by "Pyrolysis".

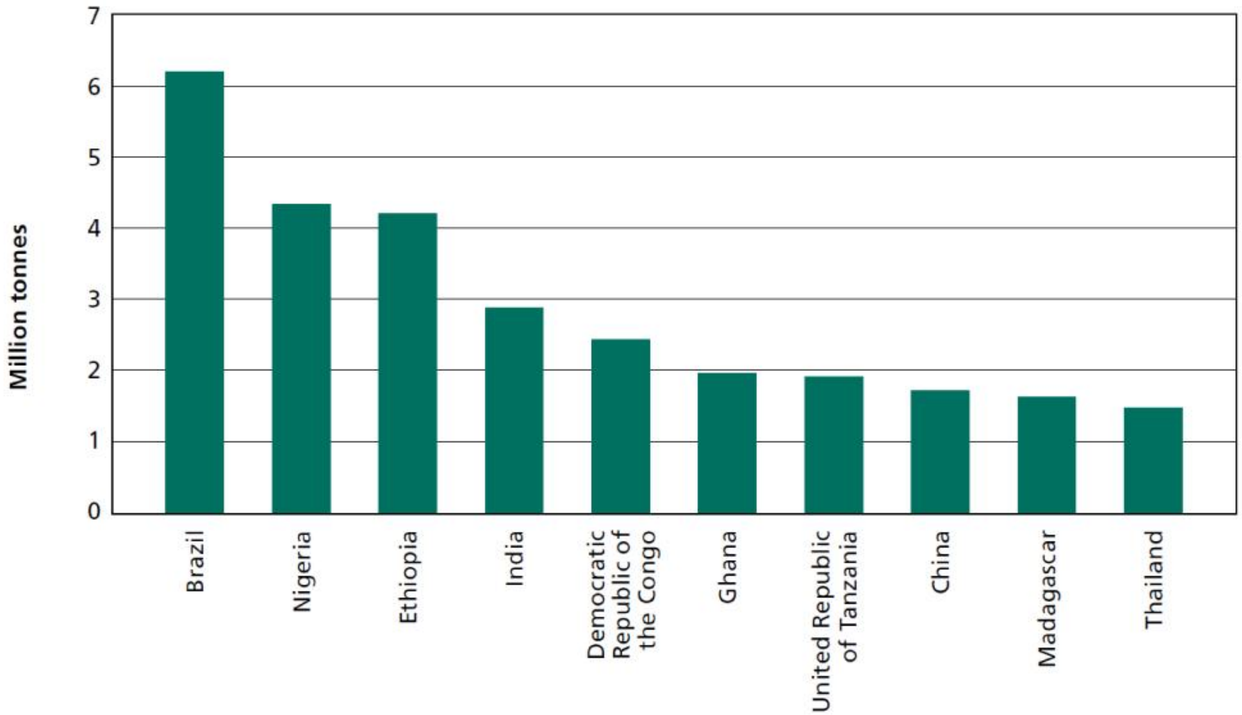
Charcoal Production around the World



Wood Charcoal around the World



Top 10 Countries producing Charcoal



Usage in Industry

Chemical Industry

- Carbon disulfide
- Sodium cyanide
- Metallic carbides
- Silicon carbide

Cement, Iron and Steel

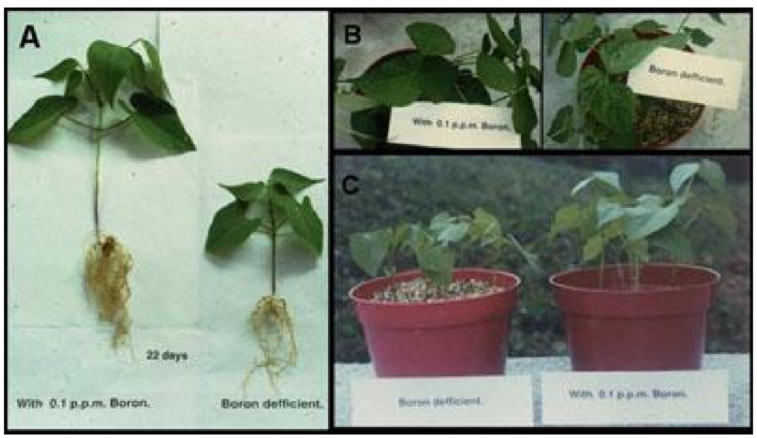
- Iron smelting
- High purity irons
- Ferro silicon
- Sintering and ore beneficiation
- Cement Manufacturing

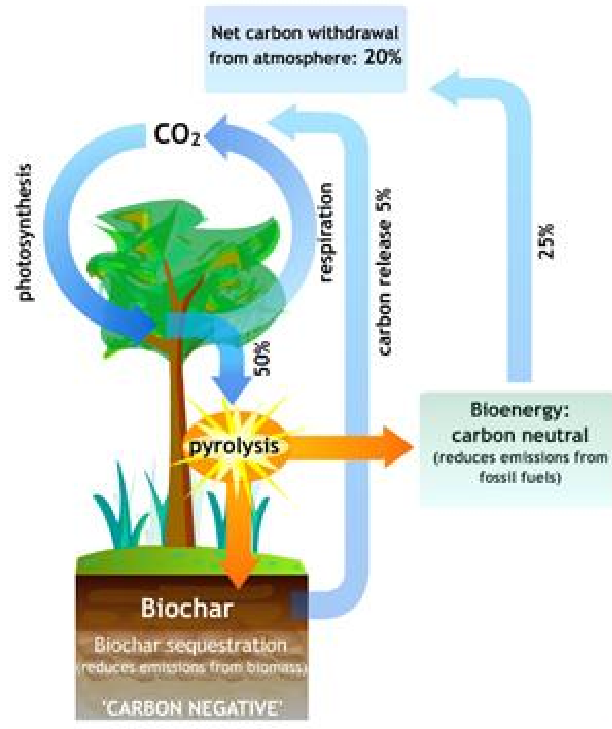
Metallurgy

- Foundry operations
- Copper smelting
- Tin smelting
- Specialized metal smelting and casting
- Electric furnace electrodes
- Sintering operations

Environmental Applications

- The reduction of Greenhouse effect starts from Soil amendment with Carbon, so the Agriculture benefits from applying Biochar in Soil is accompanied with environmental benefits, the use of Biochar in Soil amendment is greatly required while it increases the carbon concentration in soil, reduces the emissions of greenhouse gases





Charcoal as Activated Carbon for Medical Applications

Activated charcoal means that the carbon structure of the charcoal has pores in low volume which increase the surface are of charcoal to do absorption to chemical substances. It acts as Filters, and have a great health and medical benefits

Requires Low Sulfur, and uses all levels of Ash content

Usage of Charcoal

- Charcoal Marketing Shapes:
  - Lump Charcoal
    - Low Ash but High Caloric Value
    - Able to be used in many applications
  - Briquette Charcoal
    - High Ash but Medium Caloric Value
    - Able to be used in low energy applications

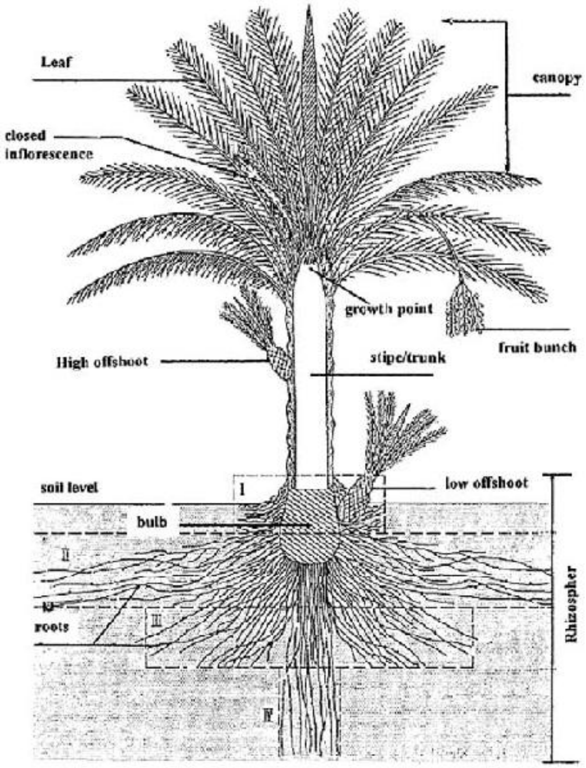
Parameters of Charcoal in Industry

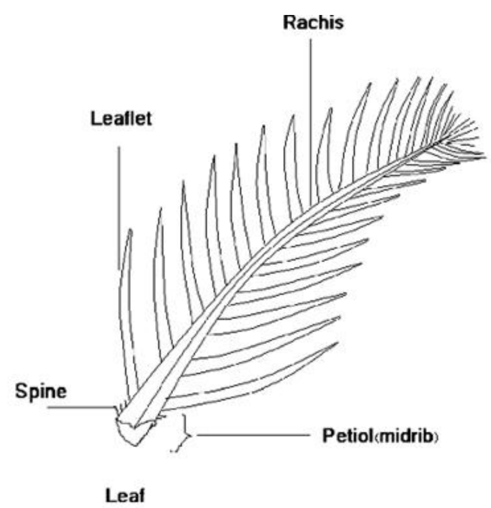
- The Sulfur, should be at low levels as much as possible to avoid environmental effects
- Carbon to Ash ratio should be as high as it could be, to utilize the biggest energy consumption
- Charcoal known as it has unreactive inorganic impurities in few amount
- Stable pore structure and chemical compatibility
- Good reduction ability
- Almost smokeless, because of its low ash content and chemical stability

Application Allocation

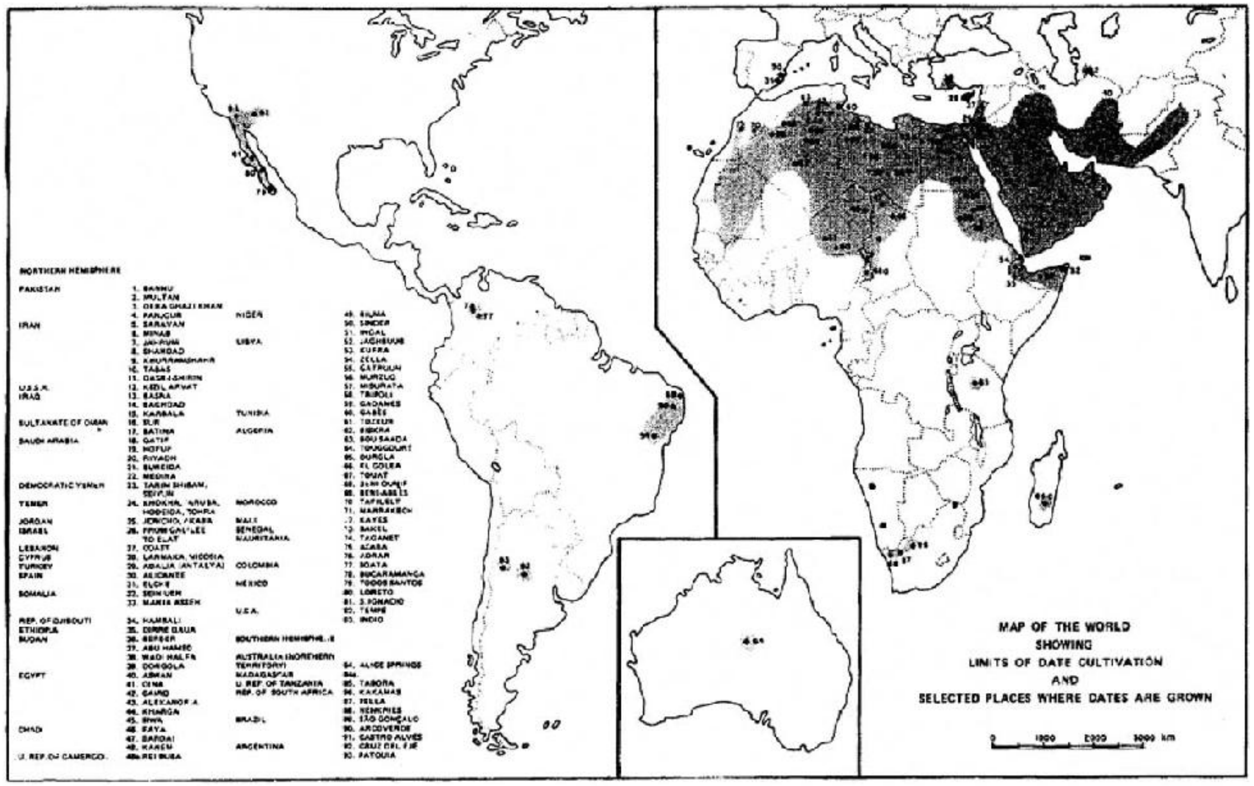
Industry	High Caloric Value High Fixed Carbon Low Moisture Content Low Volatile Matter Low Ash Content Low Sulfur Content	BPMRT SPMRT
Environment	High Fixed Caron Low Sulfur Content	All
Medical	High Carbon Content All Ash Content Levels Low Sulfur Content	All used in Activated Phase

Palm and Palm Midrib





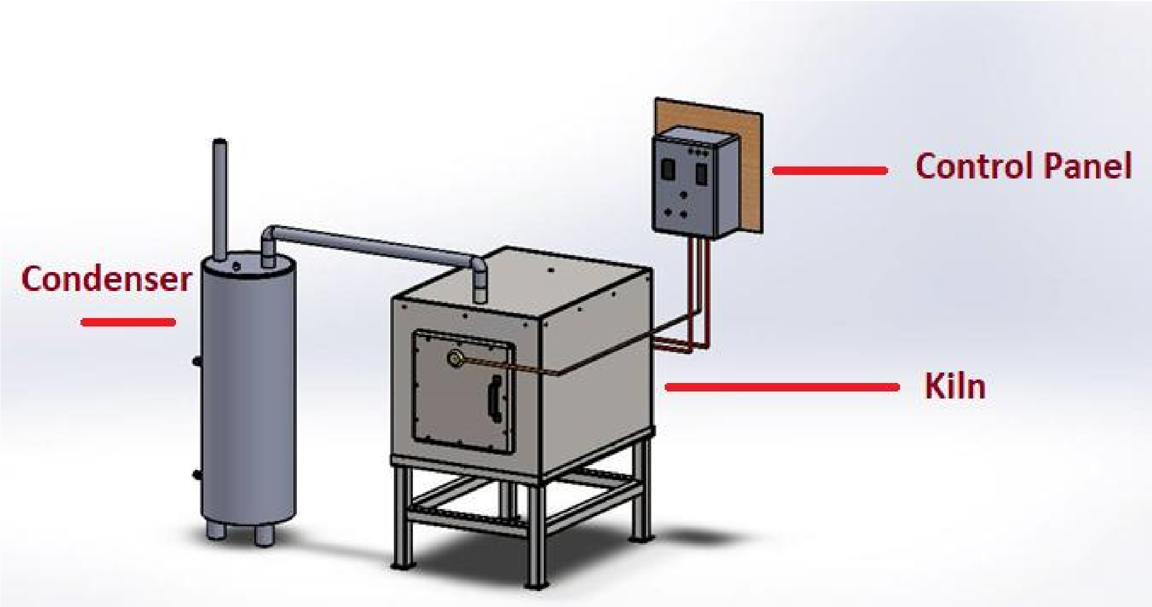
Palm Distribution around the World



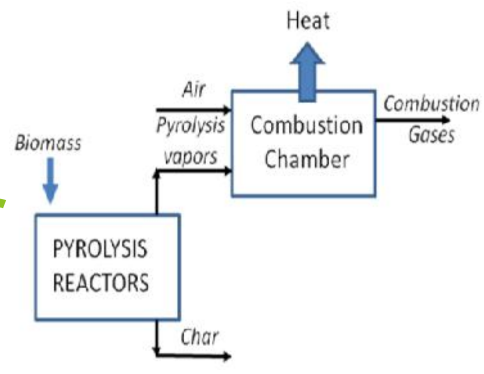
Egypt processes about 15 million Female palms.

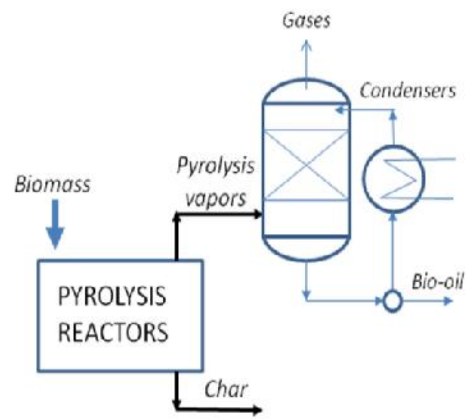
Reactor!

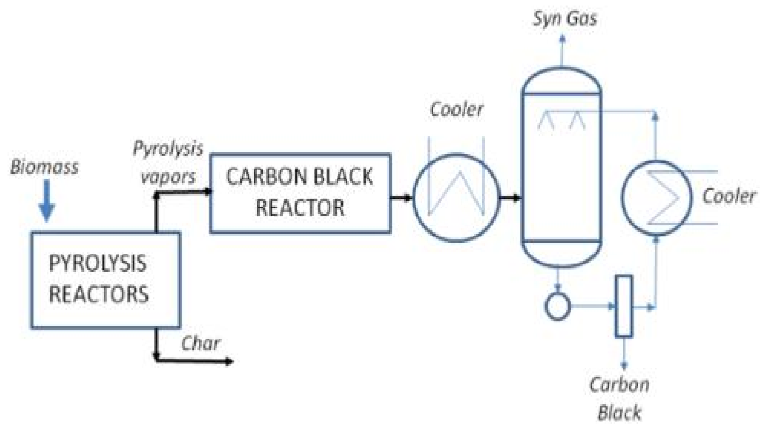
- The Device which has kiln for pyrolysis process (Carbonization) and Condenser (for gases and liquid extraction) and other auxiliary tools.



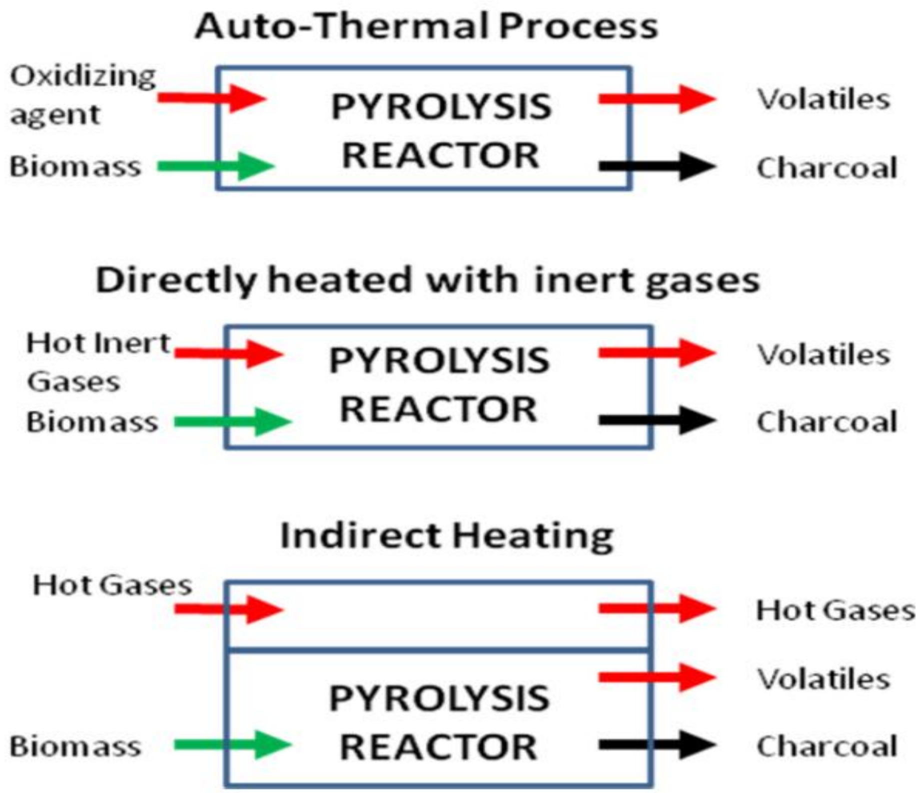
Final Product of a Reactor



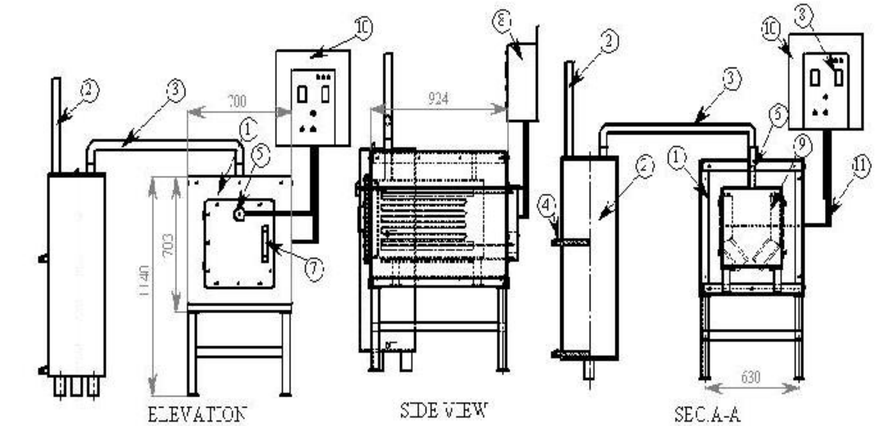


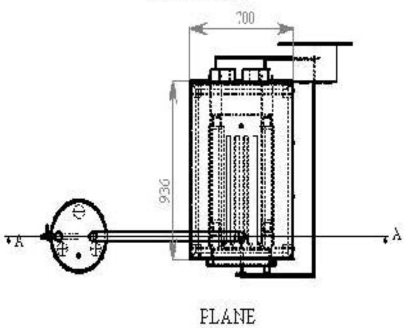


Heating Method



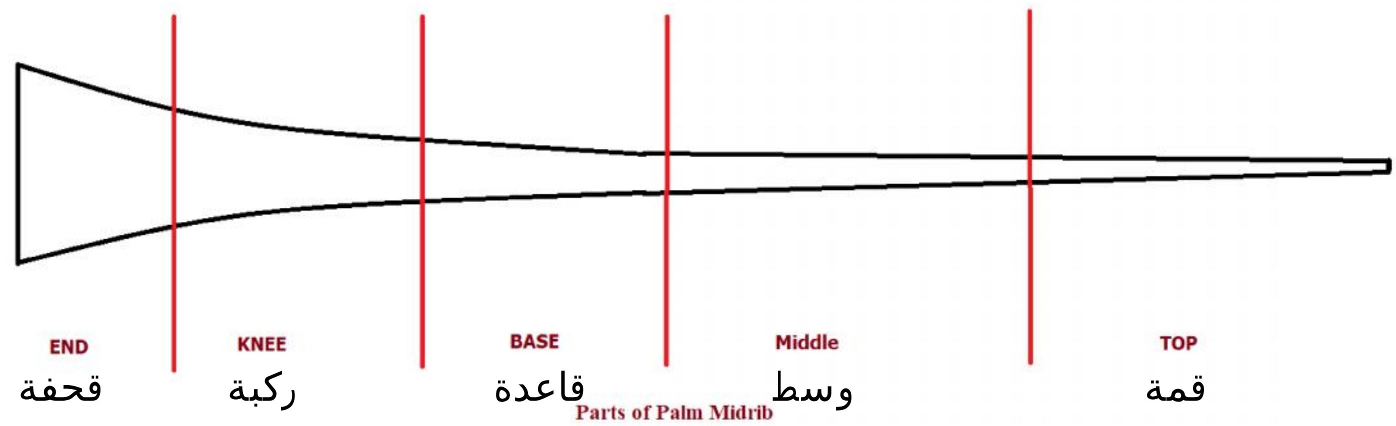
Final Design of the Reactor





ITEM NO.	PART NUMBER	QTY
1	REACTOR PYROLYSIS ASSY	1
2	CONDENSING UNIT	1
3	CONNECT PIPE	1
4	VALVE HAND	2
5	THERMOCOUPLE	1
6	INTERMEDIATE PIPE	1
7	KILN HAND	1
8	CONTROL SYSTEM	1
9	COVER FOR HEATER	1
10	WALL	1
11	WIRE	1

Palm Midrib Experimented Parts



Palm Midrib Divisions

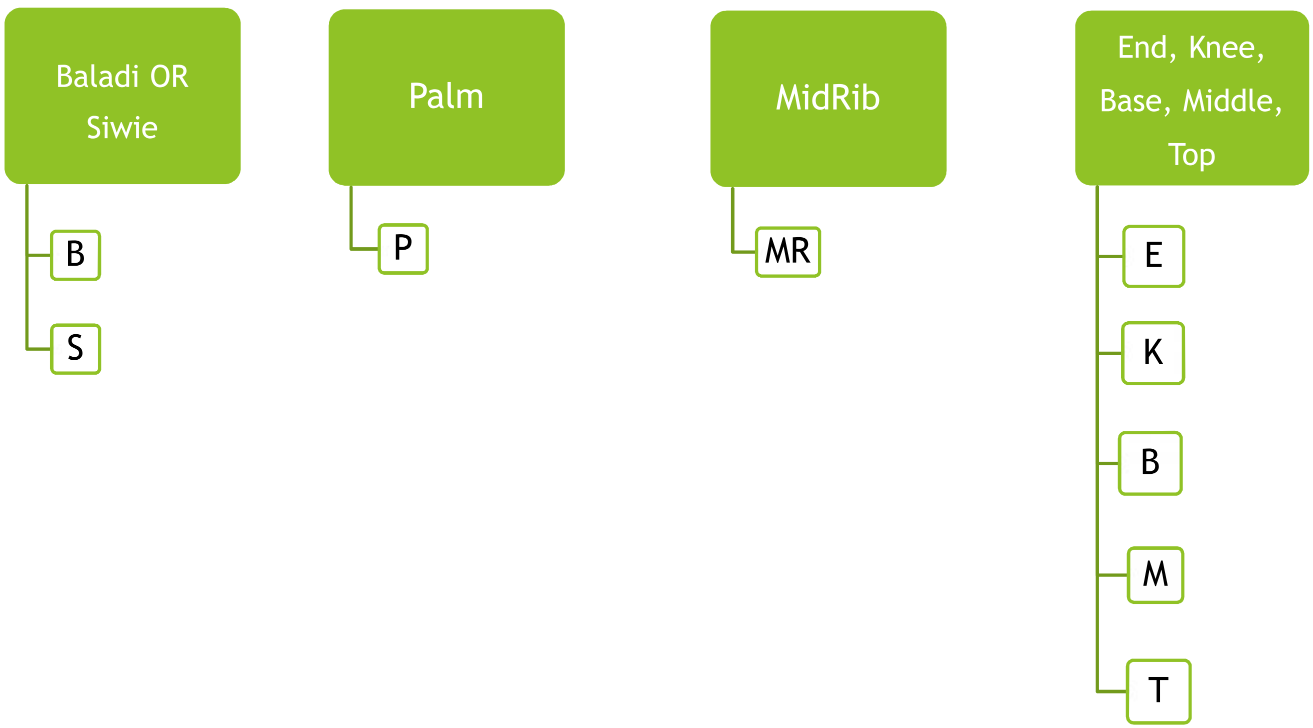
- Palm Midrib
  - Top
  - Middle
  - Base
  - Knee
  - End

Selected Palm Types and Samples

- Baladi Palm — Code
  - Midrib End Sample — BPMRE
  - Midrib Knee Sample — BPMRK
  - Midrib Base Sample — BPMRB
  - Midrib Middle Sample — BPMRM
  - Midrib Top Sample — BPMRT
- Siwie Palm — Code
  - Midrib End Sample — SPMRE
  - Midrib Knee Sample — SPMRK
  - Midrib Base Sample — SPMRB
  - Midrib Middle Sample — SPMRM
  - Midrib Top Sample — SPMRT

Sample size :16-14

Samples Coding



Analysis of Samples Before Carbonization

Specimen No.	Specimen Code	Moisture Content %	Ash %	Volatile Matter %	Fixed Carbon %	Sulfur %	Caloric Value (kCal/kg)
1	SPMRE	11.767	12.28	63.401	14.224	0.138	3,458
2	SPMRK	11.124	11.87	65.314	13.153	0.124	3,496
3	SPMRB	8.404	8.72	75.554	7.993	0.191	3,854
4	SPMRM	10.217	4.20	72.000	15.129	0.146	3,924
5	SPMRT	9.284	4.26	74.242	13.464	0.147	4,104
6	BPMRE	12.321	10.08	64.865	14.527	0.263	3,653
7	BPMRK	11.472	9.46	67.814	12.715	0.109	3,553
8	BPMRB	10.809	7.20	72.352	10.812	0.167	3,798
9	BPMRM	9.086	5.87	74.813	11.258	0.150	3,900
10	BPMRT	10.494	4.62	75.503	10.479	0.156	3,877

Analysis has been conducted in:

1. Center for Feed and Food from the Agricultural Research Center.
2. Land Center of the Agricultural Research Center.
3. Faculty of Agriculture, Ain Shams University.

Analysis of Sample After Carbonization

Specimen No.	Specimen Code	Moisture Content %	Ash %	Volatile Matter %	Fixed Carbon %	Sulfur %	Caloric Value (kCal/kg)
1	SPMRE	3.09	34.29	22.9	40.737	0.233	5,566
2	SPMRK	1.896	31.65	28.25	38.875	0.124	5,939
3	SPMRB	2.293	20.49	29.42	48.839	0.109	6,445
4	SPMRM	1.872	15.30	27.42	56.612	0.119	6,143
5	SPMRT	1.821	14.94	26.89	57.358	0.139	6,842
6	BPMRE	3.119	27.37	24.65	46.377	0.118	5,153
7	BPMRK	1.697	30.35	20.33	48.341	0.103	5,520
8	BPMRB	1.921	29.14	23.32	46.545	0.178	5,857
9	BPMRM	2.070	15.24	30.58	53.373	0.141	6,978
10	BPMRT	1.273	14.30	26.49	58.593	0.139	6,688

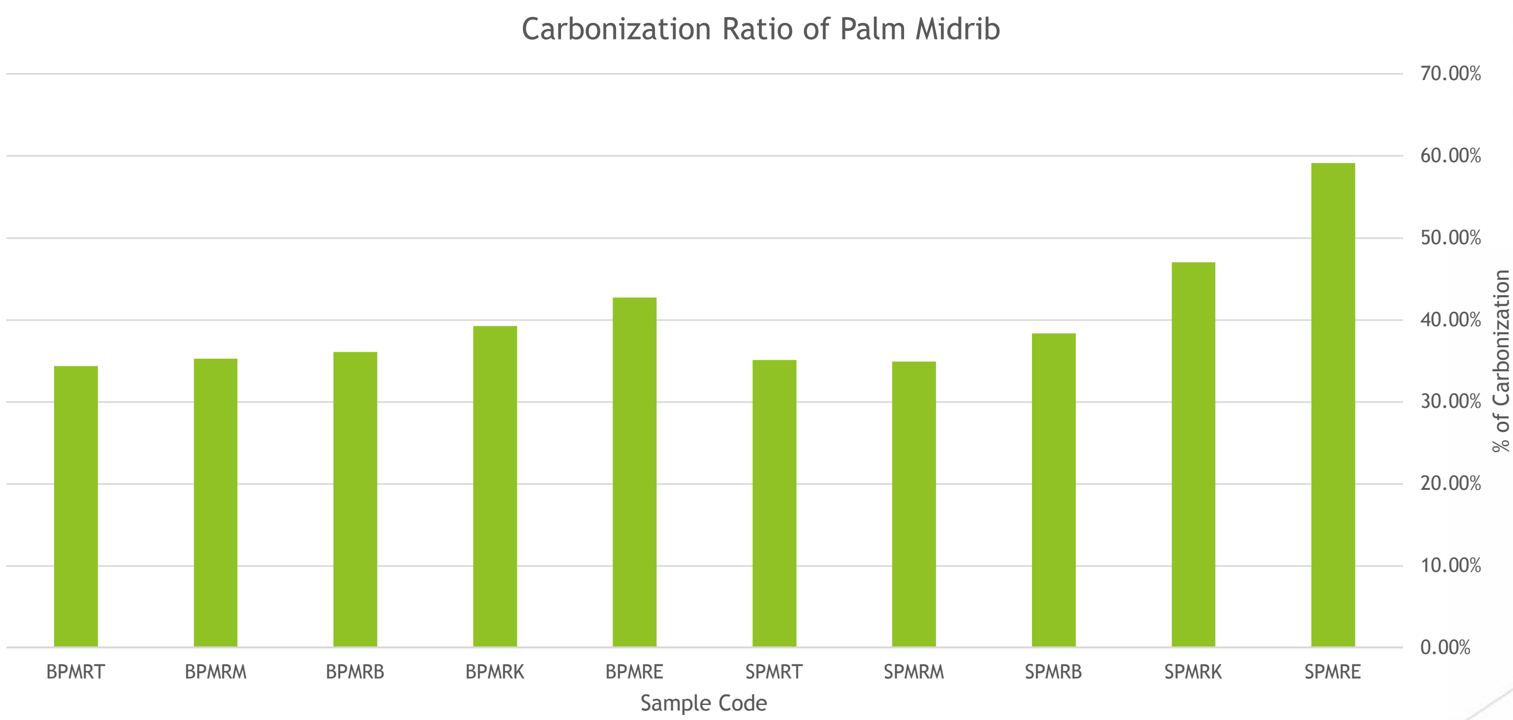
Analysis has been conducted in:

1. Center for Feed and Food from the Agricultural Research Center.
2. Land Center of the Agricultural Research Center.
3. Faculty of Agriculture, Ain Shams University.

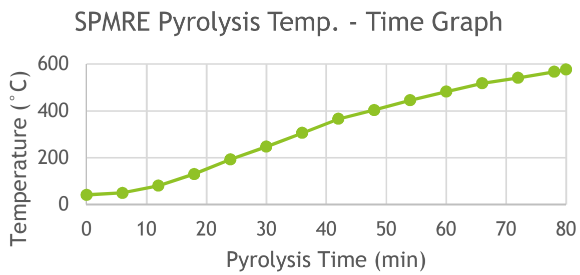
Weight Comparison

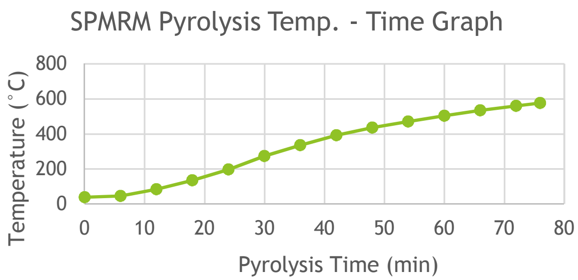
Sample NO.	Sample CODE	Weight Before Carbonization (kg)	Weight After Carbonization (Kg)	Carbonization Ratio (%)
1	SPMRE	3.00	1.1827	59.14
2	SPMRK	2.00	0.9399	47.00
3	SPMRB	2.50	0.9585	38.34
4	SPMRM	2.00	0.6981	34.91
5	SPMRT	1.50	0.5264	35.09
6	BPMRE	2.00	0.8542	42.71
7	BPMRK	2.00	0.785	39.25
8	BPMRB	2.00	0.7219	36.10
9	BPMRM	2.00	0.705	35.25
10	BPMRT	1.50	0.5155	34.37

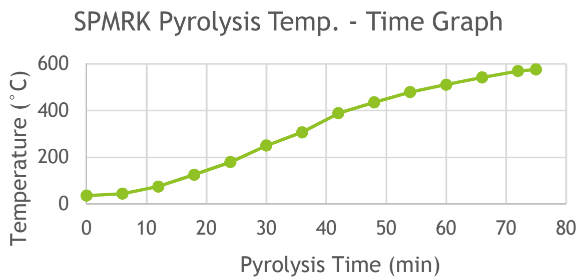
Weight Comparison Graph

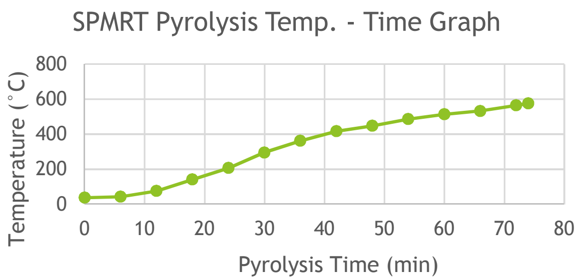


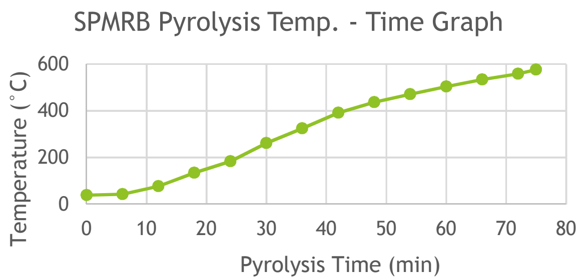
Time – Temperature Carbonization Graphs for Siwie Palm Midrib



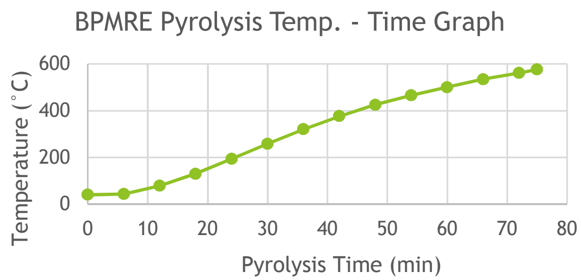


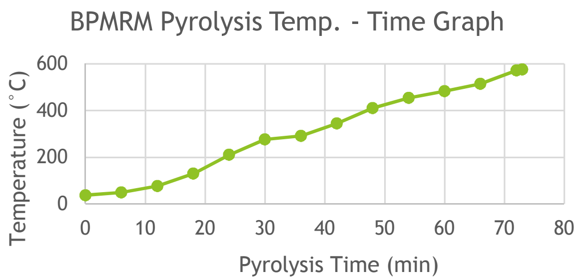


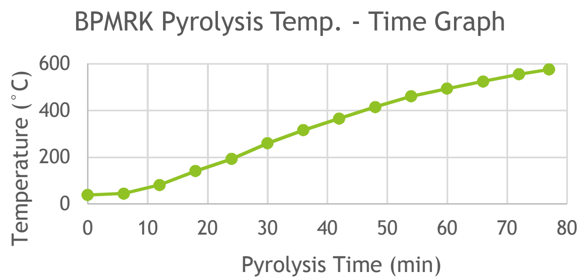


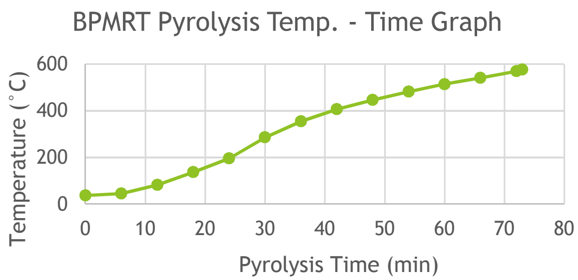


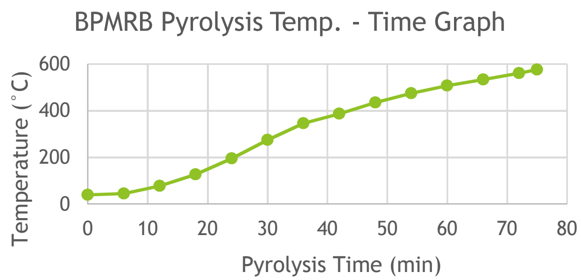
Time – Temperature Carbonization Graphs for Baladi Palm Midrib



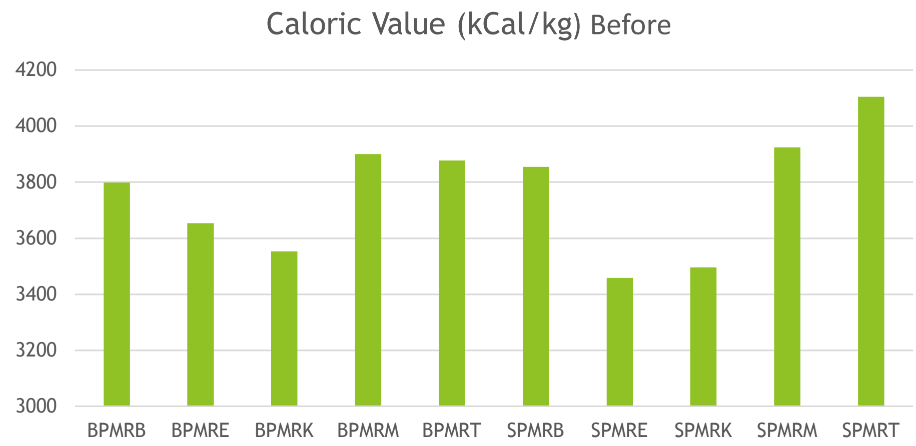


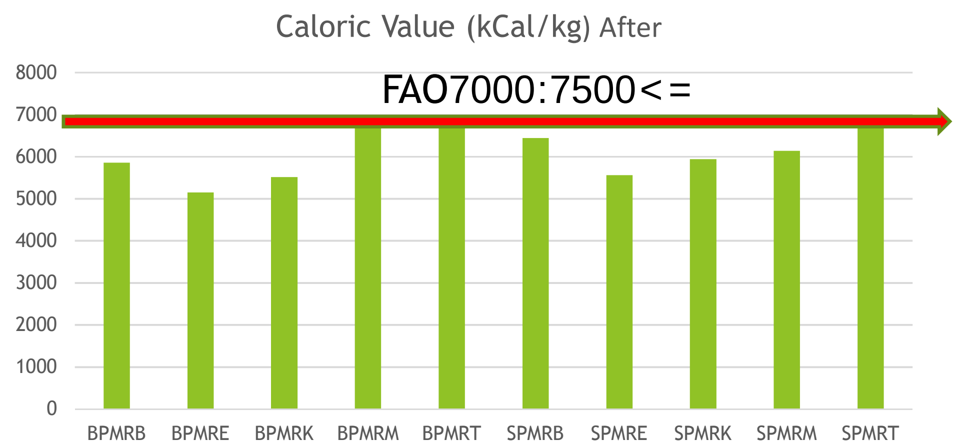




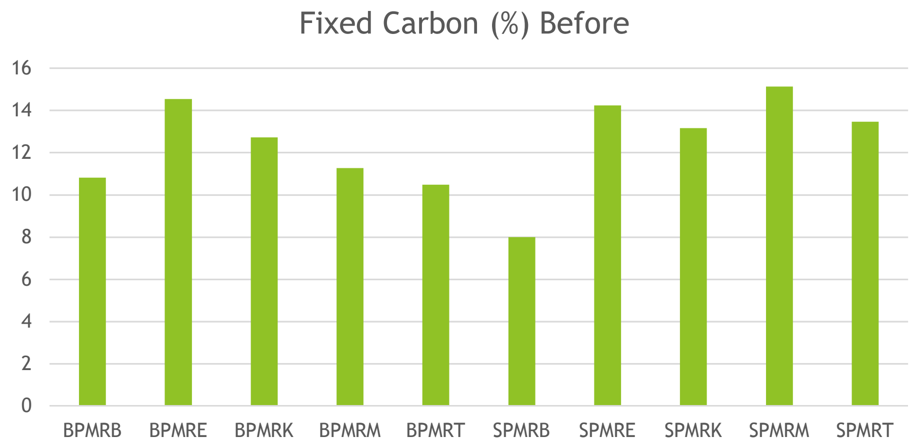


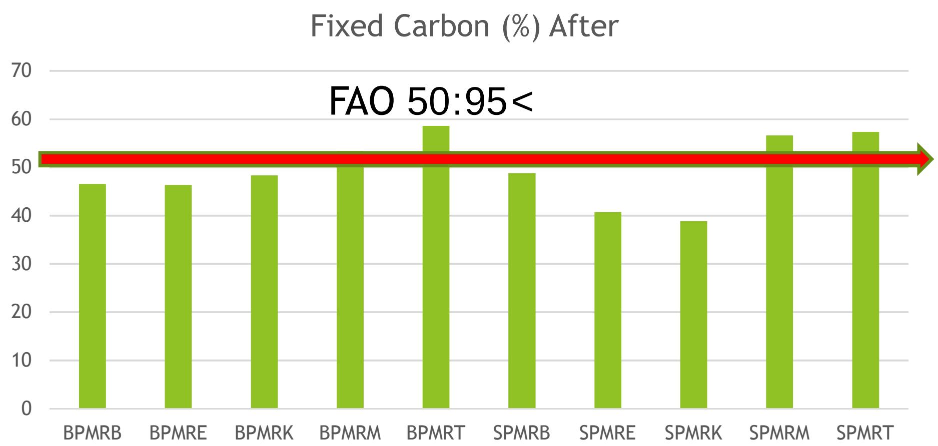
Caloric Value Before and After Carbonization



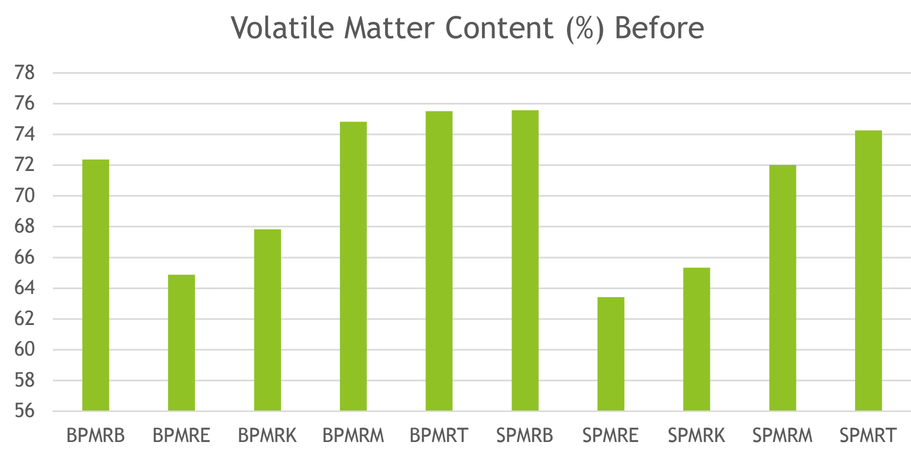


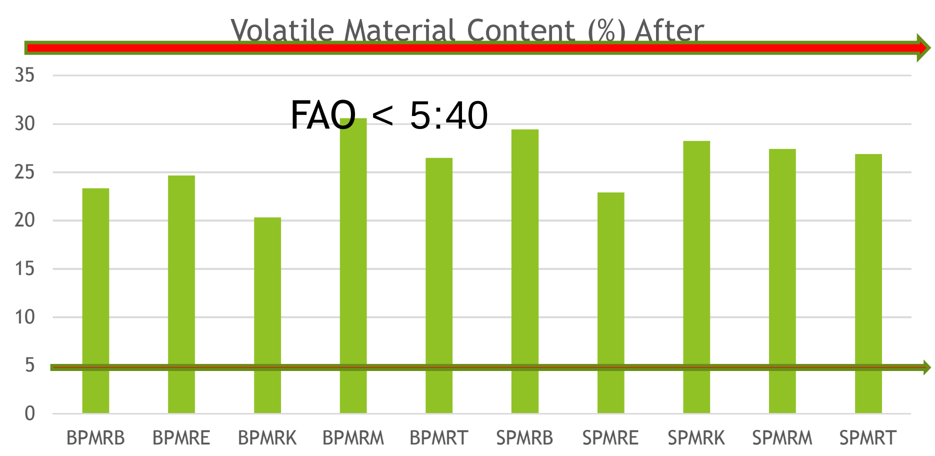
Fixed Carbon Before and After Carbonization



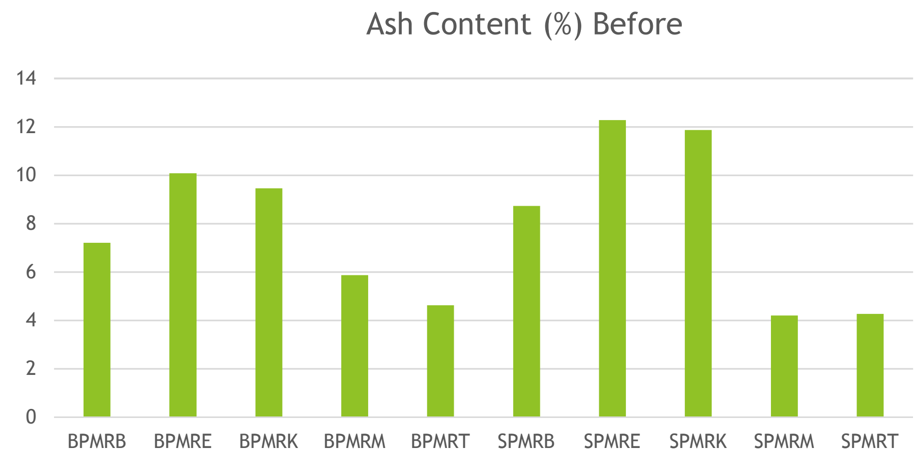


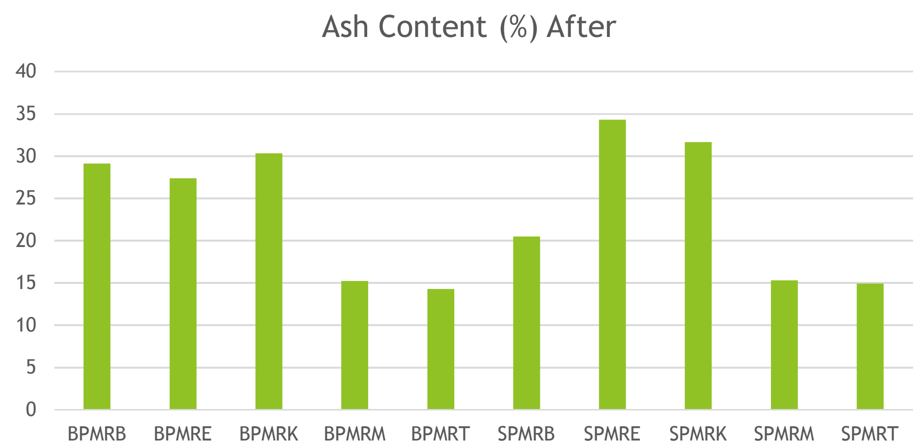
Volatile Matter Before and After Carbonization



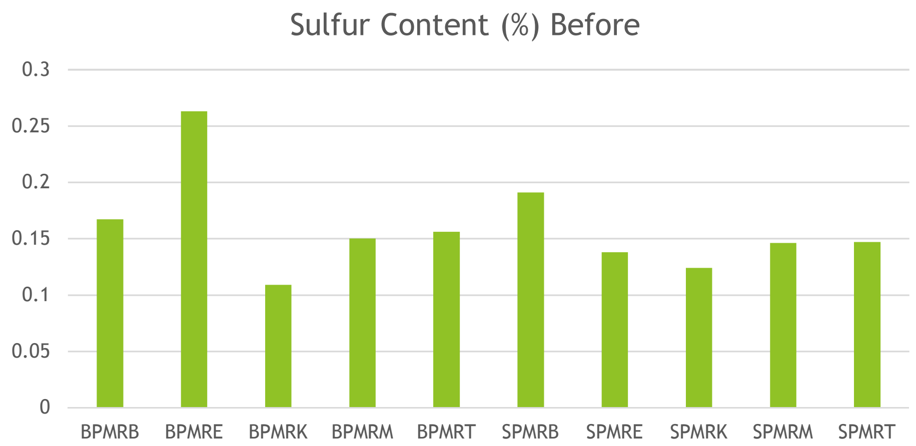


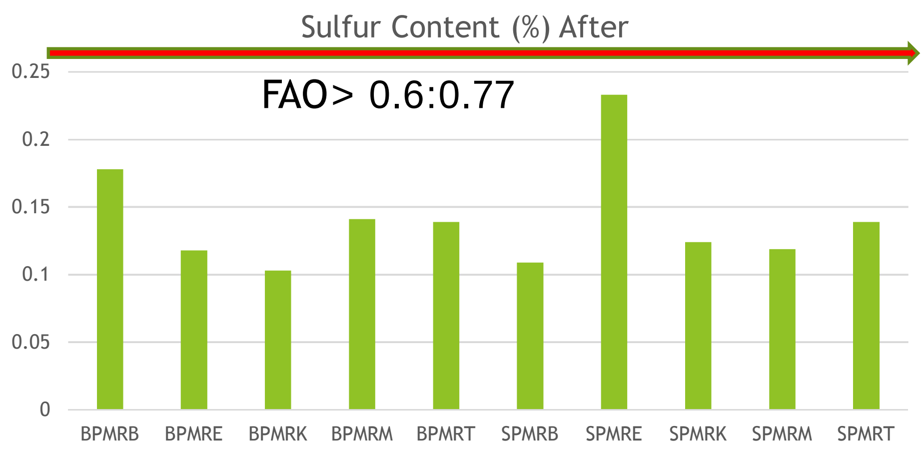
Ash Content Before and After Carbonization



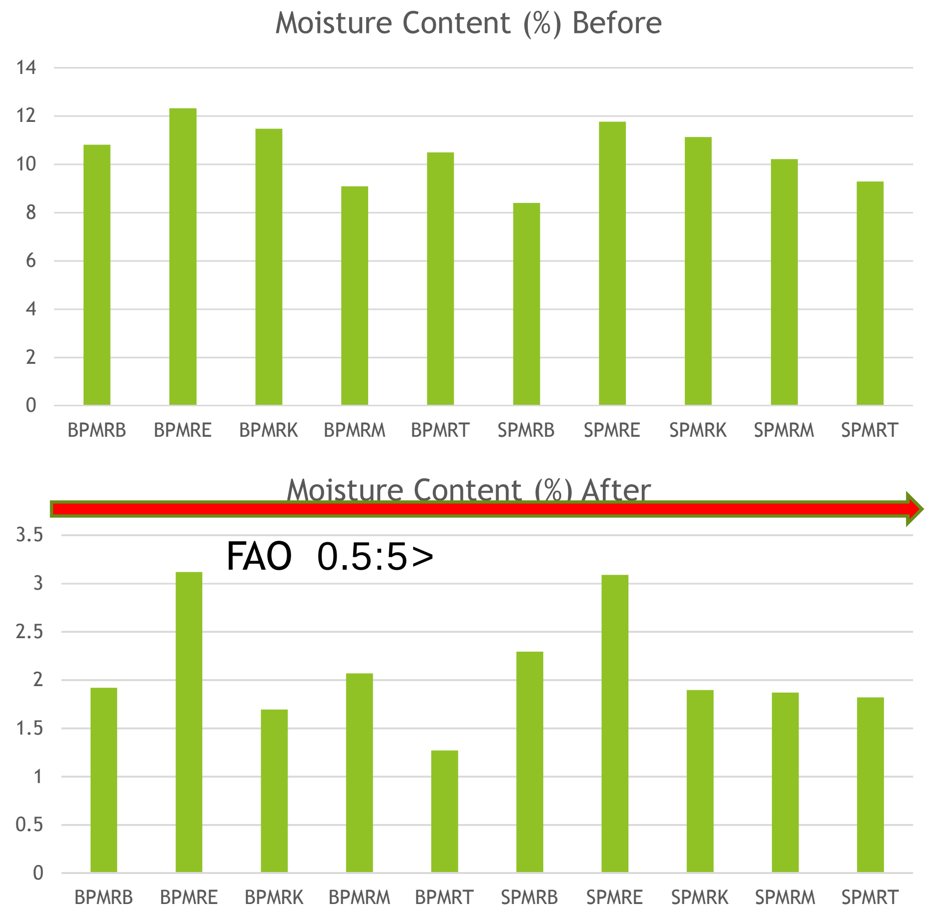


Sulfur Content Before and After Carbonization





Moisture Content Before and After Carbonization



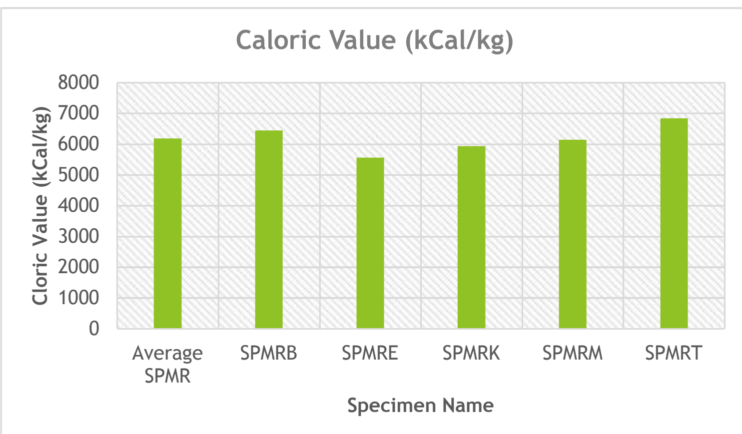
Discussion of Results

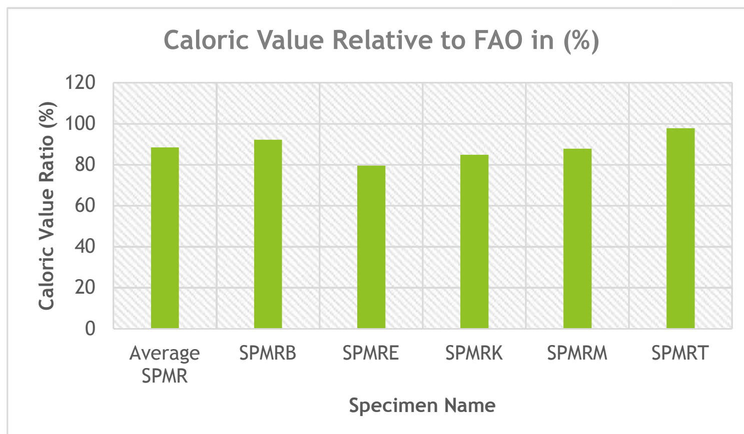
- Average Results of Siwie Palm Midrib

Specimen No.	Specimen Code	Caloric Value (kCal/kg)	Fixed Carbon (%)	Moisture Content (%)	Ash Content (%)	Volatile Matter (%)	Sulfur Content (%)
1	SPMRE	5,566	40.74	3.09	34.29	22.90	0.23
2	SPMRK	5,939	38.88	1.90	31.65	28.25	0.12
3	SPMRB	6,445	48.84	2.29	20.49	29.42	0.11
4	SPMRM	6,143	56.61	1.87	15.30	27.42	0.12
5	SPMRT	6,842	57.36	1.82	14.94	26.89	0.14
Average SPMR		**6,187**	**48.48**	**2.19**	**23.33**	**26.98**	**0.15**

Seiwi Samples, Chloric Value to FAO Limits Comparison

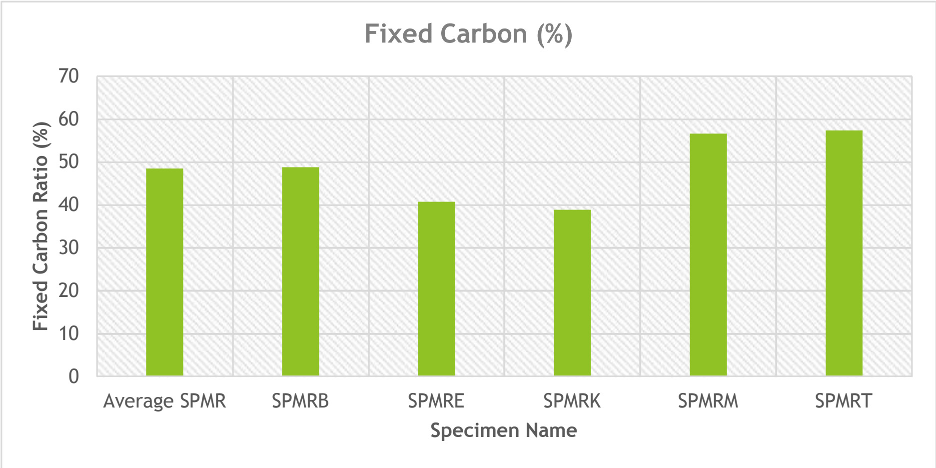
Specimen No.	Specimen Code	Caloric Value (kCal/kg)	Caloric Value by FAO (kCal/kg)	Caloric Value Ratio (%)
1	SPMRE	5,566	≥ 7,000 – 7,500	79.51
2	SPMRK	5,939	≥ 7,000 – 7,500	84.84
3	SPMRB	6,445	≥ 7,000 – 7,500	92.07
4	SPMRM	6,143	≥ 7,000 – 7,500	87.76
5	SPMRT	6,842	≥ 7,000 – 7,500	97.74
Average SPMR		**6,187**	**≥ 7,000 – 7,500**	**88.39**





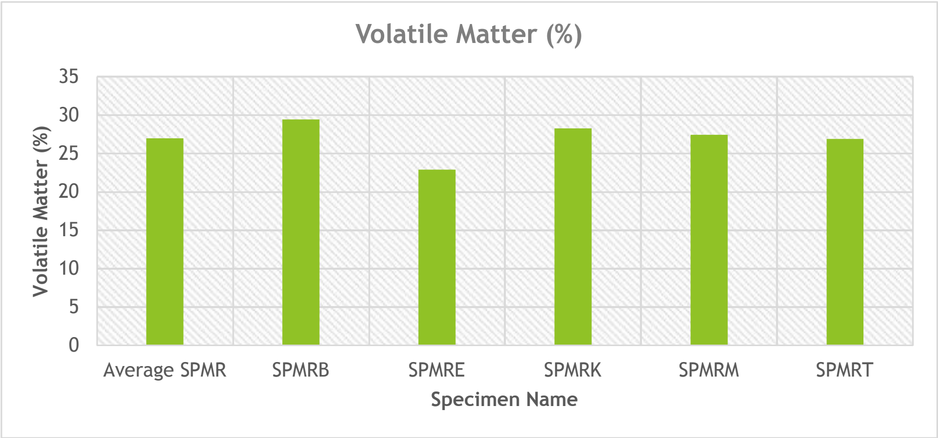
Siwie Samples, Fixed Carbon to FAO Limits Comparison

Specimen No.	Specimen Code	Fixed Carbon (%)	Fixed Caron by FAO (%)
1	SPMRE	40.74	≥ 50 - 95
2	SPMRK	38.88	≥ 50 – 95
3	SPMRB	48.84	≥ 50 – 95
4	SPMRM	56.61	≥ 50 – 95
5	SPMRT	57.36	≥ 50 – 95
Average SPMR		**48.48**	**≥ 50 - 95**



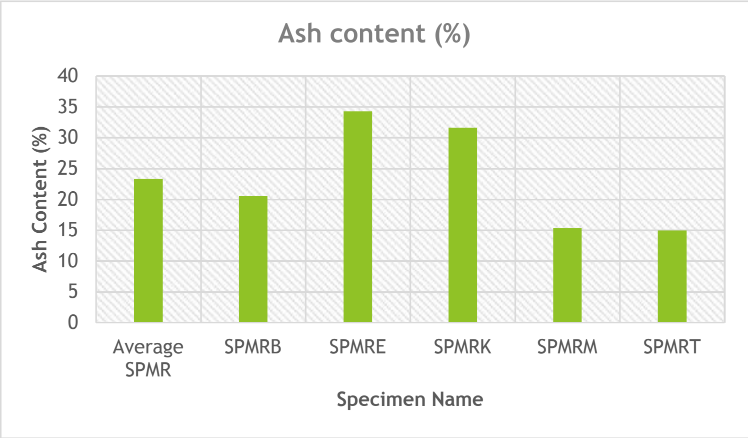
Siwie Samples, Volatile Matter to FAO Limits Comparison

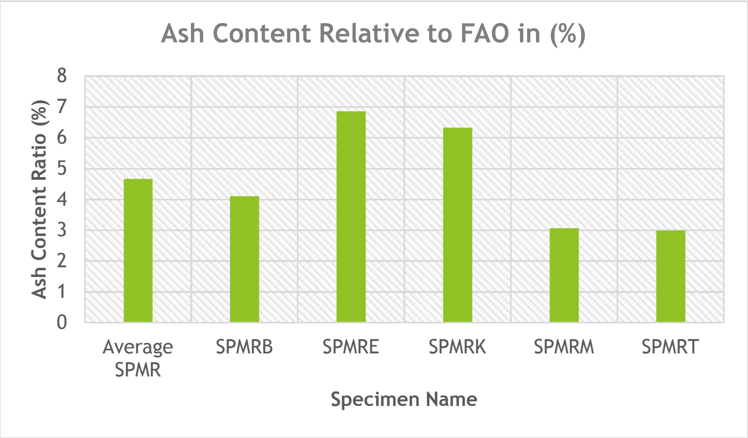
.Specimen No	Specimen Code	Volatile Matter (%)	Volatile Matter by FAO (%)
1	SPMRE	22.90	≤ 5 – 40
2	SPMRK	28.25	≤ 5 – 40
3	SPMRB	29.42	≤ 5 – 40
4	SPMRM	27.42	≤ 5 – 40
5	SPMRT	26.89	≤ 5 – 40
Average SPMR		**26.98**	**≤ 5 – 40**



Seiwi Samples, Ash to FAO Limits Comparison

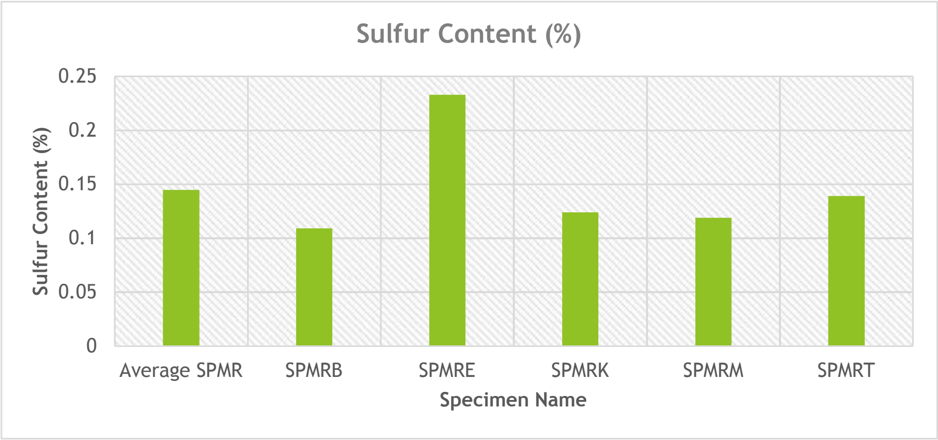
Specimen No.	Specimen Code	Ash Content (%)	Ash Content by FAO (%)	Ash Content Ratio (%)
1	SPMRE	34.29	≤ 0.5 - 5	686
2	SPMRK	31.65	≤ 0.5 – 5	633
3	SPMRB	20.49	≤ 0.5 – 5	410
4	SPMRM	15.30	≤ 0.5 – 5	306
5	SPMRT	14.94	≤ 0.5 – 5	299
Average SPMR		**23.33**	**≤ 0.5 - 5**	**467**





Seiwi Samples, Sulfur to FAO Limits Comparison

.Specimen No	Specimen Code	Sulfur Content (%)	Sulfur Content by FAO (%)
1	SPMRE	0.23	≤ 0.6 – 0.77
2	SPMRK	0.12	≤ 0.6 – 0.77
3	SPMRB	0.11	≤ 0.6 – 0.77
4	SPMRM	0.12	≤ 0.6 – 0.77
5	SPMRT	0.14	≤ 0.6 – 0.77
Average SPMR		**0.15**	**≤ 0.6 – 0.77**



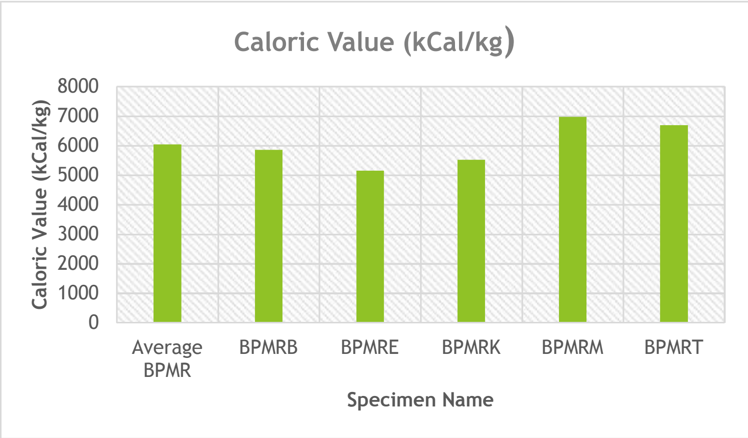
Discussion of Results

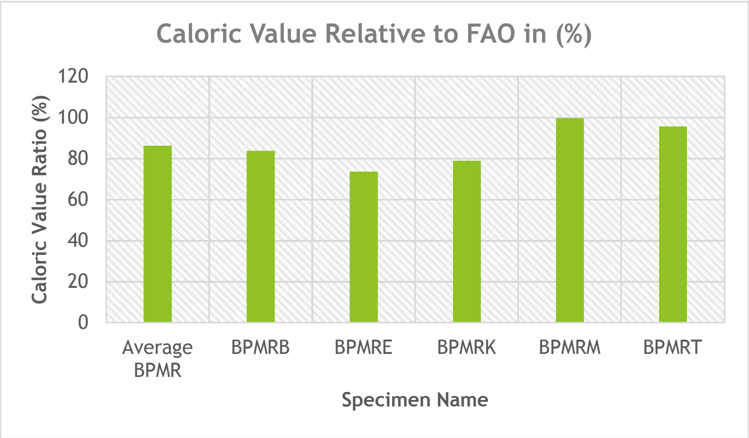
- Average Results of Baladi Palm Midrib

Specimen .No	Specimen Code	Caloric Value (kCal/kg)	Fixed Carbon (%)	Moisture Content (%)	Ash Content (%)	Volatile Matter (%)	Sulfur Content (%)
1	BPMRE	5,153	46.38	3.12	27.37	24.65	0.12
2	BPMRK	5,520	48.34	1.70	30.35	20.33	0.10
3	BPMRB	5,857	46.55	1.92	29.14	23.32	0.18
4	BPMRM	6,978	53.37	2.07	15.24	30.58	0.14
5	BPMRT	6,688	58.59	1.27	14.30	26.49	0.14
Average SPMR		**6,039**	**50.65**	**2.02**	**23.28**	**25.08**	**0.14**

Baladi Samples, Chloric Value to FAO Limits Comparison

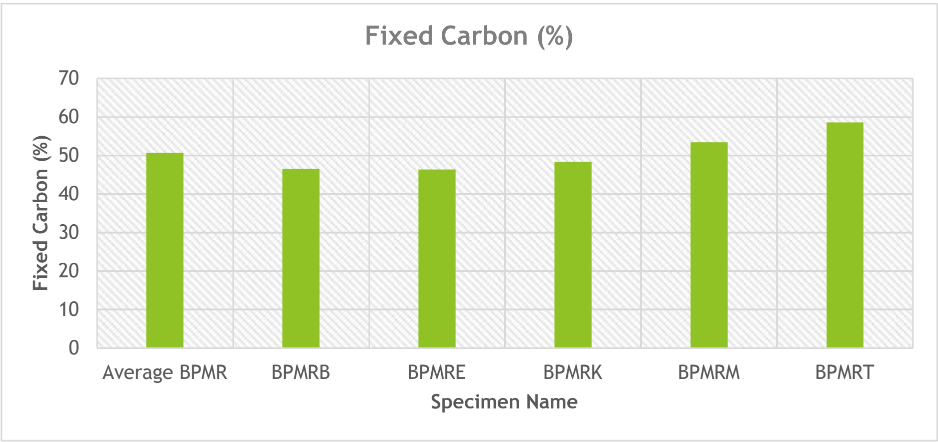
.Specimen No	Specimen Code	Caloric Value (kCal/kg)	Caloric Value by FAO (kCal/kg)	Caloric Value Ratio (%)
1	BPMRE	5,153	≥ 7,000 – 7,500	73.61
2	BPMRK	5,520	≥ 7,000 – 7,500	78.86
3	BPMRB	5,857	≥ 7,000 – 7,500	83.67
4	BPMRM	6,978	≥ 7,000 – 7,500	99.69
5	BPMRT	6,688	≥ 7,000 – 7,500	95.54
Average SPMR		**6,039**	**≥ 7,000 – 7,500**	**86.27**





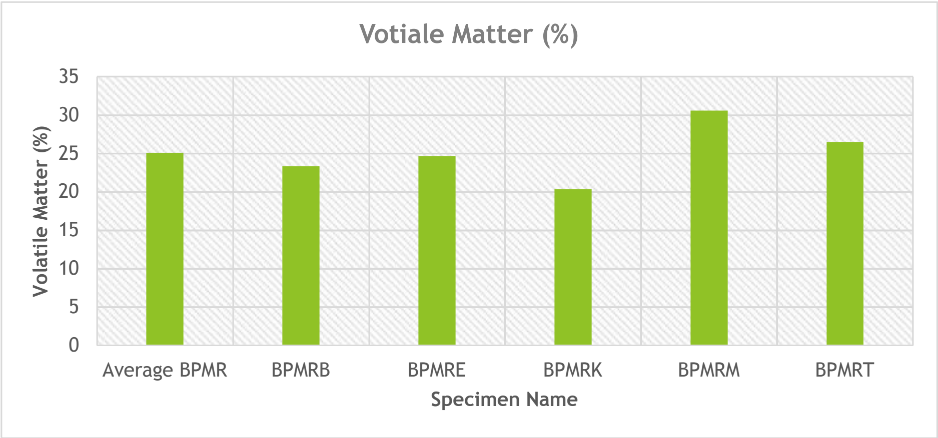
Baladi Samples, Fixed Carbon to FAO Limits Comparison

Specimen No.	Specimen Code	Fixed Carbon (%)	Fixed Caron by FAO (%)
1	BPMRE	46.38	≥ 50 - 95
2	BPMRK	48.34	≥ 50 – 95
3	BPMRB	46.55	≥ 50 – 95
4	BPMRM	53.37	≥ 50 – 95
5	BPMRT	58.59	≥ 50 – 95
Average SPMR		**50.65**	**≥ 50 - 95**



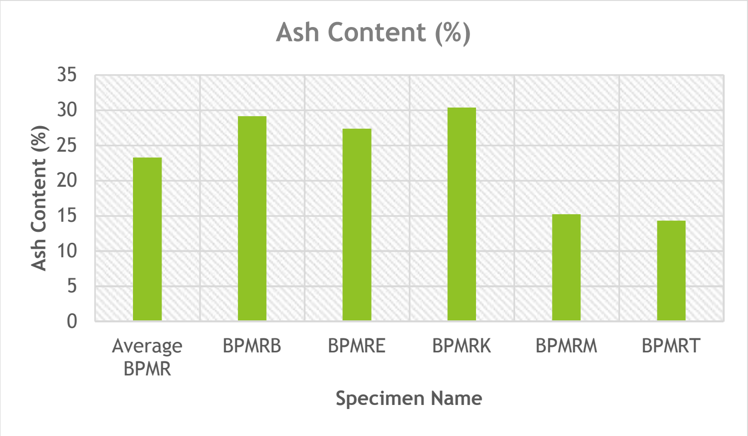
Baladi Samples, Volatile Matter to FAO Limits Comparison

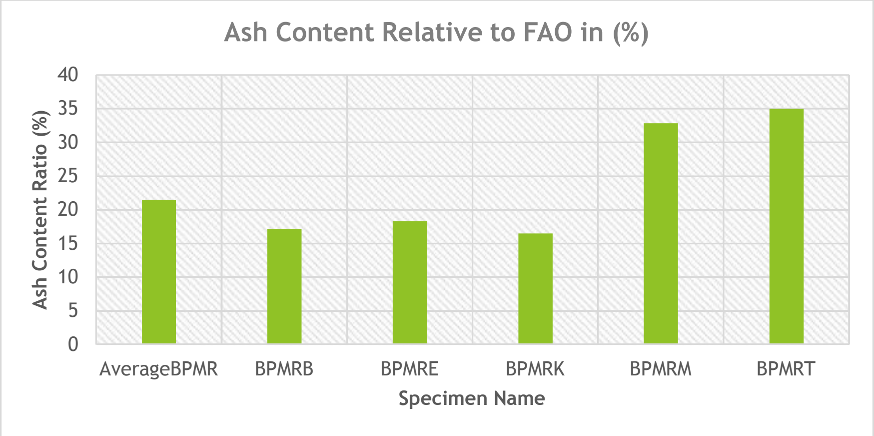
.Specimen No	Specimen Code	Volatile Matter (%)	Volatile Matter by FAO (%)
1	BPMRE	24.65	≤ 5 – 40
2	BPMRK	20.33	≤ 5 – 40
3	BPMRB	23.32	≤ 5 – 40
4	BPMRM	30.58	≤ 5 – 40
5	BPMRT	26.49	≤ 5 – 40
Average SPMR		**25.08**	**≤ 5 – 40**



Baladi Samples, Ash to FAO Limits Comparison

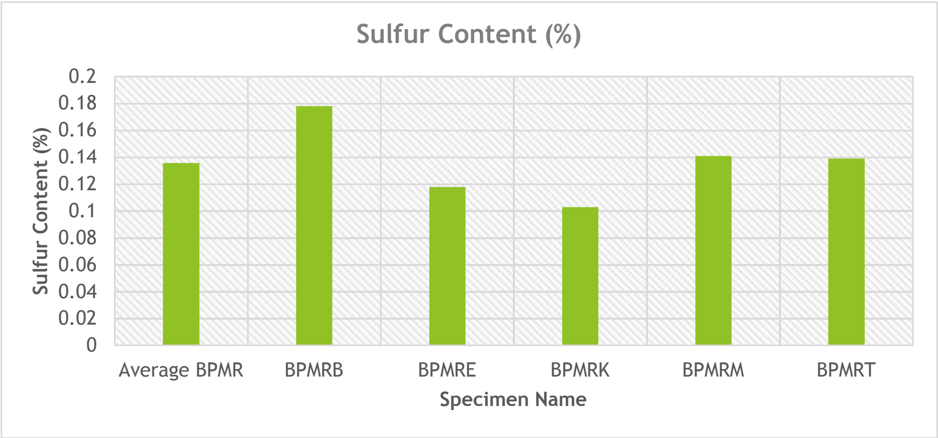
Specimen No.	Specimen Code	Ash Content (%)	Ash Content by FAO (%)	Ash Content Ratio (%)
1	BPMRE	27.37	≤ 0.5 - 5	547
2	BPMRK	30.35	≤ 0.5 – 5	607
3	BPMRB	29.14	≤ 0.5 – 5	583
4	BPMRM	15.24	≤ 0.5 – 5	305
5	BPMRT	14.30	≤ 0.5 – 5	286
Average SPMR		**23.28**	**≤ 0.5 - 5**	**466**





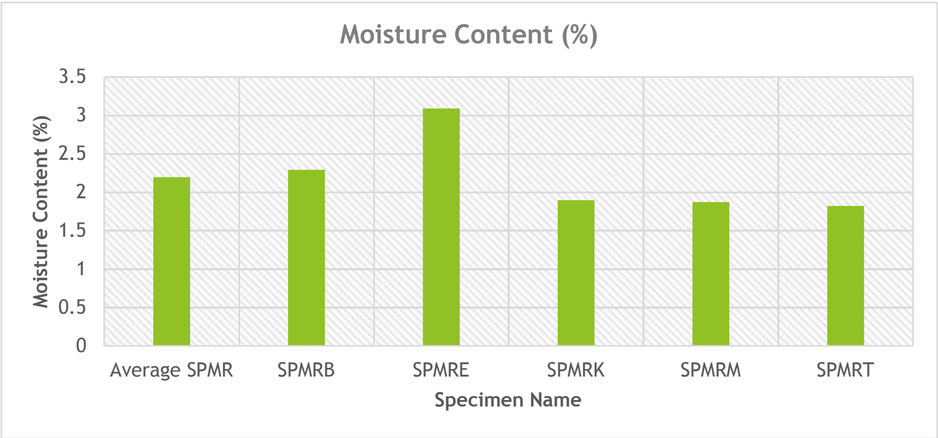
Baladi Samples, Sulfur to FAO Limits Comparison

.Specimen No	Specimen Code	Sulfur Content (%)	Sulfur Content by FAO (%)
1	BPMRE	0.12	≤ 0.6 – 0.77
2	BPMRK	0.10	≤ 0.6 – 0.77
3	BPMRB	0.18	≤ 0.6 – 0.77
4	BPMRM	0.14	≤ 0.6 – 0.77
5	BPMRT	0.14	≤ 0.6 – 0.77
Average SPMR		**0.14**	**≤ 0.6 – 0.77**



Siwie Samples, Moisture to FAO Limits Comparison

.Specimen No	Specimen Code	Moisture Content (%)	Moisture Content by FAO (%)
1	SPMRE	3.09	≤ 5 - 15
2	SPMRK	1.90	≤ 5 – 15
3	SPMRB	2.29	≤ 5 – 15
4	SPMRM	1.87	≤ 5 – 15
5	SPMRT	1.82	≤ 5 – 15
Average SPMR		**2.19**	**≤ 5 - 15**



General Benefits Arrangement

Ranke	Sample	Name
1	BPMRT	Baladi Top
2	SPMRT	Seiwi Top
3	BPMRM	Baladi Middle
4	SPMRM	Seiwi Middle
5	BPMRB	Baladi Base
6	SPMRB	Seiwi Base
7	SPMRE	Seiwi End
8	BPMRE	Baladi End
9	BPMRK	Baladi Knee
10	SPMRK	Seiwi Knee

Conclusion

- The potentiality of production of charcoal from palm midribs with satisfactory properties has been proven. The calorific value of charcoal product from Siwie and Baladi specimens are successively 88.6% and 86.2% of the FAO.
- Best Samples are the Top of Palm Midrib in Baladi, then Siwie, followed by the middle, base, knee and end studied of charcoal.
- All palm mid rib parts could to be utilized to produce charcoal.
- Activated carbon phase could be achieved during pyrolysis process by allowing for Oxygen under restricted conditions for medical applications.
- ***Palm Midrib as a Charcoal is usable and able to be utilized in a wide variety of applications.***
- ***The designed reactor in this thesis could serve in a model for the production of charcoal from palm midribs in the village conditions***

Thanks