ISSN: 2467-4915

Asian Intellect

FOR ACADEMIC ORGANIZATION AND DEVELOPMENT INC.

VOLUME 1 NO. 1 MAY 2016

Journal for Science, Mathematics, and Technology

The *Asian Intellect Journal*
for Science, Mathematics, and Technology

is an online refereed journal and is published by the

Asian Intellect

FOR ACADEMIC ORGANIZATION AND DEVELOPMENT INC.
with
SEC REGISTRATION NO. CN201539886

and office address at

BLOCK 33B, LOT 1, PHASE 2, KAUNLARAN VILLAGE, NAVOTAS CITY
and
SAN RAFAEL, TARLAC CITY

EMAIL: asianintellectorg@gmail.com WEBSITE: www.asianintellect.org

Asian Intellect
FOR ACADEMIC ORGANIZATION AND DEVELOPMENT INC.

JOURNAL for SCIENCE, MATHEMATICS and TECHNOLOGY

Volume 1, May 2016

Publication Guidelines

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5. The articles may either be written in English or Filipino. All articles written in either languages must be accompanied by an Abstract which is written in English.

6. All contributions must be original.

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INNOVATION IN THE MICROPROCESSING EQUIPMENT FOR MORINGA: ZERO WASTE MODEL

ARNULFO P. MALINIS, CHRISTOPHER O. PACARDO
Project Leader/BU Polangui Campus Dean,
Study Leader/BU Technology Commercialization Center Director*

Abstract

The project was conceptualized to innovate existing equipment to process malunggay (Moringa oleifera Lamk) and develop a "zero waste model" in order to solve its laborious and tedious processing.

Technology intervention was done in the juice extraction of the moringa leaves and stalk using the innovated crop processing machine with a capacity of 5.5 kg/hr to almost 19 kg/hr using matured and young leaves and stalks. The mean juice recovery is 62 percent. Waste meal of moringa leaves and stalk was dried and converted into powder utilizing the improved multi-crop micro-mill at a capacity of 1.23 kg/hr to 4.55 kg/hr and a mean recovery of 78.01 % as affected by the maturity of the materials. The waste in milling was packaged into tea. The system could process moringa into juice, powder and tea and be sold at 62 pesos per kg of malunggay. It has an ROI of 34.11% with a payback period of 2.1 years.

The existing extractor and micromill were modified to compose the microprocessing system for processing moringa and other similar commodities. Testing of innovated extractor to moringa was highly significant in terms of extraction time, volume of extracted juice and percent recovery of juice extracted than the manual process. The innovated microprocessing equipment for moringa has higher efficiency and capacity, however has lesser processing time, losses and power requirement. The microprocessing equipment for moringa is economically viable and feasible.

The fabrication of the prototype of "Agiseparator", downsizing of the equipment, technology commercialization, adoption of a backyard planting for moringa; health impact dissemination; determination of nutrient retention; and loss during processing and development of more products from moringa are the recommendation of the study.

Keyword: Moringa oliefera Lamk juice, zero waste model, extractor, micromill,

INTRODUCTION

Malunggay, known scientifically as Moringa oleifera Lamk, is one of the world's most useful plants. It is used as food, effective flocculants or water treatment, antibiotic, source of oil, and coagulant for turbid waters. It is cultivated in all countries of the tropics. It is easy to plant and is available year-round (Anwar F. et.al. 2007). In the Bicol region, no records for the plantation of moringa, however, backyard production are noticeable in barangays even in town centers. These backyard plantations if being bought to be processed into powder will inspire more farmers to plant moringa which will increase its production (Sandoval et.al 2013).

Moringa is also called mother's best friend and miracle vegetable by many who know moringa's beneficial uses. One hundred grams or 1 cup of cooked moringa leaves contain 3.1 g. protein, 0.6 g. fiber, 96 mg calcium, 29 mg phosphorus, 1.7 mg iron, 2,820 mg ß-carotene, 0.07 mg thiamin, 0.14 mg riboflavin, 1.1 mg niacin, and 53 mg ascorbic acid or vitamin C. The antioxidant activity of moringa is about 71%, with μ-tocopherol (vitamin E) equivalent of 45 (Babu S. 2000). It is an excellent source of vitamin A and B, and minerals such as calcium and iron. It is even an excellent source of protein, being higher than the amino acid pattern of Food and Agriculture Organization-reference protein, yet contains very low fat and carbohydrates. The leaves are incomparable as a source of the sulfur-containing amino acids methionine and cystine, often the natural minerals humans' lack (Broin M. 2006).

With this much benefit to human body, moringa now is a luminary. According to the Moringa Growers Association of the Philippines, Inc. (MGAPI), they have supplied Farmers Association with 345,000 seedlings in Cebu, Camarines Sur, Camarines Norte, Misamis Occidental, Zamboanga del Norte, and Nueva Ecija (Versoza 2012).

Lots of studies were undertaken to process this commodity into various by-products such as powder as food additive, oil, fuel, flavoring, medicine, and tea. In the Philippines there are more than 200 microprocessors engage in the processing of moringa. Such processors are using household tools and equipment to process the commodity. The process and equipment used is creating so much waste (Versoza 2012).

To address this problem, the Bicol University through its Polangui Campus innovated existing machines such as extractor and micromill to suit for the processing of moringa and create a zero waste processing technology processing model. As such this, project.

Objective

The general objective of this study is to innovate microprocessing equipment for moringa. To create a zero waste processing model for the production of juice and powder, Specifically:

1. To innovate existing juice extractor and micromill for moringa processing;
2. To design and fabricate the innovated equipment for moringa processing;
3. To test and evaluate its performance in terms of efficiency, capacity, time, losses and power requirement; and
4. To determine its technical and economic viability.

Methods

1. Technology Verification

Technology verification was done to generate data from manual separation of moringa leaves and stalks. The time, process, tools and materials used was documented to be the basis for technology intervention.

2. Ex-Ante Analysis /Technology Intervention

An ex-ante analysis was done to the process of separating leaves and stalks of moringa. Simulation of the manual processing was to study the possible technology intervention to be done to the tedious process. Creation of a mature, creative and zero waste model of moringa processing technology must be done. As a general scheme, product and by products development was done to create the zero waste moringa processing technology.

3. Innovation and Development of Prototype Model

Existing machine was innovated based on the manual extraction of moringa. The innovation was based on the problems that the machine encountered during it preliminary testing for moringa extraction. The innovation consideration also includes the simplicity and portability or ease of transport, use of locally available materials, affordable cost, capacity, efficiency and the economics of operation.

The conceptualized design was translated into working drawings/plans with specifications and costs. Consultation with the BUPC and KOLBI engineers was done for suggestions on the final design of the prototype model.

The machine was fabricated by KOLBI following the design and specifications. Materials for fabrication was procured in the local market or where the materials are available.

4. Field Testing and Evaluation

The Machines develop was tested for the mechanical separation of leaves and stalks of moringa. The moringa was procured and was used for machine pre-test or test run. The machine was evaluated as to its operation, running condition and parts coordination. In case of any defect in operation, further modification will be done to incorporate the changes. The modified model was tested and evaluated using the above-mentioned parameter. All cost incurred during the fabrication and modification of the machine was recorded to determine the actual machine cost.

Field testing of the developed machines was done in an identified field site which was using the following criteria: process, capacity, efficiency, time, quality of products, and economics of the process. Results of the test was collected and properly recorded. Tables and diagrams was designed for ease of recording and analysis of data. Machine performance was evaluated and analyzed using descriptive statistics.

Data analysis was conducted and the report of the study will be prepared.

Findings

Technology Verification

The technology verification was done with three (3) processors engage in processing moringa. The verifications test the established the data and process from stalk-leaves separation, extraction and milling operation. Three maturity levels of moringa were used to in the verification test to established the finest ripeness of moringa that could be processed. The very young maturity level is a two (2) week old moringa stalk; the young maturity level is a four (4) week old moringa stalk; and the old maturity level is the six (6) week old moringa stalk. Fifty stalk of moringa were utilized in every maturity level. The verification tests were done in single and in bulk. Milling of moringa was not included in the verification since the meal of extracted moringa leaves were considered as wastes including its stalks.

The verification test of moringa stalk-leaves separation utilizes two (2) manual method, in single and in bulk. Stalk-leaves separation reveals that it consumed four 4 hours and 50 minutes, two 2 hours and 48 minutes and 1 hour and 20 minutes to separate the leaves from its stalk for very young, young and old maturity levels, respectively. Verification test on moringa stalk-leaves separation is shown on table 1.

Verification test of manual extraction of was done using cloth. The extraction of leaves incurs 10, 9.3 and 8.7 minutes for the very young, young and old maturity levels, respectively, while it took 13, 16.2 and 22 minutes to extract the juice of stalk for the respective maturities. Verification test for manual juice extraction is shown on table 2.

Total juice recovery was established at 10.37% for very young maturity level, 12.93% for young maturity level and 15.06% for old maturity level.

Table 1.0 Verification Test for Manual Process

Table 2. Verification test for manual juice extraction of moringa leaves and stalk

Maturity of Moringa Stalks and Leaves	No. of stalks	Weight (g)	Time of detaching leaves (min)	Time of Juice Extraction (min)		Recovery (ml)		Total Recovery (%)
				leaves	Stalk	Leaves	Stalk	
M1	50 stalks	1029	290	10	13	101.50	5.38	10.37
M2	50 stalks	1195	147.82	9,3	16.2	150.39	4.18	12.93
M3	50 stalks	1257	80	8.7	22	186.48	2.77	15.06

Ex-Ante Analysis/Technology Intervention

Maturity of Moringa Stalks and Leaves	No. of stalks (in pcs)	Weight (in g)	Juice Extraction Time (in min)		Volume of juice extracted (in ml)		Extraction Recovery (in %)	
			Leaves	Stalk	Leaves	Stalk	Leaves	Stalk
M1	50 stalks	1029	10	13	101.50	5.38	9.86	0.52
M2	50 stalks	1195	9,3	16.2	150.39	4.18	12.58	0.35
M3	50 stalks	1257	8.7	22	186.48	2.77	14.83	0.22

Basing from the verification tests conducted, a process flow for processing moringa was established. The process involves the leaves-stalk separation, extraction drying and milling. Leaves and stalk separation need to be mechanized since it is very tedious and time consuming, however, due to the irregular shape of the stalk of horseradish, difficulty in designing an appropriate machine was experienced, thus, adjustment in the procedure was done by air drying method. Two (2) hours of air drying was employed to make the leaves detachable from stalk. Detaching of leaves from its stalk was done by flapping.

Another tedious method in processing moringa is the extraction. This process need also to be mechanized to obtain higher extraction capacity, greater juice recovery and the zero waste process. Existing extraction machines was tested in the extraction, however, innovation machine must be done to suit the machine in extracting moringa.

Drying was done to the extracted meals of the leaves and stalk to create a zero waste in the process. Drying was a tedious method in processing moringa, however, it was not suitable to be dried in the mechanical dryer because it requires low drying temperature because it liquefy if applied by higher temperature for abrupt drying, thus, air drying was employed.

The milling process was also identified to be mechanized since there is no substitute manual method in milling the dried moringa. Existing machine was tested to mill the commodity.

Each of these method requires operational cost. Costing of this depends on time consumed and the difficulty of the process.

Innovation in the Moringa Stalk and Leaves Separation by Flapping Method

An alternative method in separating leaves and stalk of moringa was established. Moringa was air dried for two hours to make the stalk twig soft and make the leaves separate from its stalk freely. It the method, the leaves that freely detach from the stalk after air drying weighs 160 g, 272 g, and 390 g for very young, young and old maturity level. The process had percent recovery of 34.45% for very young maturity, 78.43% for young maturity and 94.73 for old maturity. Data for the moringa stalk and leaves separation is shown on table 3.

Table 3. Innovative Moringa Stalk and Leaves Separation

Parameters	Maturity Levels		
	M1	M2	M3
	50 stalk	50 stalks	50 stalks
Weight before flapping (g)	1045	1102	1226
Wt of Leaves detached without flapping (g)	160	272	390
Wt of Leaves detached on 1st flapping (g)	41	165	232
Wt of Leaves detached on 2nd flapping (g)	30	105	115
Wt of Leaves detached on 3rd flapping (g)	0	63	76
Wt of Leaves detached on 4th flapping (g)	0	0	0
Total weight of leaves detached (g)	252	605	813
Wt of leaves not detached in the stalk (g)	479.5	166.4	42.2
Total Detached Leaves (%)	34.45	78.43	94.73

Machine Innovation, Fabrication and Testing of Moringa Juice Extractor

Innovation in the existing extracting machine was done by modifying its hopper and extracting chamber to suit for the moringa and other similar commodities. Fabrication of machine was done at Tropics Agro Industry in Naga City which is capable to craft the machine. It carefully follows the design drawing with its measurements. Available local food grade materials were used in the fabrication of machine. The machine was composed of hopper, extracting chamber, adjuster, transmission, frame and primemover. The figures and pictures for machine design, fabrication, perspective picture and pictures of testing is shown on Fig. 1, 2, 3, 4, 5, respectively.

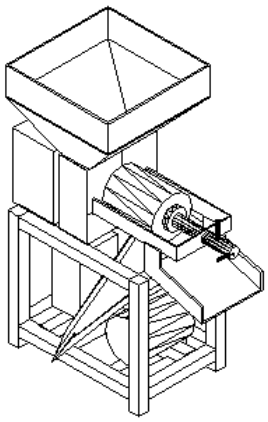

Fig. 1.0 Design Sketch of Malunggay Extractor

Fig. 2.0 Fabrication of the machine

Fig. 3.0 The perspective view of Extractor

Fig. 4.0 Testing of Machine using Moringa leaves

Fig 5.0 Testing of Machine using Moringa Stalk

Fig. 6.0 Testing of Machine using Moringa Stalk with leaves

Machine Testing

Machine testing were done at Bicol University Polangui Campus, Polangui, Albay. Testing of the machine was done three times using three (3) maturity levels of moringa to validate its initial result in terms of capacity, efficiency and percent recovery. The data were subjected to DMRT and analysis of variance by method and maturity of moringa.

Analysis on test result shows that the time of extraction to each maturity level of moringa leaves is significant at 5% level but not on moringa stalk. The obtained extraction time on moringa leaves is highly significant on method used. However, the extraction time for stalk is highly significant on both maturity and method. This is because maturity affects much on the hardness of the stalk to be extracted in manual method. Extraction time of moringa leaves and stalk is presented in table 4 and 6, respectively. Analysis of variance extraction time of moringa and stalk is presented on table 5 and 7, respectively.

The volume of juice extracted for both moringa leaves and stalk are not significant at 5% level. However, they are highly significant on maturity, method and both. This means that the method of extraction affects so much to the volume of juice extracted. Volume of juice extracted for both moringa leaves and stalk is presented on table 8 and 10 respectively. The Analysis of Variance for the juice extracted is shown on table 9 and 11, respectively.

The extraction recovery for both moringa leaves and stalk are not significant at 5% level. The extraction recovery for leaves are highly significant on method and maturity. Extraction recovery for the stalk is significant on maturity and highly significant on method. This means that the maturity of the moringa stalks contribute to its hardness and affects the extraction recovery. The extraction recovery for moringa leaves and stalk is shown on table 12 and 14, respectively. The analysis of variance for the extraction recovery of moringa leaves and stalk is shown on table 13 and 15, respectively.

Table 4. Extraction time (min) of juice as affected by method of extraction and maturity of *moringa* leaves

Table 5. ANOVA of extraction time of juice as affected by method of extraction and maturity of *moringa* leaves

Table 6. Volume of juice (ml) extracted as affected by method of extraction and maturity of *moringa* leaves

Method of extraction	Maturity			Mean
	M1	M2	M3	
Manual	10.00	9.30	8.70	9.33
Mechanical	1.36	1.37	1.39	1.37
Mean	5.68	5.34	5.05	5.35

[1]*Means followed by common letter are not significantly different at 5% level (DMRT)*

Table 7. ANOVA of volume of juice extracted as affected by method of extraction and maturity of *moringa* leaves

Source of Variation	df	Sum of Squares	Mean Squares	Obs F	*p* value	Sig
Maturity (Ma)	2	1.2127	0.6064	3.363	0.069	ns
Method (Me)	1	285.1272	285.1272	1581.551	0.000	**
Ma x Me	2	1.3287	0.6643	3.685	0.057	ns
Error	12	2.1634	0.1803			
Total	17	289.8320				

Ns = not significant
*** = significant at 1% level*
Cv = 7.93%

Table 8. Extraction recovery (%) as affected by method of extraction and maturity of *moringa* leaves

Method of extraction	Maturity			Mean
	M1	M2	M3	
Manual	101.50	150.39	186.48	146.12
Mechanical	259.00	448.00	658.00	455.00
Mean[1]	180.25 c	299.20 b	422.24 a	300.56

[1]*Means followed by common letter are not significantly different at 5% level (DMRT)*

Table 9. ANOVA of extraction recovery as affected by method of extraction and maturity of *moringa* leaves

Source of Variation	df	Sum of Squares	Mean Squares	Obs F	*p* value	Sig
Maturity (Ma)	2	175694.2903	87847.1452	4329.141	0.000	**
Method (Me)	1	429321.5785	429321.5785	21157.132	0.000	**
Ma x Me	2	74242.0303	37121.0152	1829.338	0.000	**
Error	12	243.5046	20.2921			
Total	17	679501.4037				

** = *significant at 1% level*
cv = *1.50%*

Method of extraction	Maturity			Mean
	M1	M2	M3	
Manual	9.86	12.58	14.83	12.42
Mechanical	60.19	57.93	62.99	60.37
Mean[1]	35.03 b	35.26 b	38.91 a	36.40

[1]*Means followed by common letter are not significantly different at 5% level (DMRT)*

Table 10. Extraction time (min) of juice as affected by method of extraction and maturity of *moringa* stalk

Source of Variation	df	Sum of Squares	Mean Squares	Obs F	*p* value	Sig
Maturity (Ma)	2	57.0103	28.5051	95.102	0.000	**
Method (Me)	1	10344.9728	10344.9728	34513.922	0.000	**
Ma x Me	2	18.7027	9.3513	31.199	0.000	**
Error	12	3.5968	0.2997			
Total	17	10424.2826				

** = *significant at 1% level*
cv = *1.50%*

Table 11. ANOVA of extraction time of juice as affected by method of extraction and maturity of *moringa* stalk

Table 12. Volume of juice (ml) extracted as affected by method of extraction and maturity of *moringa* stalk

Method of extraction	Maturity			Mean
	M1	M2	M3	
Manual	13.00	16.20	22.00	17.07
Mechanical	1.82	1.80	1.81	1.81
Mean[1]	7.41 c	9.00 b	11.91 a	9.44

[1]*Means followed by common letter are not significantly different at 5% level (DMRT)*

Source of Variation	df	Sum of Squares	Mean Squares	Obs F	*p* value	Sig
Maturity (Ma)	2	62.3443	31.1722	47.604	0.000	**
Method (Me)	1	1047.4465	1047.4465	1599.603	0.000	**
Ma x Me	2	62.5363	31.2681	47.751	0.000	**
Error	12	7.8578	0.6548			
Total	17	1180.1849				

** = *significant at 1% level*
cv = *8.57%*

Table 13.

Method of extraction	Maturity			Mean
	M1	M2	M3	
Manual	5.38	4.18	2.77	4.11
Mechanical	168.00	203.00	241.00	204.00
Mean[1]	86.69 c	103.59 b	121.89 a	104.06

[1]*Means followed by common letter are not significantly different at 5% level (DMRT)*

ANOVA of volume of juice extracted as affected by method of extraction and maturity of *moringa* stalk

Source of Variation	Df	Sum of Squares	Mean Squares	Obs F	*p* value	Sig
Maturity (Ma)	2	3718.0101	1859.0051	210.181	0.000	**
Method (Me)	1	179802.0545	179802.0545	20328.599	0.000	**
Ma x Me	2	4290.2301	2145.1151	242.529	0.000	**
Error	12	106.1374	8.8448			
Total	17	187916.4321				

** = *significant at 1% level*
cv = *2.86%*

Table 14. Extraction recovery (%) as affected by method of extraction and maturity of *moringa* stalk

Method of extraction	Maturity			Mean
	M1	M2	M3	
Manual	0.52	0.35	0.22	0.36
Mechanical	63.57	61.88	63.50	62.98
Mean[1]	32.05 a	31.12 b	31.86 a	31.67

[1]*Means followed by common letter are not significantly different at 5% level (DMRT)*

Table 15. ANOVA of extraction recovery as affected by method of extraction and maturity of *moringa* stalk

Source of Variation	df	Sum of Squares	Mean Squares	Obs F	*p* value	Sig
Maturity (Ma)	2	2.9083	1.4541	5.656	0.019	*
Method (Me)	1	17645.6898	17645.6898	68629.117	0.000	**
Ma x Me	2	2.7129	1.3564	5.276	0.023	*
Error	12	3.0854	0.2571			
Total	17	17654.3964				

* = *significant at 5% level*
** = *significant at 1% level*
cv = 1.60%

Drying of Moringa

To create a zero waste model, the recovered meal from extraction of moringa leaves and stalk were subjected to drying to produce moringa powder. Three (3) drying method was done to moringa. Air drying was in the shaded area, oven drying was done for 4 hours and sun drying was in 8 hours. The drying process was done on both leaves, stalk and stalk with leaves. Significant result was observed in the sundrying considering the number of hours of drying the moringa. Result of moringa drying is shown in table 16.

Table 16. Results in Drying Moringa at Different Drying Methods

Parameters	Drying Method		
	Air Drying	Oven Drying	Sun Drying
Weight of fresh moringa (g)	500	500	500
No. of stalks (pcs)	68	65	68
Weight of stalks (g)			
Primary	131.0	147.50	132.50
Secondary	70.8	61.5	71.10
Weight of leaves (g)	297.10	290.8	295.5
Temperature (°C)	33	55	45
Air drying of leaves for 5 days (g)	93.2	-	-
Air drying of stalks for 5 days (g)	51.9	-	-
Oven drying of leaves for 4 hours (g)	-	84.5	-
Oven drying of stalks for 4 hours (g)	-	40.8	-
Sun drying of leaves for 8 hours (g)	-	-	89.00
Sun drying of stalks for 8 hours (g)	-	-	50.20

Adoption and Testing of Multi-crop Micromill for Milling Moringa

The BUCAF-KOLBI multi-crop micromill was adopted for milling and conversion of dried moringa into powder. Minor modifications were done in the machine to suit in moringa processing like size of sieve and pins.

The sun dried leaves, stalks, and stalk with leaves are utilized and separately tested in the micro-mill.

Results revealed that the machine has a the highest capacity of 4.55 kg/hr and a high efficiency of 98.71% in milling leaves of M3. The lowest milling capacity was obtained in the dried stalks of M1 and M2. Maturity level 3 (M3) is the best maturity and material for powder production. Result of the micro-mill machine test is shown on table 17.0.

Table 17. Results of Milling Moringa Using Micromill

Parameter	Level of Maturity								
	M1			M2			M3		
	Leaves	Stalk	Stalk w/ Leaves	Leaves	Stalk	Stalk w/ Leaves	Leaves	Stalk	Stalk w/ Leaves
Weight of dried material (g)	302	299.8	289.60	295.5	287.0	290.0	305.50	287.8	294.60
Wt of milled material (g)	223.84	220.17	205.96	226.62	234.45	230.26	245.74	241.66	238.51
Efficiency (%)	78.02	78.30	78.15	87.35	91.28	89.22	98.71	99.37	98.11
Recovery (%)	74.12	73.44	71.12	76.69	81.69	79.40	80.44	83.97	80.96
Capacity (kg/hr)	3.12	1.21	1.68	3.77	1.23	1.91	4.55	3.2	3.7

Socio-Economic Implications

The processing technology for moringa that creates zero waste model has produced three products: the juice, the powder and the tea. The juice that is a product of extraction was subjected to packaging and ready for marketing. The meal that was dried and subjected to milling was packaged as flavoring to pastries and baked goods. The waste in milling was packaged into tea. Thus, the technology is a zero waste model.

The microprocessing equipment is now ready for promotion and adoption by the processors and targeted clienteles. To provide a macro-scenario showing the economic impact of processing say that the extracting machine could process around 10 kg per hour then it could extract the juice of about 16800 kg per year. This means that an additional income of Php 420,000.00 per year will be earned by the farmers in a community with one (1) extractor at Php 25/kg of

moringa. This is aside from the Php 666, 544 income if the moringa will be process through juice, powder and tea. The system could process moringa into juice, powder and tea and be sold at 62 pesos per kg of moringa. It has an ROI of 34.11% with a payback period of 2.1 years. Thus, moringa processing would create business and job opportunities for the various sector of the community.

Conclusions:

1. The existing extractor and micromill were modified to compose the microprocessing system suited for processing moringa and other similar commodities.
2. Testing of innovated extractor for moringa shows that it is highly significant in terms of extraction time, volume of extracted juice and percent recovery of juice extracted comparing to manual process while testing of micromill likewise show high recovery and efficiency in maturity 3.
3. The innovated microprocessing equipment for moringa has higher efficiency and capacity, however has lesser processing time, losses and power requirement.
4. The microprocessing equipment for moringa is economically viable and feasible.

Recommendations:

1. Development of the prototype of "Agiseparator" through DOST-TAPI prototype assistance program must be done to incorporate in innovated microprocessing equipment.
2. Downsizing of the equipment to suit the needed capacity of the microprocessors.
3. Determination of nutrient retention and loss during processing.
4. Conduct commercialization through promotion and marketing.
5. National agencies, Schools and communities should adopt a backyard planting which would include moringa as one of the commodity.
6. Dissemination of the health impact of moringa to increase the demand to moringa products.
7. Development of more products from moringa.

ACKNOWLEDGEMENT

Behind every persistence is one's success, but we never enjoy that success without accrediting other people's help. Success is not only worthy by claiming it by yourself. For life's journey can never be alone that no matter how big or small others help can be, they will always be a part of that success. To all those people and agencies that have made it possible for the proponents of this research project, they salute you for believing on them more than they do. The group wishes to extend their deepest gratitude to BU through the BURDC for allowing them to conduct the Project, to the malunggay processors, for giving their know how on the processing methodology, to BUPC for the assistance in the traveling expenses, and to the management of the Tropics Agro-industries Inc. for the technical and financial support in fabricating the machines.

We dedicate this piece of work to the ALMIGHTY, to the farmers and to our families.

The Research Team

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MODELLING AND SIMULATION OF A THERMAL HEAT WASTE CONVERSION TO ELECTRICAL ENERGY USING LABVIEW

Engr. GILLERT M. BONGCAC, MoE
Mindanao State University – Iligan Institute of Technology
Iligan City, Philippines
phyton_gil@yahoo.com

ABSTRACT

This study presents the conceptual design, theoretical modelling and simulation on the thermal to electrical energy conversion of the thermoelectric generator using the exhaust waste heat from the motor vehicles using Labview. The vehicle components modelled are the temperature of the exhaust system and the TEG characteristic parameter base on the TEG data sheets. The conversion of the energy system where based on the vehicle engine parameters and the preference parameter of the TEG and vehicle. Results shows that the parametric reference of the vehicles can be meet by combining different TEG connections. Also, the model has already proved useful in ideal thermoelectric experiments in the laboratory computer-based environment.

Keywords: Energy conversion modelling and simulation, Thermal to electrical energy conversion, TEG Energy conversion using Labview, Energy conversion modelling and simulation using Labview.

INTRODUCTION

The raising concerns over fuel consumption and engine efficiency have shifted the interest of the automotive industry towards producing fuel efficient vehicle. This gives birth to concepts and technologies such as hybrids and electric vehicles. However since most of the fuel energy is lost in the form of waste heat in the exhaust, thermoelectric generator can be utilized to recover those waste heat energy and converts it into supplementary electrical energy to the vehicle system. (Said et al. 2016). Thermoelectric effect is a simple phenomenon based on the thermal and electrical characteristics of a material. The thermoelectric effect, generally known as the Seebeck effect, gives rise to this inherent EMF or voltage due to the material property known as the Seebeck coefficient.

The main advantage of thermoelectric power is, it is a solid state energy conversion that does not have mechanical or liquid based moving parts. Hence, modules can be designed to be compact, stable as well as being reliable and noiseless (Kobbekaduwa & Subasinghe, 2016). Modelling of TE device or the behaviour of individual materials is an important prerequisite for the design and control verification of the final output device. Hence, the model has to be integrated seamlessly to the overall system model that may contain other electrical, thermodynamic, or mechanical components (Felgner et al., 2014). Numerous research work on modelling a thermoelectric material or module been done using software such as SPICE (Mourmourni & Baker, 2015, Li er al., 2014) as well as Dynamic and static modelling of TE modules using MATLAB/ Simulink (Kane & Singh, 2012, Yusop et al., 2014). The modelling of thermal and power generation behaviour of these TEGs have been extensively studied (Yusop & Ayub, 2013) and the output values have also been modelled and estimated using novel techniques such as Artificial Neural Networking (Ciylan, 2011).

In this study, the research focuses on modeling and simulation of thermal to electrical energy conversion system of heat waste using Labview and to reduce the load on the generator/alternator of the motor engine by converting the waste heat from the exhaust gas of the vehicle into electrical source for the motor vehicle.

Objectives

The study aims to:

1. Modelling and simulation of a thermal energy heat waste conversion to electrical energy using Lab view.
2. Evaluate the parameter performance of the modelled design with respect to different heat waste temperature.
3. Evaluate the efficiency of the modelled design.

Thermoelectric Generator Principle

In 1821 Thomas Johann Seebeck discovered that when two different current carrying conductors are joined into a loop, with a temperature difference maintained between the two junctions formed by the loop, an electromotive force (emf) is generated. Such a loop is called a thermocouple, the emf generated is known as a thermoelectric emf or Seebeck voltage, and the phenomenon is known as the Seebeck effect, as shown in Figure 3. The following equations govern the thermoelectric. The Seebeck coefficient S and the voltage output V of the TEG module is defined as:

$$S = \frac{Vmax}{Th} \quad (1)$$

and

$$V = S\Delta T - IR \quad (2)$$

where Th is the emitting temperature and Vmax is the maximum voltage of the thermoelectric module. ΔT is the temperature difference which is equal to Th – Tc and this temperature difference can be used to calculate the output current, which can be expressed as

$$I = \frac{S\Delta T}{2R} \quad (3)$$

where R is the electrical resistance which can be calculated as

$$R = \frac{Vmax(1 - \Delta Tmax/Th)}{Imax} \quad (4)$$

The efficiency of a thermoelectric material is described using a dimension less figure of merit Z. A good TEM must combine a large Seebeck coefficient S with low thermal conductivity K_{TH} and electrical resistance R Hence FOM is given by,

$$Z = \frac{S^2}{RKth} \quad (5)$$

The thermal conductivity K_{th} of a TEG and the efficiency TE_eff of the whole system are shown below, where Qe is the exhaust heat available or heat loss in exhaust gas and P is the matched power of the vehicle.

$$K_{th} = \frac{Qe}{\Delta T} \quad (6)$$

and

$$TE\_eff = \frac{(100)P}{Qe} \quad (7)$$

The required number of thermoelectric elements n_e for the vehicle and the heat loss in exhaust gas Qe can be calculated using,

$$n_e = \frac{Qe}{2[(SI(Th + 273)) - (I2R/2G) + (Kth(Th - Tc)G)]} \quad (8)$$

and

$$Qe = m_e Cp(1000)(Th - Tc) \quad (9)$$

where mass flow rate of exhaust gas m_e is given by

$$m_e = mf + ma \text{ , } mf = \frac{SFC(P)}{3600} \text{ , and } ma = eff(R)(N)Vs/120 \quad (10)$$

The exhaust heat of the motor vehicle is directly proportional to the rated revolution per minute, heat capacity of the exhaust gas, volumetric efficiency, air density, specific fuel consumption. compression ratio, and engine capacity of the motor engine.

METHODOLOGY

Modelling and Simulation

In "1999 Bosch Automotive electrics and electronics Handbook" the average electrical power consumption of an automobile is about 600 watts (Bosch, 1999). This load is carried by an inefficient engine/alternator system. The simulated design works on the principle of thermoelectricity: when the junctions formed by joining two dissimilar current carrying conductors are maintained at different temperatures, an electro motive force (emf) is generated in the circuit. The current carrying conductors are known as thermoelectric elements and the couple formed out of the two current carrying conductors is known as thermoelectric couple. In a typical generator heat exchangers are used to transfer heat from the heat source and the sink to junctions of the thermocouple. The heat exchangers and the thermoelectric couple unit is known as a thermoelectric generator (TEG). The simulated design used the vehicle exhaust gas as its heat source.

Given the fundamental specifications of a TEG directly from the manufacturer's datasheets, the parameters of the proposed model can be calculated by Eqs. 1-10. The proposed model and its subsystem for the TEG module is stimulated using Labview as shown in Fig. 4 and Fig. 5.

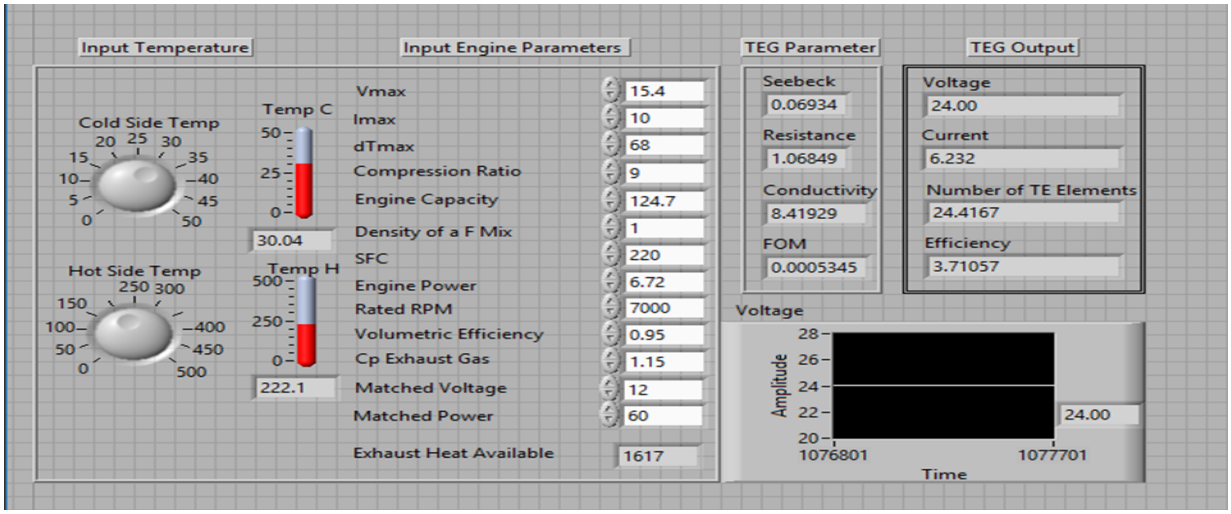


Figure 4. Front Panel of the System

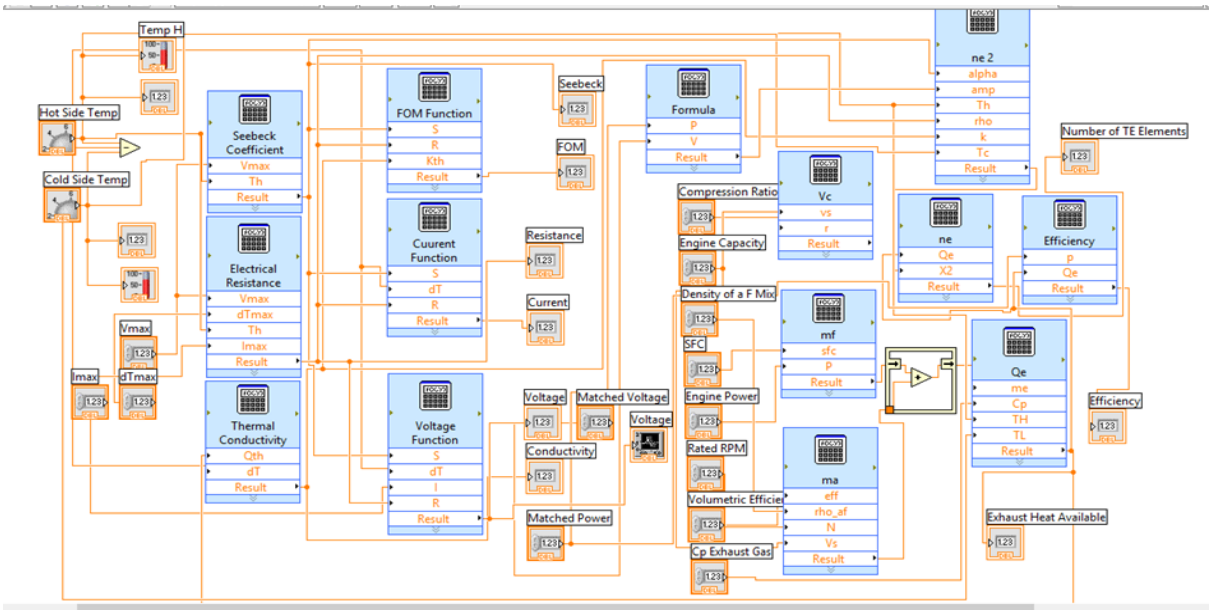


Figure 5. Block Diagram of the System

For the TEG vehicle exhaust application, it is highly desirable to match the output voltage and the load power. The modelling and simulation of the energy conversion of the TEG is done using Eqs. 1-6. And the voltage and current output can be simulated using Eqs. 2 & 3. Figure 6 shows the block diagram of the energy conversion from thermal to electrical.

The engine parameter of the vehicle, as showed in Fig. 7, is then inputted to determine the exhaust heat available which can also be simulated using Eq. 9. The number of thermoelectric element can also be determined using Eq. 8 based on the matched output voltage and load power of the vehicle.

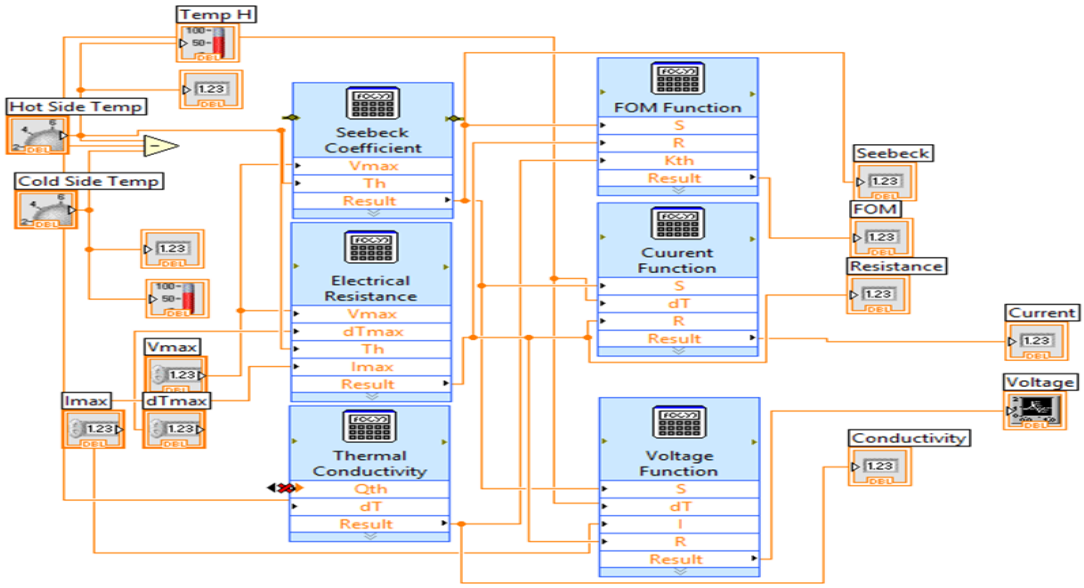
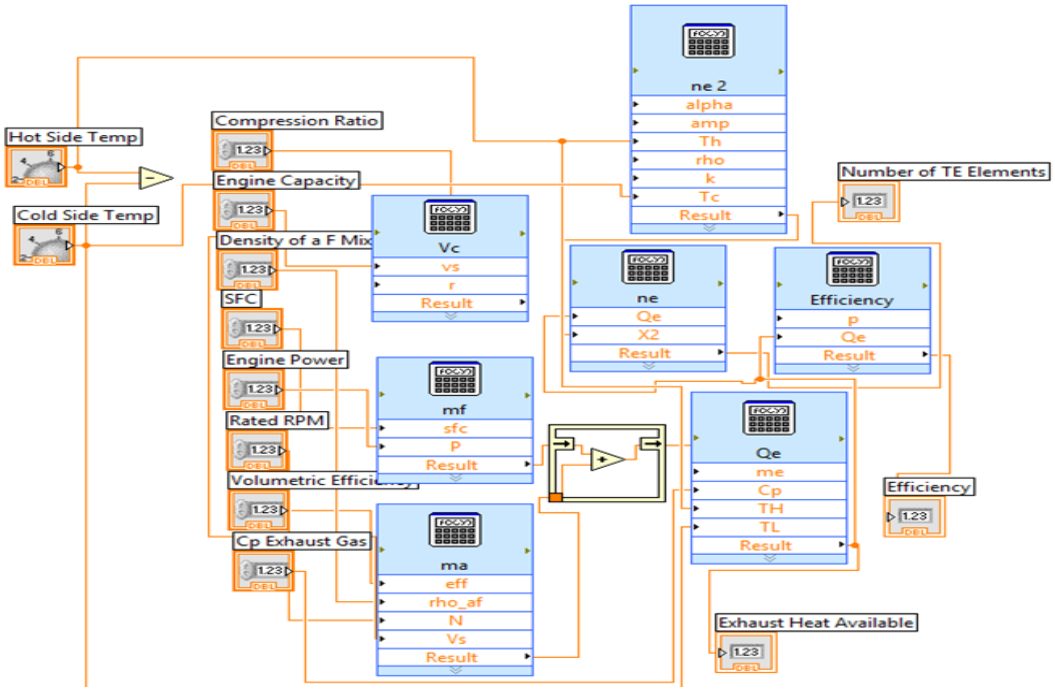


Figure 6. Block Diagram of the TEG Energy Conversion



RESULTS AND DISCUSSIONS

Table 1 (a-c) shows the simulated output of the TEG with different input temperature in the hot side and cold side of the TEG. The output voltage increases as the hot side of the TEG is increase while the output current decreases. This is due to the increase of TEG resistance and decrease of seebeck coefficient as the temperature increase. The seebeck coefficient decreases because of the increase in the temperature of the hot side of TEG while the FOM decreases because its directly proportional to the seebeck coefficient, as shown in Table 2.

Table 1: Simulated Data on Output Voltage and Output Current

Tc	Th	Vo	Io
10	200	24.79	7.2
10	210	25.08	7.04
10	220	25.034	6.91
10	230	25.58	6.79
10	240	25.8	6.69
10	250	26	6.59
10	260	26.18	6.51
10	270	26.35	6.436
10	280	26.5	6.36
10	290	26.66	6.31
10	300	26.8	6.25

Tc	Th	Vo	Io
20	200	24.02	6.82
20	210	24.35	6.69
20	220	24.64	6.579
20	230	24.91	6.48
20	240	25.15	6.39
20	250	25.38	6.32
20	260	25.59	6.25
20	270	25.78	6.18
20	280	25.96	6.13
20	290	26.13	6.08
20	300	26.28	6.08

Tc	Th	Vo	Io
30	200	23.25	6.44
30	210	23.61	6.34
30	220	23.94	6.25
30	230	24.24	3.17
30	240	24.51	6.11
30	250	24.76	6.04
30	260	25	5.99
30	270	25.21	5.94
30	280	25.41	5.896
30	290	25.6	5.86
30	300	25.77	5.82

Table 2: Parametric Performance of TEG

Difference	Seebeck Coefficient	FOM
190	0.077	0.00069
200	0.073	0.00061
210	0.070	0.00055
220	0.067	0.00049
230	0.064	0.00044
240	0.062	0.00040
250	0.059	0.00037
260	0.057	0.00034
270	0.055	0.00031
280	0.053	0.00028
290	0.051	0.00026

For the performance of the whole design, as shown in Table 3, the efficiency decreases while the difference of the cold and hot side of the TEG increases. This is due to the increase of exhaust heat available in the motor cycle.

Table 3: Simulated Data on Efficiency

Difference	TE Element	Efficiency
190	20.04	4.17
200	22.08	3.94
210	23.93	3.74
220	25.53	3.55
230	26.86	3.38
240	27.90	3.23
250	28.66	3.09
260	29.18	2.96
270	29.46	2.84
280	29.56	2.73
290	29.51	2.63

CONCLUSION

The modelling and simulation of the energy conversion of the TEG has successfully designed and tested in Labview. It shows that the current and voltage output was generated by increasing the thermal difference between the cold side and hot side of the TEG. Since electric energy was produced by the simulation, it shows that when used in a motor vehicle, it can give electrical source in an electric dependent parts of the motor vehicle and charge up batteries which results to fuel consumption economy.

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DEVELOPMENT OF A WEB-BASED NUTRITION INFORMATION SYSTEM FOR THE PUBLIC ELEMENTARY PUPILS OF THE PROVINCE OF ALBAY

MICHAEL ANGELO D. BROGADA, MA. CORAZON R. NAZ
Bicol University College of Science Computer Science/Information Technology(CS/IT) Department - Extension Service Center
Legazpi City, Albay Philippines 4500

ABSTRACT

This study aims to develop a Web-Based Nutrition Information System that will monitor the nutritional status of the public elementary pupils in Albay. Study 1 which covered implementation from August 2013 to July 2014, aims specifically: 1) to assess current system in the monitoring of the nutritional status of the public elementary pupils in Albay; 2) to identify the necessary equipment and technologies needed which are significant for the utilization of the web-based information system in the agencies involved; 3) to develop a web-based information system that will automatically and systematically cater for the operations involved in conducting the monitoring process; 4) to develop the user's manual of the web-based information system, and 5) to conduct training to end-users regarding the utilization of the web-based information system.

The benchmarking proved that current manual system in monitoring the nutritional status of the elementary pupils is challenging in terms of providing accurate, reliable, complete and useful information thus a web-based information system is needed to solve these difficulties. Rapid Application Development (RAD) methodology was utilized in the development of the software which consists of four phases - requirements planning, user design, construction and cutover phase.

WBNIS provides a simplified method of computation and generation of nutritional status report through the use of web forms and spreadsheet application for the teachers, school nutrition coordinators and principal at the school level using their desktop computers or mobile devices. The submission of nutritional status report of the pupils from the school level, district, division and regional levels is easier thus, consolidation of the reports are automatic.

Keywords:*ICT for Health, Nutrition Information System, Device Responsive, Web-based Systems, BMI*
Web link:*http://beta.projectwbnis.ph/*

Introduction

The use of reliable information provides a powerful tool for planning, decision-making, monitoring and evaluation. However, its usage for a complete link from local source to the regional levels is inadequate. For instance the development of the information systems such as the Field Health Service Information System (FHSIS) and the Philippine Health Statistics identified some gaps such as the absence of the standardized indicators and information requirements and untimeliness of information for planning, decision and policy making and appropriation for budgetary considerations (Tan, 2007). Besides, nutrition is not a part of the relevant information in the FHSIS.

Two studies for investigation are interrelated one after the other. The results of study 1 on the benchmarking of the current system in the monitoring of the nutritional status of schoolchildren would be the input to the development of a web-based nutritional status information system. Likewise study 2 would be an evaluation of the developed web based information system in monitoring the nutritional status of the elementary schoolchildren in Albay. The existing system of entry, computation and presentation of nutrition data deserves attention for more efficient and effective method to provide accurate reliable, complete and useful information. This research study is in support to the development of health and related information for policy making and to deliver quality health care and services information and communication technology for health to accelerate the gathering and processing (PCHRD,2011).

Objectives

Study 1 aims to develop a Web-Based Nutrition Information System as a tool to monitor the nutritional status of the public elementary pupils in Albay. Specifically for the first year of implementation that covered August 2013 to July 2014, this study aims:

1. To assess current system in the monitoring the nutritional status of the public elementary pupils in Albay;
2. To identify the necessary equipment and technologies needed which are significant for the utilization of the web-based information system in the agencies involved;
3. To develop a web-based information system that will automatically and systematically cater for the operations involved in conducting the monitoring process;
4. To develop the user's guide on the operation of the web-based information system, and
5. To conduct training to end-users regarding the utilization of the web-based information system.

Methodology

A framework is followed in the assessment of the current system through benchmarking and the web-development using the Rapid Application Development (RAD) by Martin (1991). It uses a group approach that utilizes consultation and deliberation during the actual development of the system. It has four phases on its life cycle namely: 1) requirements planning, the systems planning and analysis phase, 2) user design, wherein users during this phase interacts with the system analyst and developer in order to come out with a model and prototype that will represent the system processes, outputs and inputs, 3) construction, which focuses on program and application development tasks with the participation of the different stakeholders, and 4) cutover, which covers the implementation phase, data conversion, testing, changeover to the new system, and user training. RAD is intended for the development and delivery of a system at soonest possible time.

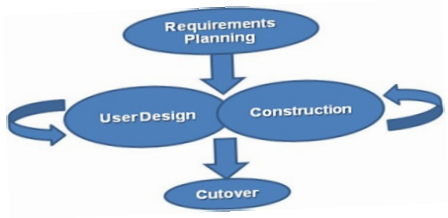

Figure 1. Rapid Application Development Methodology

The study was conducted in selected elementary schools of Legazpi City and Daraga, Albay with existing BU extension project. Descriptive Research was employed in the use of the quantitative approach in the summary presentation of the evaluation results. The qualitative research made use of the focus group discussion (FGD) in three batches with 6 to 12 respondents each consisting of Feeding Coordinators, Grades 1 & 2 teachers and IT Coordinators from two sites. Key informant interview was held to 15 respondents from DepEd district and division offices of Albay and Legazpi City, as a validation to the structured interview results. The secondary data and records on the profile of schoolchildren were reviewed at the school sites and division office.

Proper protocol was followed prior to the conduct of data collection. On agreed designated dates with the respondents, key informant interview was held from August –September 2013.The FGD was conducted on October 12, 18 and November 15, 2013 at the BUCS-CS/IT Department. Results of key informant interviews were collated and summarized by profile of the respondents and category of questions using the 5-point scores. Results of the FGD were transcribed and collated according to similarity and difference of responses.

Findings

Study 1 includes a discussion of the current system in the monitoring of school children, profile of human and physical resources, system development of the Web-based Nutrition Information System, development of user's manual and training results.

1. Current System in the Monitoring of School Children

Using the results of the key informant interview, Table 1 shows an analysis of the current system in the monitoring of the nutritional status of schoolchildren. In terms of the accuracy of data, the respondents claimed that the teacher-advisers and Nutrition Coordinators were very capable in the conduct of the weight and height measurement, height conversion to meters, body mass index (BMI) determination and status classification. Most responses indicated that weight measuring and height measuring devices were moderately functional. Some would still use the bathroom and tape measure posted on walls that produced discrepancy in results. Timeliness of report submission of nutritional status (NS) data was said to be on schedule for use during financial planning and schedules of DepEd officials' visit.

However, use of manual process in BMI computation was slower than the computerized method. The IT coordinator used the Learning Information System (LIS) software in encoding BMI raw data submitted by the feeding coordinator and grade level advisers. Delays happened when internet connection is inaccessible.

As to the speed of data processing, completeness of data per section and grade was done as homework or through assistance of IT coordinator with use of software to catch up for submission at expected schedule in August. Aggregation of nutritional status data was done by section, grade level, school and sex for all categories posted on bulletin boards to attribute

for accessibility of the data. However, some data were moderately retrievable and accessible if compiled only with the Nutrition Coordinator or at the level of section advisers. Traceability of the pupils for readiness of use was affected by untallied records at the school level if checked and reviewed by school nurse-in charge and by the Division Nutrition Coordinator. Any interested user can obtain particular data from accessible schools. Most of the respondents expected that the NS data should be used for planning, decision making and identification of health, nutrition and other interventions (e.g. school feeding, sports competition, selection of 4Ps beneficiaries, remedial measures for National Achievement Test performance).

Table 1. Analysis of the current system in monitoring the nutritional status of pupilsi n Daraga and Legazpi City sites

Particulars	Ave. Score	Descriptive Rating
1. Accuracy of data a. Measurement, computation and nutritional status classification	3.87	Very capable
b. Weight and height measurement	3.77	Moderately functional
2. Timeliness of reporting	3.70	On schedule
3. Speed of Data Processing	3.52	More than what is expected
4. Accessibility of data sets	3.56	Moderately accessible and reliable
5. Usefulness of data	3.45	Presence of expectation

Cost-Efficiency of the Current System

Table 2 presents key informant results in terms of the cost-efficiency of the current system which are partially economical. It means that the processes involved in the monitoring the nutritional status of pupils entailed cost that may not be cheap to the users even if it is performed in an expected period of time considering the resources at hand.

Table 2. Average score and descriptive rating for cost efficiency of current system.

Particulars	Ave. Score	Descriptive Rating
Weight & Height Measurement	2.47	Partially economical
Manual Computation	2.33	
Filling out forms	2.23	
Use of calculator/use of computer in data processing	2.43	
Cost of IT expert	2.17	

Issues, Problems and Probable Solutions in the Existing System for Monitoring of Nutritional Status of Elementary Pupils

Table 3. Issues and problems with corresponding Solutions

Issues/Problems	Probable Solution
Defective weight and height measurement	Requisition of weight and height measuring devices
Delayed processing of NS data due to multiple assignments	Capacity building on weight and height measurements, BMI computation using program, software, program or web system for efficiency of data processing, retrieval, aggregation, timely reporting and utilization.
Untrained teachers/IT coordinators on tools and system for BMI computation	
Untrained staff on nutritional status and software processing	

Flow of Submission of Nutritional Status Report

A consolidated nutritional status report starts at the school signed by the nutrition coordinator and noted by the School Principal for submission to the District Coordinator for Nutrition/District Nurse-in-charge. The District Coordinator consolidates the report noted by the Public School District Supervisor for submission to the Division Coordinator for Nutrition. The Division Coordinator for Nutrition checks and consolidates the district nutritional status report by city or municipality. Then, a provincial nutritional status report is summarized and consolidated. Furthermore, the city or provincial report, noted by the Division Head for Health and Nutrition and the Schools Division Superintendent is submitted to the DepEd Regional Coordinators for Nutrition.

2. Profile of Human and Physical Resources

As regards to the personnel involved in data processing of BMI and related data, each school has a Feeding/Nutrition Coordinator, Clinic Teacher and ICT Coordinator.

Identifying the necessary equipment and technologies needed for the web-based information system, most schools in Albay mentioned the use of the LIS. The LIS is intended for maintaining the registry of learners. (http://lispractice.deped.gov.ph,2012). It does BMI computation. It has featured data validation, summary of data in Excel format and printing of copy. Based on FGD results, the LIS has limitations when offline. Once the LIS is closed, retrieval cannot be done in another program; it is controlled at the Division Office and is opened with the IT Coordinator's password number. It is commonly used in tracking the learners' enrolment but not the nutritional status data of the pupils as of this School Year 2013-2014 meanwhile housekeeping is done.

Six schools were recipients of the DepEd Computerization Program in obtaining 5 to 9 units of computers in 2013. Based on the inventory of equipment and technologies, internet access was made via a broadband or DSL with 1-3 mbps internet speed and regular internet connection. Some schools have limited access to MS Excel/Template and LIS for BMI computation. Some IT coordinators devised their own database system using the MS Excel software. Most schools were inadequate of computer facilities including IT room, supplies, financial allocation and internet connections.

Aside from the LIS, the DepEd schools used the Enhanced Basic Education Information System (E-BEIS), an Information and Communications Technology solution that provides summary of school-based information and web-enabled processes to ensure that up-to-date data/information is made available to the school, division, region and central office (www.depednaga.com.ph, 2011).

Another is a BMI software developed by Ronnie Caringal, a math teacher of Canubig, Calapan City.It provides an automatic computation for age, BMI and nutritional status by BMI. It had undergone several revisions after validation from various occasions before a final copy "BMI Software-HNC (final copy-04-24-13) is made available for use (Activities of My BMI Program, 2013) by the DepEd. A summary report can be generated at elementary, special education and secondary level to consist Grades 7 to 12 following the required document format of DepEd . The program used the group links of Microsoft Excel Files to produce the nutritional status report at various levels.

If it will follow the web-based system, areas of improvement are identified in the 1) absence of monitoring the progress of the nutritional status per child from baseline to endline from one school year to the next school year, 2) manual process of report consolidation at the district and national levels, 3) the limitation on the use of BMI only to determine the nutritional status of the child , 4) non-visibility of formulas used to enable for verification, 5) presence of reports in tabular formats but not in graphical presentations, 6) offline program that did not allow immediate access if needed and 6) difficulty in archiving the records for the program composed of multiple files.

As regards to the seminars attended, most of the IT coordinators had been to a day-seminar on computer literacy and BMIS computation with at least two hour hands-on exercise followed by self-study and consultation with colleagues. Some teachers need additional or advanced IT trainings to enhance their functions and to make reports easier with regards to BMI status.

3. Information System (WBNIS)

a) *Software Technologies*: The researchers used PHP Hypertext Preprocessor in the development of the web-based system and MYSQL as the backend database. Codeigniter framework was also used in the server-side scripting. It is a rapid development web application framework based on Model-View-Controller development pattern. The systems' user interface was

designed using BootStrap, a popular HTML, Cascading Style Sheets (CSS), and Javascript (JS) framework for developing responsive, mobile first projects on the web.

b. Database Structure: The researchers adapted the relational model in creating a normalized database structure. Database tables, views, relationships and constraints were created to contain the data of the students, teachers, school, nutritional status and reports of the nutrition information system.

c. Architectural Design: WBNIS was designed as 3-tier architecture. It is client-server architecture composed of database tier, middle tier and client tier in which the functional process logic, data access, computer data storage and user interface are developed and maintained as independent modules on separate platforms. The system retrieves data from the MYSQL database server – database tier, through the web pages using web browsers – client tier. These web pages are PHP files – middle tier, stored in the Apache Web Server. PHP serves as a bridge to retrieve and manipulate data in the database.

d. Physical Environment and Resources: The following are the software and hardware needed to operate the system.

- Web Server: Apache
- Server-side Scripting Language: PHP 5.6.3
- Database Server: MYSQL 5
- Web Browser: Chrome, Firefox
- Spreadsheet Application: MS Excel, Open Office Calc
- Web hosting and Web Domain
- Internet Connection of at least 200kbps per user
- Desktop Computer or MobileDevice
- Printer

e. System Functions: WBNIS provides the following functions and features:

- Profile Management System – This module allows the administrator to manage information about the student, school, district, division, region, teacher, school year and grade levels.
- Automated BMI Computation– This function utilized a look-up feature on the World Health Organization (WHO) Weight-for- Age and BMI-for-Age Tables.
- Report Submission – The class adviser can submit his nutritional status report by uploading the filled up spreadsheet file using a desktop computer or mobile device.
- Approval Scheme on Submitted Reports –The nutrition coordinators of the district, division and region verify and approve the report submitted by the school.
- Messaging Scheme –This module allows users to send messages to other users of the system.
- Consolidation of Nutritional Status Report – Reports submitted by the school, district, and division are automatically consolidated and archived. Individual nutritional status reports are also generated.
- Reports Generation – The reports generated by the system are presented in tables, graphs and chart formats.
- Users Management –The administrator can add, update or delete users of WBNIS.
- Device Responsive- WBNIS layout can adjust to the user's device or gadget.

4. User Manual:The developed user's manual is integrated to the web-based system, thus can provide help and documentation in using the software.

5. Training Results*:* A training-workshop was conducted on August 9, 2014 at Computer Laboratory 205 and 206 of BUCS. Twenty-five (25) participants composed of 8 feeding coordinators, 10 ICT coordinators and 7 class advisers attended the workshop. The workshop serves as initial evaluation of the developed system. The following are the suggestions of the participants: (1) need for a unified account per school that will have the privilege to submit nutritional status report of different grade level; (2)the developed system to adapt the new BMI formula implemented by the World Health Organization; (3) date of deworming to be included in the

nutritional status report; (4)existing report in MS Word may be converted to MS Excel format for easier computation, and (5)student profile in the DepEd LIS may be extracted to avoid re-inputting of student data.

Conclusion

As regards the benchmarking of the current system in monitoring the nutritional status of schoolchildren and development of the Web-based Nutrition Information System, key points were arrived at:

1. In the current system, there were inaccurate data despite the capability of teachers on weight and height measurements but using moderately functional weight and height devices; timeliness of reporting was on schedule; speed of data processing was more than expected; data sets were moderately available and accessible; usefulness of data was expectedly present; existing systems were partially economical in application to manpower, use of forms and manual or the computerized process on BMIS determination, and FGD results revealed that Excel program and LIS were economical than the manual calculator because it is time consuming but quite expensive.

2. IT equipment and technologies skills and training are still wanting although facilities and internet connections are available in some schools. LIS and software developed by Canubig still requires improvement.

3. Considering the problems and the solutions posed with the current system and the training results, the development of web-based nutrition information suggest data accuracy, data aggregation and timeliness for use in the refinement of an existing web-based system reporting.

4. User's guide for the WBNIS can be functional after it is assessed with possible set of users.

5. Training results from possible users served as initial evaluation of the developed WBNIS.

Recommendations

Based on the fore-going results, this study recommends the following:

1. The developed WBNIS may be used for pilot testing by the DepEd in generating the nutritional status reports of pre-elementary and elementary pupils thus be evaluated using ISO 9126-1 quality model.
2.
3. Data on deworming, clinical symptoms for anemia, vitamin B deficiency and dental caries can be included in the web–based system to generate nutritional status report of individual, school, district, division or region.
4. If efficiency is proven on use at different levels after piloting, WBNIS is recommended for adoption at national level.

Acknowledgement

The authors expressed special thanks to the DepEd Legazpi City and Albay Divisions for the conduct of the key informant interview, FGD, review of secondary data and ocular visits in the selected elementary schools. The Principals, Nutrition Coordinators, ICT Coordinators, and Planning Officers at division and district levels are indebted to for the source of data.

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ESTIMATING ENVIRONMENTAL SUSTAINABILITY OF BROILER FARMS IN DAVAO CITY

JOETEDDY BARZAGA BUGARIN
Faculty/Researcher, Dept. of Business Adminsitration, University of Southeastern Philippines
Davao-Bukidnon Road, Davao City

Abstract

The study was conducted to come up with the environmental sustainability of broiler farms in Davao City. Net carbon emission was used to come up with environmental sustainability estimates of broiler farms in the area. It is calculated through the difference between CO_2 emissions and CO_2 sequestration. Carbon emission was measured using the methodology outlined in Cheeps & Chirps' Poultry's Carbon footprint calculator while CO_2 sequestration was measured using the method of Brown Country.

The study found out that the poultry farms in the area are constantly faced with extreme variations in temperature. All of them are facing extreme cold while 95% of them are faced with extreme hot. Costa in 2009 reported that poultry flocks are particularly vulnerable to climate change because birds can only tolerate narrow temperature ranges. These variations in temperature cause significant losses to their production. When combined the industry suffers almost 200,000 pesos with these two climatic hazards in one production cycle.

The study found out that the total carbon emitted by the industry was estimated at 4,205.3 tons with an average emission of 221 tons per broiler farm. Combining all these farms, they can sequester a total of 884.35 tons of carbon with an average farm sequestration of 46.5 tons. The overall sustainability of the broiler industry was identified to be a net carbon emitter of 3,320.9 tons.

The final finding of the study revealed that net carbon emission is an indicator of the cost of damages brought about by the climatic hazards more specifically the extreme hot and cold variations in temperature. The positive relationship between the two variables suggests that the higher the net carbon emitted, the more vulnerable are the broilers to temperature variations, manifested by higher cost of damages or farm losses. This lead the study to suggest that broiler farms should find and strike a balance between their carbon emissions and sequestrations since this balance leads them to potential gains in efficiency.

INTRODUCTION

In some areas in the Philippines, a mere understanding and awareness of the different climatic hazards seem not enough for the agricultural sector to be resilient manage the risks associated by these hazards brought about by the ever changing climatic conditions nowadays. Environmental sustainability studies more particularly in the context of carbon sequestration could be a fount of fundamental ways and strategic techniques to reduce the impact of climate change in the agricultural sector. Moreover, our country has limited information or studies regarding mitigations against climate change when it comes to the broiler production. This could possibly serve as an alternative way of addressing the negative effects and impacts or damages that could come from extreme weather or climatic conditions experienced particularly by broiler farms.

This particular type of study intends to provide awareness and information to broiler farmers on how to mitigate the effects of climate change in the context of environmental sustainability. This study is to aid them in making understand the significance of environmental sustainability of their farm, study the negative impacts their industry contribute in the environment and on how to certainly reduce it by means of carbon sequestration. Furthermore, this study attempts to provide substantial inputs in crafting policies regarding the development of broiler industry in Davao City. More specifically, efficient and effective strategies in lessening if not eradicating the ill effects of climate change to broiler production.

General Objectives

One of the major goals of every agricultural activity is to attain food security and in this study it is in the context of the broiler industry. With this, identifying and specifically estimating the environmental sustainability of broiler farms in the area could help secure the supply of chicken meat which will have positive externalities not only among broiler producers but also on the market in general, thus making it more available to consumers.

Specific Objectives

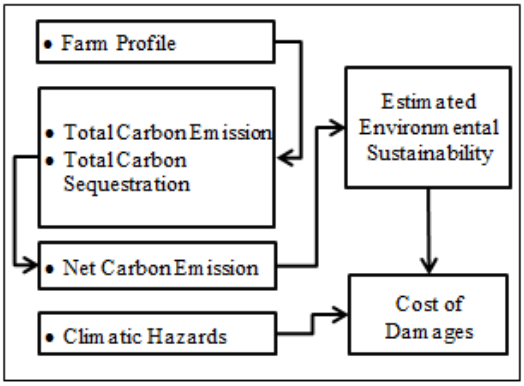
a. To obtain the profile of broiler farms;
b. To identify different climatic hazards affecting the farm;
c. To estimate cost of damages from climatic hazards;
d. To estimate the total carbon emission of each broiler farm;
e. To estimate the carbon sequestration rate of each broiler farm;
f. To estimate the level of environmental sustainability of each broiler farms through the net carbon emission.
g. To measure the effect of net carbon emission to the cost of damages from climatic hazards.

METHODOLOGY

Analytical Framework

The study used the following analytical framework shown in figure 1. Profile of each farm defined the levels of carbon emission and sequestration. Difference between the total carbon emitted and total carbon sequestered formed the net carbon emission which measured the environmental sustainability of the farm. The level of environmental sustainability in terms of net carbon emission affected the cost of damages or losses among broiler farms that were associated and caused by climatic hazards.

Figure 1. Analytical Framework



Method Used

The study had a two part research, the first part explored and described the characteristics of the profile of the broiler farms, identified the different climatic hazards affecting the farm. The second part involved the estimation of the cost of damages brought by climatic hazards, total carbon emission, total carbon sequestration, net carbon emission and measuring the effect of environmental sustainability estimates to the cost of damages from climatic hazard in each broiler farm. The study used descriptive method via one-shot survey through a face-to-face interview with the respondents which formed the basis in coming-up with the data.

Data Gathering Instrument

The primary data used were gathered through a face to face interview with the broiler farmers. During the interview, the respondents were asked based on the two (2) sets of questionnaires. The first set contained questions regarding profiles of broiler farms, climatic hazards, and estimated cost of damages. The other set of questions contained questions on carbon emission and carbon sequestration of broiler farms.

Sampling Technique

The respondents of this study were the registered commercial poultry farmers in Davao City. The researcher employed the census of registered commercial poultry farms in Davao City based on the DTI -BNRS list of poultry farms, as there were only 19 of them.

Procedure of the Study

The study conducted a cross sectional survey with the permission of the respondents. The main problem and objectives of the study were explained to the respondents to get their full understanding of the problem and cooperation during the conduct of the interview. Subsequently, the data gathered from the responses of the respondents were processed, analyzed and presented using Microsoft Excel.

Data Analysis

The gathered data were analyzed using descriptive statistics and regression analysis. In the case of broiler farm profile, climatic hazards and estimated cost of damages, all of these data were analyzed through descriptive statistics such as frequency counts, percentages and means. For estimating environmental sustainability, the following tools were used:

- Poultry's Carbon footprint (Cheeps & Chirps, 2009) CO2 emission from the broiler houses averaged 5.5 tons per 1,000 broilers marketed. Cited by J. Jacobs of the University of Kentucky

- Carbon Counting Method (Brown Country, 2012) as cited by Villiers C. et. al.

$$W*0.45 = \frac{0.15*D^2*H*120\%*72.5\%*50\%*3.6663}{\text{Tree Age}}$$

Where:

W = Weight of CO_2 sequestered in the tree per year
D = Tree diameter in inches, and
H = Tree height in feet.
0.25 = constant coefficient if the D<11 inches
0.15 = constant coefficient if the D>11 inches
3.6663 = ratio of CO_2 to carbon
50% = average carbon content of a tree
72.5% = dry average of the dry weight of the tree
120% = average weight of the green weight of the tree
0.45 = Conversion factor of pound to kilogram

- NCE = Net Carbon Emitted – Carbon Sequestered

To measure the effect of net carbon emission to the cost of damages from climatic hazards the simple linear regression model was used.

$$COD/ha = b_0 + b_1 NCE/ha$$

Where:

COD/ha estimated cost of damage from climatic hazards per hectare.

b_0 Cost of damage when broiler farm starts to be sustainable

b_1 Cost of damage per kilogram of carbon emitted in the farm.

NCE/ha Net carbon emission per hectare of broiler farm in kilograms.

RESULTS AND DISCUSSION

Distribution of Respondents

Table 1 shows the total number of respondents and their corresponding addresses. All of the respondents are located in the third district of Davao City as it is a known area for agricultural production.

Table 1. Distribution of Broiler Farms

Respondent #	Address
1	Dacudao, Calinan
2	Villafuerte, Calinan
3	Gumalang, Calinan
4	Wangan, Calinan
5	Kawayan, Calinan
6	Wangan, Calinan
7	Biao, Guianga
8	Mahayahay
9	Acacia, Tugbok
10	Pungot, Biao
11	Pungot, Biao
12	Angalan, Tugbok
13	Angalan, Tugbok
14	Angalan, Tugbok
15	Tagakpan, Tugbok
16	Baracatan
17	Tibuloy, Toril
18	Tibuloy, Toril
19	Tibuloy, Toril

Profile of Broiler Farms in Davao City

The profile of broiler farms in Davao City is summarized in table 2. As can be seen in this table, broiler farms employ an average of 8 per farm; they have been in operation for an average of 13 years and operating in an average area of 3.27 hectare piece of agricultural land. In average they are farming around 38,359 chicken heads in an average of 4 chicken houses.

Table 2. Farm Profile of Broiler Farms in Davao City

Farm Profile	Mean
Number of Employees	8
Years of Operation	13.05
Area of Farm (Ha.)	3.27
Number of Chicken House	4
Number of Chicken Heads	38,359

Climatic Hazards in Broiler Farms in Davao City

The city of Davao is known to be less hit by typhoons and this information was validated in table 3. There was only one recorded incidence of typhoon, only 1 farm claimed to be affected and sustained damages from typhoon. Though flood on the other hand is known to exist in the city, the broiler farms made sure that they would not get affected by it, and these farms were located as far as possible from flood prone areas or low lying areas. There were only 2 farms or 11% of the farms in the city that were affected by flood but majority are not. The most common problems among broiler farms with regards to the climatic hazard were extreme temperatures, extreme hot was a problem to 94% of the farms and extreme cold was experienced by all of the broiler farms.

Estimated Cost of Damages from Climatic Hazards

Table 3. Climatic Hazards in Broiler Farms in Davao City

Climatic Hazards	Frequency	Percentage
Typhoon	1	5.26
Flood	2	10.53
Drought	5	26.32
Extreme Hot	18	94.74
Extreme Cold	19	100.00

Estimated losses from the different climatic conditions were summarized in table 4. It can be observed that the broiler farms who suffered from extreme climatic conditions in table 4 is not consistent with table 3, this happens due to the fact that some farms have experienced extreme climatic conditions but have not sustained losses. Table 4 shows consistency with table 3 as to the frequency of farms who suffered from different climatic hazards. Information about the average cost revealed that the most damaging climatic hazard is flood followed by extreme hot then extreme cold and drought, while the least damaging climatic hazard in the city is typhoon.

Total Carbon Emission

The estimation of carbon emission from broiler farms in table 5 was adopted from the methodology used in the 2009 journal Cheeps and Chirps, "Poultry's Carbon Footprint" as cited by Jacobs of the University of Kentucky in 2009. A constant multiplier of 5.77 kilos of carbon dioxide CO_2 is emitted by every broiler being marketed was used in the study to estimate the total carbon emission from the broiler farms in the area. The process of estimation was done by simply multiplying the number of chicken being farmed with the constant multiplier. In this manner the product is now the total amount of CO_2 emitted by every broiler farm in the area. In table 5, CO_2 . emission of broiler farms in the area were presented. The table revealed that broiler farm number 10 was the biggest broiler farm in terms of broiler chicken production and consequently it was the biggest source CO_2 in the city with 865,500 kilos of CO_2. in a single production cycle. This is very close to the average carbon emission in the US which is estimated at 847 tons per year as reported by Dunkley in 2013. The approximated annual emission of poultry farm # 10 for the entire year with a 5 production cycles was estimated at 4,327,500 kilos or 4,327.5 tons of CO_2. The lowest CO_2 emission came from farm number 6 with 34,620 kilos of CO_2. Total CO_2 emission was estimated at 4,205,297 kilos at an average of 221,331 kilos per broiler farm.

Table 4. Estimated Cost of Damages from Climatic Hazards

Climatic Hazards	Frequency	Percentage	Ave Cost
Extreme Cold	18	94.74	51,000
Extreme Hot	17	89.47	142,647
Drought	4	21.05	49,500
Typhoon	1	5.26	10,000
Flood	1	5.26	500,000

Table 5. Estimated Carbon Emission of Broiler Farms

Farm #	Avg. No. of Chicken Heads (a)	Carbon Emission in kg of CO_2 ((a) x 5.77*))
1	35,000	201,950
2	54,000	311,580
3	38,000	219,260
4	65,000	375,050
5	63,000	363,510
6	**6,000**	**34,620**
7	70,000	403,900
8	26,100	150,597
9	16,000	92,320
10	**150,000**	**865,500**
11	20,000	115,400
12	6,500	37,505
13	30,000	173,100
14	30,000	173,100
15	21,721	125,330
16	13,000	75,010
17	58,500	337,545
18	14,000	80,780
19	12,000	69,240
	Total	4,205,297
	Average	221,311

* Estimated CO_2 emission of 1 broiler.

Carbon Sequestration Rate

Table 6 shows the total carbon sequestration from the different broiler farms in Davao City. The total carbon sequestration was computed using the carbon counting method formulated by Brown Country (2012) adopted by Villiers et. al. Using this method broiler farm number 15 has the highest carbon sequestration at 166,287 kilos of CO_2. On the downside 4 broiler farms has not planted any trees around there area and so no carbon sequestered was recorded from these farms. The total CO_2 sequestered was 884,354 at an average rate of 46,544.99 per farm.

Table 6. Estimated Total Carbon Sequestration

Name of Farms	Total Carbon Sequestration (TCS) (kg of CO_2)**
1	4,138.79
2	4,060.80
3	0
4	4,831.19
5	41,975.85
6	55,903.51
7	0
8	14,748.30
9	4,633.35
10	0
11	2,356.46
12	163,245.37
13	36,444.44
14	6,273.91
15	**166,287.45**
16	112,557.64
17	78,914.90
18	0
19	187,982.87
Total	884,354.83
Average	46,544.99

** TCS = ((0.25 x D^2 x H x 120% x 72.5% x 50% x 3.6663) / Age) x 0.45

Environmental Sustainability of Broiler Farms

The net carbon emission of each farm is presented in table 7. The figures enclosed in parenthesis were negative values which mean that these farms with negative net carbon emissions were considered as carbon sinks and thus they are environmentally sustainable broiler farms.

Furthermore, the sustainability of each broiler farm depends primarily on the sequestration rate from the trees planted. If the farm has no trees no carbon sequestration happens in the farm, the scenario for a farm to be sustainable is that it should be able to offset its carbon emission through carbon absorption from trees.

There are 5 broiler farms that posted to be environmentally sustainable; these are 6, 12, 15, 16 and 19. Among the five 12 was documented to be the most environmentally sustainable followed by 19, 15, 16 and 6. A closer look at the difference between 12 and 15 farms revealed that even if 15 has a higher sequestration rate than 12, 12 has lower carbon emission than 15, which means that 12 is farming less chicken relative to the available number of trees surrounding its farm than 15 farm.

Other farms were recorded to be unsustainable. The two most unsustainable broiler farms were 10 with a net CO_2 emission of 865,500 kilos, followed by 7 with 403,900 net CO_2 emission. Common to these farms is that they don't have available trees surrounding their area to absorb their CO_2 emissions. Overall the total CO_2 emission of the broiler industry in the city is 3,320,942.34 kilos at an average emission of 174,786.44 kilos per farm.

Table 7. Net Carbon Emission of Broiler Farms

Number of Farms	Total Carbon Emission (kg of CO_2)	Total Carbon Sequestration (TCS) (Kg of CO_2)	Net Carbon (CO_2) Emissions (kg)
1	201,950	4,138.79	197,811.21
2	311,580	4,060.80	307,519.20
3	219,260	-	219,260.00
4	375,050	4,831.19	370,218.81
5	363,510	41,975.85	321,534.15
6	34,620	55,903.51	(21,283.51)
7	403,900	-	403,900.00
8	150,597	14,748.30	135,848.70
9	92,320	4,633.35	87,686.65
10	865,500	-	865,500.00
11	115,400	2,356.46	113,043.54
12	37,505	163,245.37	(125,740.37)
13	173,100	36,444.44	136,655.56
14	173,100	6,273.91	166,826.09
15	125,330	166,287.45	(40,957.28)
16	75,010	112,557.64	(37,547.64)
17	337,545	78,914.90	258,630.10
18	80,780	-	80,780.00
19	69,240	187,982.87	(118,742.87)
		Total	3,320,942.34
		Average	174,786.44

( ) negative carbon emissions

Sustainability and Damages

The selected output for the regression analysis on the effect of net carbon emission to the cost of damages is presented in table 8. The summary statistics revealed that the overall model is significant at 95% confidence level with an F < 0.05 and that the predictor NCE/ha is a significant predictor of COD/ha with a p-value of < 0.05.

From the summary of output the estimated regression equation to capture the effect of net carbon emission measured in kilogram of CO_2 per hectare to the cost of damage measured in peso per hectare is as follows;

COD/ha = 49,763.95 + 0.84 NCE/ha*

The equation above suggests that when broiler producers start to be sustainable, that is their NCE is equal to 0 or their carbon emissions is just equal to their carbon sequestration, their estimated cost of damage per hectare from climatic hazards was still equivalent to 49,763.95 pesos. The parameter of NCE/ha or the slope of the equation suggests that the cost of a kilo of CO_2 emitted in the environment the broiler farmer pays 0.84 cents as cost of damages from climatic hazards. This further suggests that a kilo of CO_2 being absorb in their area, there is a corresponding 0.84 cents savings from the damages caused by climatic hazards. To be free from damages this model computes the needed NCE/ha has to be –59,242.8 as shown in figure 3, which means that carbon sequestered in the farm should exceed carbon emitted in the farm by 59,242.8 kilos per hectare. To experience a zero loss or zero cost of damage from the usual climatic hazard in the study site, the figure above translates into an approximately 23 additional trees with specific characteristics that are 12 years old for every 34,620 chicken heads farmed. Other combinations can be determined from the data set.

SUMMARY AND CONCLUSIONS

1. Broiler farms in the study area employed an average of 8 workers to produce an average of 38,359 broiler chicken. The climatic hazards commonly faced by almost all of them were extreme cold and extreme hot temperatures. From these climatic hazards, losses ranged between 51,000 to 142,647 pesos per production cycle.
2. The broiler farms in the study site emitted a total of 4,205,297 kilos of CO_2 at an average of 221,311 per broiler farm and sequester 884,354.87 kilos at an average rate of 46,544.99 kilos per farm. With these numbers the total net emission of the industry was estimated at 3,320,942.34 kilos of CO_2.
3. Thus, with these figures the estimated sequestration rate was around 21%, which means that broiler farms have a lot of room for improving their environmental sustainability level.
4. Furthermore, it was found in the regression analysis that the net carbon emission significantly affected and increased the cost of damages to climatic hazards at a rate of 0.83 cents per kilo.

Table 8. Regression Analysis on the Effect of Net Carbon Emission to the Cost of Damages

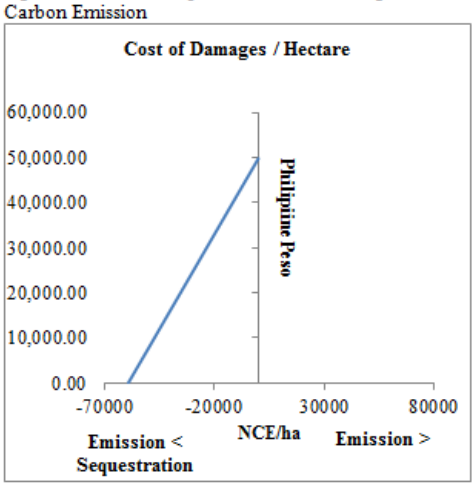
Regression Statistics	
R Square	0.326396644
Observations	19

ANOVA	
	Significance F
Regression	0.0106139*

	Coefficients	*P-value*
b_0	49763.95201	0.32189
b_1	0.837247176	0.01061*

* Significant and 95% confidence level.

Figure 3. Relationship of Cost of Damages & Net Carbon Emission



RECOMMENDATIONS

1. Since most of the broiler farmers faced with varying extreme temperatures in their farms it is therefore recommended in this study that broiler farms must find a way to effectively maintain and control the temperature in their broiler houses. Different strategies which are inexpensive and non-capital intensive technologies must be tried and explored to control temperature in broiler houses. Though there are auto- climate control technologies that can be used in broiler houses, these technologies may not be affordable to the common

broiler raisers in the study site, thus it is highly recommended to test other sustainable strategies in climate control.

2. Furthermore the study revealed that most of the broiler farms are environmentally unsustainable and this means that the broiler industry is a source of CO_2 emissions in the area. Further, there are broiler farms that are environmentally sustainable and they are considered as carbon sinks, which in the international scene are commodities that can be traded. These findings led the researcher to recommend that the average broiler farm has to offset some 59,242.8 kilos worth of carbon per hectare by planting additional number of trees that can absorb this amount of carbon.

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PROCESSING OF ARAMANG (*Nematopalaemon tenuipes*) POWDER

LENIMFA P. MOLINA, Ph.D., WILMA Q. CHUA, MS., LORYN G. AMOG
Cagayan State University – Aparri
Maura, Aparri, Cagayan
lenimfamolina@yahoo.com

Abstract

This study utilized aramang in the preparation of aramang powder. The product will be used in the preparation of other valuable products. The study generally aimed to process and standardizes the method in the preparation of aramang powder. It specifically aimed to determine the sensory qualities of the processed aramang powder using three (3) cooking methods, determine the consumer's acceptability, its return on investment and its nutrifacts.

Sensory assessment of the product was done from 0 – day to 30 – days at weekly interval. Results revealed no significant differences on appearance, odor, and general acceptability of the aramang powder using the three (3) cooking methods.

Result of nutrition facts done at DOST Regional Office – Tuguegarao City revealed the following nutrient content of aramang powder: moisture 13.57%, ash 11.17%, fat 0.05%, protein 68.87%, carbohydrates 6.34% and sodium 296.61 mg/100 g. This shows that the value of nutrients present in aramang powder is excellent and good for consumption as food. The level of acceptability was evaluated as "very much liked".

Keywords: Aramang Powder, Sensory Qualities, Cooking Methods, Nutrient Content

INTRODUCTION

Fisheries post-harvest technology is concerned with the utilization of catch. It can be interpreted to mean all techniques and processes done on the fish after harvest whether or not a change in physical and chemical form occurs (Santos, 1995) as cited by Calanoga *et al*., 2002.

Shrimps have gained popularity not only in the Philippine market but also in foreign markets like Japan and Taiwan. They are exported usually in dried form. However, preserving these species becomes a problem especially when they are caught in abundance and the weather condition is not favourable.

The spider shrimp (*Nematopalaemon tenuipes*), locally called aramang, and is a soft-shelled shrimp endemic to the coastal area of Aparri, Cagayan. It is harvested sustainably all year round. Harvested aramang deteriorates rapidly and is consequently sold at low price in the market. It is one of the flagship products of Aparri under the "One Town, One Product" program of the Philippine government, adding to the economic importance of this species.

Aramang is eaten raw as "kilawin" with minced onions, ginger, calamansi and salt to taste. Housewives also use aramang in the preparation of "ukoy" which is utilized as viand, snack or "pulutan" for those who drink wine. Aramang could also be cooked into "adobo". Some process it into powder just after drying. The end product has a very strong ammoniacal odor and it does not stay longer as disclosed by the processors during the interview conducted.

Bragadottir *et al.,* (2007) conducted a study on Stability of fish powder made from *Pollachius virens* as measured by lipid oxidation and functional properties. Results revealed that the product, fresh fish powder exhibited slight antioxidant activity in a model system of linoleic acid emulsion. The freshly made powder had low lipid extractability in polar solvents and over 30% free fatty acids (FFA). Further lipid oxidation took place during storage, independent of storage temperatures. Functional properties measured by color changes, water-binding capacity, apparent viscosity and protein solubility changed more storage at 30°C than 0°C.

In a study conducted by Santana, et al (2012) on technology for production of surimi powder and potential applications, results revealed that surimi powder can be kept at ambient temperature without frozen storage and that the powder has a lower distribution cost compared to the frozen surimi.

Similar to aramang powder, surimi powder's advantages are ease of handling, more convenient storage and its usefulness in dry mixtures (Green and Lanier, 1985).

Drying refers to dewatering, which means removing liquid water from the product (Chen, 2008). The drying process involves the removal of volatile substances (mostly moisture) from a product (Menon and Mujumdar as cited by Santana, et al, 2012). Prolonging the storage life of a product is the main objective of drying technologies developed in food industries.

Another method of moisture removal from a product is through freeze drying. Huda et al, (2001a) evaluated freeze – dried surimi from threadfin bream, *Nemipterus sp*. Purple – spotted bigeye, *Priacanthus tayenus* and lizardfish, *Saurida sp.* The surimi made from these species was treated with 3.5% sucrose and 0.15% phosphate as cryoprotectants and then freeze dried until a moisture content of 5% was reached. Results of the study revealed that freeze dried surimi from threadfin bream had better properties compared to the 2 other species used in the study.

The effect of oven drying method using temperatures of 50^{o}C, 60^{o}C and 70^{o}C on the functional properties of fish protein concentrate from lizardfish was studied by Huda et al, (2000a). This study concluded that a drying temperature of 60^{o}C was the most ambient temperature and it requires 12 hours to reach less than 10% moisture content of FPC.

Other potential drying methods like solar and mechanical drying are also being used by processors and researchers. Sun drying is environmentally friendly less expensive compared to other drying methods (Musa et al., 2003c). Solar drying is used in drying fish in Bangladesh and can reduce moisture content from 80% to 20% (Sodha et al., 1987).

This scenario encouraged the researchers to come up with a new technology to utilize aramang in the preparation of aramang powder that could have a longer shelf life with minimal ammoniacal odor. The product will be used in the preparation of other valuable food products that could be served when aramang is not fished. The aramang powder produced will be utilized in the preparation of various aramang products namely: polvoron, ice cream (aramang – enriched strawberry ice cream), aramang – enriched eucheuma candy, aramang noodles and seasoning. These will be the new products to be developed and standardized which are protein – enriched necessary for growth and development.

These products will be sold as additional food items in stores, school canteens and groceries and will surely help in the development and growth of the aramang industry in the locality. It also paves the way for the availability of the products in groceries, stores, pasalubong centers and other food outlets in nearby municipalities of Aparri even after the fishing period for aramang is over. It would even mean a cheap source of protein to barrio folks where supply of aramang is inadequate. Therefore malnutrition could be solved particularly protein deficiency.

OBJECTIVES OF THE STUDY:

This study generally aimed to determine the best process prior to aramang powder formulation, standardization of aramang powder, consumer's acceptability and determine the nutrition facts of the processed aramang powder. It specifically aimed to determine the sensory qualities of the aramang powder as to color, odor and general acceptability.

METHODOLOGY

Materials needed

Fresh aramang	Grinder/ pulverizer
Drying trays	weighing balance
Steamer	Spoons
Casserole	Non – sticky pan
Ladle	Mixing bowls
Foil pack	Sealer
Oven dryer	Furnace
Containers	Stove

Procurement of Aramang Samples

Aramang samples were obtained from the catch of aramang fishers in Aparri. Procured samples were brought to the Regional Integrated Coastal Resource Management Center (ICRM) Laboratory.

Preparation of the Aramang Powder

Three sets of samples were prepared and washed ready for aramang powder preparation. One set was steamed, another was boiled and the last set was immediately dried prior to toasting, these pre – processing treatments are related to the study of Opstvedt (1975) and Pike *et al*., (1990) which involves heating and drying during production that promotes lipid oxidation.

The sun dried aramang were ground ready for product evaluation on its sensory qualities to determine which among the three (3) processes on aramang powder preparation produces a good quality of aramang powder. The best powder produced was used in the product formulation studies.

A. For toasting process

The aramang samples were washed thoroughly then sun-dried for eight (8) hours, then weighed and toasted for 3-5 minutes or until crispy. Toasted aramang were ground using an electric pulverizer. This process was repeated until the desirable texture of the powder was obtained ready for sensory assessment.

B. For boiled process

Fresh aramang samples were washed thoroughly, boiled for five (5) minutes and sun-dried for eight (8) hours, then weighed and immediately ground using an electric pulverizer. The process was repeated until the desired texture of the powder was attained. The powdered aramang was weighed and packed ready for sensory assessment.

C. For steamed process

The fresh aramang were washed thoroughly and steamed for five (5) minutes then dried for eight (8) hours under the sun. After drying, the aramang samples were weighed and ground using an electric grinder until the desired texture of the powder was attained. The powdered aramang were weighed and packed ready for sensory assessment.

Packaging of Aramang Powder

The processed powder was weighed using analytical balance then packed individually in a small foil packs at five (5) gram each pack. The packed powder were sealed and kept in a food storage cabinet for sensory evaluation. Sampling was done every after seven days until the product deteriorated in its quality attributes.

Aramang Powder Profiling

The processed aramang powder was subjected to quality profiling. The freshly made aramang powder was assessed and evaluated as to its color, odor, and general acceptability using a scoresheet adopting a seven – point hedonic scale.

Sensory Evaluation of Aramang Powder

Members of the laboratory panelists were selected from the post-harvest staff and trained COFMS students of the College of Fisheries and Marine Science. There were 10 members of the Laboratory Panel. Sensory evaluation was conducted to determine the sensory attributes using the descriptive sensory evaluation for colour, odour, and general acceptability. The panelists were given score sheets and presented the samples for them to evaluate the product. The score sheets made use of the 1-7 hedonic scale, where in 7 is the highest score and 1 is the lowest. General acceptability of the aramang powder was also conducted to determine its acceptability using the 7 point hedonic scale.

Consumers' Acceptability

The product was presented to 50 consumers – respondents which were composed of 40 housewives from Aparri, Buguey, Sta. Teresita and Gonzaga, 10 in each municipality and 10 teachers, facilitative staff and students of CSU – Aparri which were randomly selected. Using the hedonic scale, score – sheets were given to the consumers for them to check the appropriate scale based on their evaluation of the powder. Fifty (50) score – sheets were collected from the respondents in four (4) municipalities and teachers, staff and students CSU – Aparri. Data was tabulated as to the consumer's degree of liking and/or disliking of the product.

Food Nutri – Facts Analysis

One hundred grams of the aramang powder which was prepared using the steamed process was brought to the Department of Science and Technology (DOST) for nutritional facts analysis.

The following methods were done by the staff of the Department of Science and Technology (DOST) Regional Office – Tuguegarao City to the aramang powder.

A. Moisture

Accurately weighed sample was placed in aluminium dish and dried at 105^{o}C in an oven for one hour. The dish with residue was weighed to determine weight loss as moisture following Official Method of Analysis (OMA-AOAC (925.23)

B. Crude Protein

A suitable amount of sample was digested at 410^{o}C with sulphuric acid using copper sulphate – potassium sulphate as catalyst. The digested sample was diluted with water. Forty percent sodium hydroxide was added to liberate ammonia and subsequently steam distilled using Kjeltec Distilling apparatus. The liberated ammonia was collected in Boric acid receiver solution then titrated with standard acid. (OMA-AOAC 936.15)

C. Ash

Suitable amount of sample was charred on a hotplate and burned to ash in a muffle furnace at 550°C ± 1 °C until the residue is white or nearly white. (OMA-AOAC 942.05)

D. Total Fat

Suitable amount of dried sample was extracted with solvent using soxhlet for 4 hours at solvent condensation rate of 5-6 drops/s. Solvent used was evaporated and fat residue was dried at 100°C for 30 minutes, cooled and weighed following Official Method of Analysis (OMA-AOAC 920.39).

E. Carbohydrate

Carbohydrate was computed from minus 100 minus the sum of total fat, crude protein, ash and moisture.

F. Sodium

Suitable amount of sample was charred on a hotplate and burned to ash in a muffle furnace at 550°C ± 1 °C until the residue is white or nearly white. Ash is dissolved in diluted acid and sodium is determined through atomic absorption spectrophotometer. (OMA-AOAC 942.05 and OMA-AOAC 985.35).

DISCUSSION OF RESULTS

Sensory qualities of the processed aramang powder

The assessment on the sensory qualities of the processed powder using three (3) processes was made possible through the effort of ten laboratory panelists. The researcher presented the three (3) samples to the panelists with the sensory score sheet for them to check the appropriate assessment on the corresponding sample. The evaluation included the sensory test on Appearance, Odour and General Acceptability of the product. These sensory attributes must be favourable in order to gain acceptance for human consumption (Barlow and Pike, 1977). The results of the sensory evaluation are presented in Tables 1-3.

Table shows the different mean score on Appearance of aramang powder using the different processes done during the sampling days. Steamed aramang powder has the highest score until day 30.

Table 1a Sensory Evaluation on Appearance (color) of Aramang Powder

Day	Boiled	Steamed	Toasted
Day 0	5.9	6.3	6.0
Day 7	5.6	5.6	5.7
Day 14	5.0	5.3	5.4
Day 30	4.2	4.6	4.4
Mean	**5.2**	**5.5**	**5.3**

Legend: 7-light orange 6-slightly dark orange color 5-moderately dark orange color 4-neither light nor dark orange color 3-dark orange color 2- moderately dark orange color 1-very dark orange color

Toasted aramang powder has a mean score of 5.3 and boiled aramang powder has the lowest mean score, but they have the same characteristics as to appearance described as moderately dark orange color on the 30th day of storage. Due to the different processes used in the research study, the natural color of the aramang that is pink became lighter after the samples have undergone steaming (5 minutes), toasting (3-5 minutes) and boiling (5 minutes).

Anova table on appearance in the different treatment shows that there is no significant difference among the treatments.

Table 2a shows the different mean scores on

Table 1b Anova of Appearance in three (3) different Aramang Powder

Source of Variance	Df	SS	MS	F_c	F_t	Remarks
Samples	2	0.16	0.08	4.93	5.14	NS
Block	3	4.53	1.51			
Error	6	0.09	0.016			
Total	11					

NS - not significant

Odour of aramang powder using the three (3) different processes done prior to the preparation of the aramang powder. Steamed aramang powder has the lowest score. Boiled aramang powder has a mean score of

Table 2a Sensory Evaluation on Odour of Aramang Powder

Day	Boiled	Steamed	Toasted
Day 0	5.3	5.3	6.3
Day 7	5.0	4.9	6.8
Day 14	4.9	4.7	6.4
Day 30	4.0	3.9	6.5
Mean	**4.8**	**4.7**	**6.5**

Legend: 7-sttrong aramang odor 6-moderate aramang odor 5-slight aramang odor 4-midway between slight aramang and ammoniacal odor 3-slight ammoniacal odor 2- moderate ammoniacal odor 1-strong ammoniacal odor

4.7, steamed and boiled have the same characteristics on odour described as slight aramang odour. It was observed that boiling and steaming has minimized the strong aramang odor in the processed aramang powder. On the other hand, toasting the aramang prior to its preparation into powder has contributed to the characteristic strong aramang odour in the product.

Table 2b Anova for the Odour of the different treatments on aramang powder

Source of Variance	Df	SS	MS	F_c	F_t	Remark
Samples	2	0.40	0.19	3.72	5.14	NS
Block	3	4.42	1.48			
Error	6	0.32	0.05			
Total	11					

NS - not significant

Anova table on odour in the different treatment shows that there is no significant difference among the treatments.

Table 3a Sensory Evaluation on General Acceptability of Aramang Powder

Day	Boiled	Steamed	Toasted
Day 0	6.3	6.6	6.4
Day 7	5.7	5.9	5.8
Day 14	5.0	5.2	5.4
Day 30	4.3	4.p5	4.9
Mean	**5.3**	**5.5**	**5.6**

Legend: 7-like very much 6-like moderately 5-like slightly 4-neither like or dislike 3-dislike slightly 2-dislike moderately 1-dislike very much

Table 3a shows the different mean score on General Acceptability of aramang powder using the different processes done prior to the preparation of the aramang powder. Toasted aramang powder has the highest score of 5.6 followed by the steamed aramang powder with a mean score of 5.5, both toasted and steamed have the same characteristics on general acceptability described as like moderately. Boiled aramang powder has the lowest mean score; it has a descriptive characteristics of like slightly.

Anova table of general acceptability of different

Table 3b Analysis of Variance (ANOVA) of General Acceptability

Source of Variance	df	SS	MS	F_c	F_t	Remarks
Samples	2	0.19	0.09	4.22	5.14	NS
Block	3	5.77	1.98			
Error	6	0.14	0.02			
Total	11					

NS - not significant

treatments shows that there is no significant difference among the treatments.

Consumers' Level Acceptability

Sensory evaluation was used for measuring the acceptability level of the product. Acceptability of the product was based on consumer reaction in terms of their degree of liking or disliking the given product under a given set of conditions. The consumers composed of housewives from four municipalities and trained laboratory panel of CSU – Aparri. Aramang powder was presented to the consumers for evaluation. Consumers were given sensory score sheets for them to check the appropriate level of acceptability.

The consumer's level of acceptability was assessed by the 40 housewives in 4 barangays and 10 teachers, facilitative staff and students of CSU – Aparri and is presented in the table below. The table shows that the level of acceptability was evaluated as "liked very much".

Table 4 Consumers Acceptability Test for Aramang Powder

Consumer	Total Respondents	Level of Acceptability							
		Like very much		Like moderately		Like slightly		Neither like or dislike	
		F	*%*	*F*	*%*	*F*	*%*	*F*	*%*
Teachers, staff & students	10	7	14	3	6				
House wives	40	16	32	14	28	10	20		
Total	**50**	**23**	**46**	**17**	**34**	**10**	**20**		

Over – all Mean - 6.5
Adjectival Description/Rating - like very much

Score Range

Like very much	7-	6.5- 7
Like moderately	6-	5.5- 6.49
Like slightly	5-	4.5- 5.49
Neither like nor dislike	4-	3.5- 4.49
Dislike slightly	3-	2.5- 3.49
Dislike moderately	2-	1.5- 2.49
Dislike very much	1-	1.0- 1.49

Table 6 Nutri-facts analysis of aramang powder using the steamed pre-process.

Nutrition Facts	
Moisture	13.57%
Ash	11.17%
Crude protein	68.87%
Total fat	0.05%
Carbohydrate	6.34%
Sodium, mg/100g	296.61

Table 6 reveals the nutritional value of the processed (stamed) aramang powder based on the analysis done at DOST R02; it yielded the following nutrient contents: moisture 13.57%, ash 11.17%, fat 0.05%, protein 68.87%, carbohydrates 6.34% and sodium 296.61 mg/100 g. These nutrients present in aramang powder are excellent and good for consumption as food. This result is related to the study conducted by Adeleke and Odedeji, (2010) on acceptability studies of bread fortified with tilapia fish flour. They concluded that the proximate analysis results showed increment in the proximate constituents of bread as more tilapia fish protein flour was added which made the product meet the dietary requirements. Similarly, Jeyasanta et al., (2013) reported in their study on utilization of trash fishes as edible fish powder and its quality characteristics and consumer acceptance that their product could be added to food of nursing mothers. They suggested that their product could be an alternative source of protein and minerals for consumers and also used for those who are allergic to dairy products.

CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of the study the following conclusions were drawn:

1. Sensory qualities of aramang powder were not significantly affected by the three processes used.
2. Level of acceptability was evaluated as 'liked very much".
3. It also shows that the value of nutrients present in aramang powder is excellent and good for consumption as food.

The following recommendations were arrived at based on the results of the study.

1. Use of BHT/BHA to lengthen the keeping quality of aramang powder.
2. Study on the keeping quality of the aramang powder in chilled condition.
3. Study on the shelf – life of the aramang powder using different packaging materials.
4. Study of the use of the processed aramang powder in product formulation.

ACKNOWLEDGEMENT

We would like to express our gratitude to the university president, the vice president for RDET, the director for research, the campus executive officer, for their support to research activities, laboratory technician of the Department of Science and Technology for the nutri-facts analysis of our product, the members of the laboratory panel and the consumers' acceptability respondents who evaluated the processed aramang powder.

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UTILIZATION OF SEA VEGETABLE (*Eucheuma sp.)* AS PASTA ALTERNATIVE

ROSEBELLA L. MALO
College of Fisheries, Carlos Hilado Memorial State College
Enclaro Binalbagan, Negros Occidental, Philippines
E-mail: rosebellamalo@yahoo.com

ABSTRACT

Sea vegetables (Eucheuma sp.) are unique in all vegetables in term of nutritional profile and its uses in food industry. The Processed Eucheuma Seaweed (PES) are used in food preparation as additives. The study was conducted utilizing dried Eucheuma as main raw material pasta in the preparations of palabok, carbonara and salad. The product was subjected to sensory evaluation using 9 point hedonic scale to determine the quality attributes and its general acceptability. The quality of palabok had a mean score of 8.5 which means like very much, carbonara had a mean score of 8.0 interpreted as like very much and the salad had a score of 8.6 interpreted as extremely like. In term of acceptability the carbonara had a score of 8.3 or like very much, palabok had 8.8 or extremely like and the salad had a score of 8.7 which meant extremely like. The appearance, odor and taste of the product had the mean scores higher than 8 which meant that the dried sea vegetable can be utilized as pasta alternative for salad, carbonara and palabok. The texture of salad and carbonara was rated 7.5 which required to be improved to increase the hedonic score and the acceptability of the product. The result of the study will serve as bases for technology transfer and promotion for the preparation in Technology Commercialization Plan (TCP).

Key words: pasta , sea vegetable, Eucheuma sp. sensory evaluation ,quality,

INTRODUCTION

Sea vegetables,which are commonly referred to as algae or seaweed, have been a staple food since ancient times. In recent years, there has been a growing interest in so-called functional food groups, amongst which seaweeds would seem to be able to play an important role since they can provide physiological benefits, additional to nutritional as, for instance, anti-hypertensive, anti-oxidant or anti-inflammatory [Goldberg,1994, Madhusudan et al,2011) . Many biologically active compounds are present in seaweed, which can be used as therapeutic agent and particularly rich in iodine, which is essential to the functioning of the thyroid and of the nervous system, in vitamin B12, and in selenium. Overall, seaweeds are rich in vitamins, minerals, proteins, poly -unsaturated fatty acids, and dietary fibers, and numerous clinical studies have demonstrated the health benefits of seaweed consumption and linked them to the nutrient composition of seaweed (Shahidi, Young et al. 2008; Venugopal 2011). In addition to their health benefits, seaweeds possess a wide range of important gastronomic and food-preservation properties(Kushi,Cunningham et al. 2001; Bocanegra, Bastida et al. 2009; Fitzgerald, Gallagher et al. 2011; Venugopal 2011).

Worldwide only about 221 species of algae in which 125 belong Rhodophyta (Red algae) In phycocolloid industry, the most commonly used, commercial carrageenans are extracted from *Kappaphycus alvarezii* and *Eucheuma denticulatum* [Hugh , 2003]. Large carrageenan processors have fuelled the development of *Kappaphycus alvarezii* (which goes by the name ―cottonii‖ to the trade) and *Eucheuma denticulatum* (commonly referred to as ―spinosum‖ in the trade) Red algae are particularly rich in phycocolloids (especially carrageenans) and in phycobiliproteins (Mabeau and Fleurence 1993; MacArtain, Gill et al. 2007; O'Sullivan, Murphy et al. 2010; Fitzgerald, Gallagher et al. 2011). They are often referred to as *agarophytes* or *carrageenophytes*, and they are widely used commercially for the production of thickening and gelling agents, prebiotic fibers, and food

colourings (Fleurence 1999; Laurienzo 2010; Kim 2011). Red algae are also particularly rich in carotenoids and in B vitamins (Mabeau and Fleurence 1993) The Eucheuma contain broadest ranges of mineral, containing mineral in the ocean (Prasad et al,2008), has a variety of unique phyto nutrients, an excellent source of iodine, vitamin k, B vitamin folate and anti ,viral property . The Eucheuma reaches the ultimate consumer as awhole or particulated and, dried material is one of the seaweed forms

The product innovation from sea vegetable is considered to be essential to the long term survival and profitability of food(Earle 2000), A study is conducted to utilize dried sea vegetables as pasta alternative and to determine quality and acceptability of dried seaweed utilize as pasta

MATERIALS AND METHODS

Materials

Dried sea vegetables (*Eucheuma sp*.) were used as innovative pasta alternative. The dried material were taken from Manjuyod, Bais, Negros Oriental
Preparation of sea vegetable as pasta alternative

The dried *Eucheuma* were cleaned thoroughly by washing in running water to remove adhering extraneous materials .Clean seaweeds were soaked in rice washing overnight and rinsed thoroughly the next day. Clean material were cut into 1 inch for salad and carbonara and 1 ½ inch for palabok. Hot water were poured over the materials and allow to stay for 3 minutes then rinse in running water and drained.

Sea vegetable Salad

The formula of salad were 500 grams Eucheuma, ½ kilo mayonnaise, ¾ cup condensed milk, 227 grams sliced pineapple, ¼ evaporated milk, ¼ all purpose cream, ¼ raisins,135 grams grated cheese, 2 teaspoons coffeemate, 1 teaspoon gulaman powder. All the liquid ingredients were mixed well then added to the Eucheuma mixture and refrigerated for 2 hours then served cold.

Sea vegetable Carbonara

The materials were 500 grams Eucheuma, ¼ cup mayo magic mayonnaise, ¼ cup evaporated milk, ¼ cup all purpose cream, 4 slice cooked ham, 1 clove chopped garlic, 2 pieces chopped onion, 2 table spoon cooking oil, 2 teaspoon salt. Garlic and onion were sauted until brown, then the sliced ham was added and seasoned with salt and cook for 2 minutes. The sauted ingredients were poured to the prepared Eucheuma. Mayonaise was added and mixed well. Coffee mate and gulaman powder was added to the whip milk and all-purpose cream. The mixture were poured gradually to the prepared materials and served hot.

Sea vegetable Palabok

The ingredients were 500 grams Eucheuma, 200 grams boiled peeled shrimp, ½ shrimp broth, 1 clove chopped garlic, 2 pieces chopped onion, 50 grams achuete, 2 teaspoon salt, 2 teaspoon sugar and 2 teaspoon gulaman powder. Sauté garlic and onion, add shrimp and cook for 5 minutes. Add shrimp broth with achuete, add sugar and season with salt. Let it boil for 2 minutes, add gulaman powder. Add the boiling mixture to the Eucheuma, sprinkle black pepper and garnish with chives and sauted garlic. Served hot.

Sensory Evaluation

The product were subjective to sensory evaluation.The product were evaluated using human senses to determine the quality attributes and evaluated in terms of appearance, odor, texture and taste and analyze using score card sheet(Soekarto,1985,Dewi, 2011). This method is considered an objective instrument of measure with a considerable degree of reliability (Pangborn, 1978) and validity (Prell, 1976). This evaluation is a valuable tool in solving poroblems involving food acceptance food ability (Larmond, 1977).

The product were evaluated by 10 panelist which composed of 3 office staffs, 4 research staffs and 3 instructor teaching food technology of Carlos Hilaodo memorial State College, Binalbagan Campus. Panelist are usually office, research staff or a group of workers (Larmond, 1977).The instrument used in measuring the quality is the hedonic rating scale (Peryam,1957,Kroll,1990)were the panelist are asked to indicate on a scale of 9 point the degree to which they like or dislike the samples (Schutz,2001). A score of 9 is given to the entry “like extremely to dislike extremely with a scale of 1” and with a mid point of 5 being neither like nor dislike.
Statistical Analysis

The panel preference whether they like or dislike the product were treated using percentage. Descriptive mean were used to analyzed the quality and acceptability of processed product using sea vegetable as pasta alternatives.

RESULTS AND DISCUSSION

Dried *Eucheum*a were prepared into seavegetable salad, carbonara and palabok. The product were subjective to preference test were to determine whether they like or dislike the product (Katz P. 1985)The liking of the product were rated by 10 panelist as show figure 1.

For the 10 panelist, 7 out of 10 panel or 70%

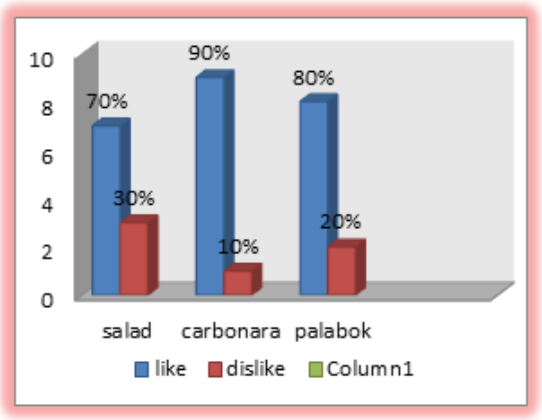

Figure 1 Responses of panelist to the different products using sea vegetable pasta.

like the seaweed salad, 9 out of 10 or 90% like carbonara and 8 out of 10 or 80% like palabok. For dislike 3 out of 10 or 30% for salad,10% for carbonara and 20% for palabok. These are the test normally employed for product development and improvement (Sparber 1996).

The attributes of the different product were evaluated using human perception (Kramer and Twigg, 1983). The product were evaluated employing multi sample test. The sensory score on quality and acceptability of each product were analyzed as shown in table 1, 2 & 3.

Table 1. Mean Score of Seaweed Salad

Quality	Mean	Interpretation
Appearance	8.8	Extremely like
Odor	8.7	Extremely like
Texture	7.9	Like very much
Taste	8.9	Extremely like
Acceptability	8.7	Extremely like

The taste of seavegetable salad has a higher of all quality attributes followed by appearance and odor with the interpretation of extremely like. Taste is an important parameter when evaluating sensory evaluation of foods. Appearance is important attribute in food choice and acceptance and smell is an integral part of taste and general acceptance of the food before it is put in the mouth (Free Choice profiling). The texture has a lowest mean of a 7.9 which is interpreted as like very much and with the acceptability of 8.7 which mean extremely like.

The odor has a highest mean with the score of 8.5 followed by appearance and taste with a score higher than 8 which mean like very much. The texture has the lowest mean of all the attributes with a score of 7.4 interpreted as like moderately. The acceptability with a score of 8.3 which mean like very much as shown in Table 2.

Table 2. Mean Score of Seaweed Carbonara

Quality	Mean	Interpretation
Appearance	8.2	Like very much
Odor	8.5	Like very much
Texture	7.4	Like moderately
Taste	8.1	Like very much
Acceptability	8.3	Like very much

The taste of palabok obtain a higher score, next is appearance interpreted as extremely like. The texture followed which is like very much and the odor obtain a lowest score interpreted as like very much. The acceptabilty has a mean of 8.8 which meant extremely likeas shown in Table 3.

Table 3. Mean Score of Seaweed Palabok

Quality	Mean	Interpretation
Appearance	8.7	Extremely like
Odor	8.1	Like very much
Texture	8.4	Like very much
Taste	8.9	Extremely like
Acceptability	8.8	Extremely like

The average quality and acceptability of the product were evaluated as shown in figure 2. The sensory analysis testing of food product is the ultimate test to assist the flavor and taste qualities of the product. It involves the measurement and evaluation of the range on the sensory attribute of food (Huss, 1994). Th e sensory relies on people to make various required judgement and make panelist the measuring instrument (ITC, UNCTAD/GATT,1991).

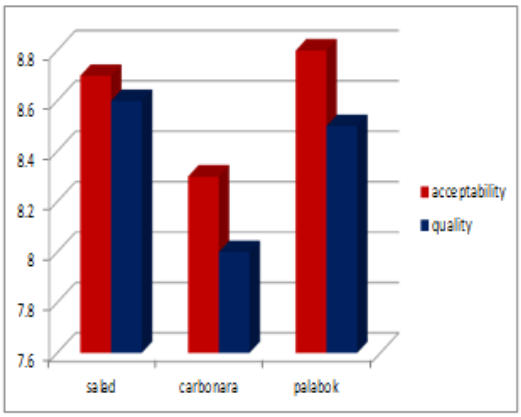

Figure 3: Average Mean Score of the Quality and Accepatability of the Innovative Products

The product having a high in quality attribute is the salad, next is palabok and carbonara having a lowest score which is interpreted as like very much. The acceptability of palabok obtain a higher score with a rating of 8.8 followed by salad and with the lowest score is carbonara that is less accepted of all the product.

For food acceptance, comments and suggestions of panelist are basis for the improvement for the innovative product (Labell,1987). It is the most important factor influencing success in market place (Earle MD.,2000)

CONCLUSION

The dried sea vegetable (*Eucheuma sp.*) can be used as pasta material in preparation for salad, carbonara, palabok. .The quality and acceptability of the product is like extremely and moderately by the panelist. The evaluation further shown that the texture of the product needs to be improved to increase panelist acceptance. The sea vegetable pasta can be used as material in preparation of different product that can be served in all occasion.

RECOMMENDATION

Chemical and Physical analysis must be conducted specifically on texture profile analysis. Further studies on consumer acceptance , econonmics, convenient of using sea vegetable pasta and using natural ingredients in processing of different products. .The result of the study will encourage processors to used available and healhtiest affordable organic material to be used for further product development. The results of the study will serve as bases for the technology transfer and promotion for the Technology Commercialization.

ACKNOWLEDGEMENT

The author would like to thanks to the Faculty and staff of the college and to the students taking up Bachelor of Science in Fisheries (BSFi IV) of the Carlos Hilado Memorial State College Binalbagan Campus for their assistance and support in the completion of the manuscript..

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DESIGN OF AN OPTIMAL POWER GENERATOR CIRCUIT BY HARNESSING ENERGY THROUGH FOOTSTEP

Engr. Gillert M. Bongcac, MoE
Jose Rizal Memorial State University
Main Campus, Dapitan City, Philippines
phyton_gil@yahoo.com

ABSTRACT

This study presents an optimal power generator circuit using footstep energy harvester. The design constitutes a piezoelectric transducers and a harvester circuit. The design was modelled and simulated using COMSOL Multiphysics software and verified using actual experiment. The optimal dimension of the transducer and enhanced dimension power output of the harvesting circuit was evaluated and the performance of the design was verified through actual experiment. The different motion does not affect the generated output voltages but the generated voltages are directly proportional to its applied load. Power were produced through walking and running which is enough to charge-up cellular phones and other handheld gadgets.

Keywords: Footstep power generator, Footstep harvester circuit, Optimal design of a footstep harvester circuit.

INTRODUCTION

Renewable energy is a natural form of ambient environmental energy sources such as light, wind, water, heat, and pressure. There are also renewable energy sources made from utilizing natural and chemical elements to form a useful energy such as biomass energy, geothermal energy, ocean thermal energy, ocean wave energy, and nuclear energy. Energy harvesting from footstep pressure is the main thesis of the study. By using piezoelectric materials, generation of electrical energy will be possible. The researchers want to study this area because of the trend of outgoing small and portable electric sources.

In recent years, interest in energy harvesting has increased rapidly, and harvesting vibration energy using piezoelectric materials has attracted a great deal of attention (Porwal H. 2013). Piezoelectric transducers are usually used to harvest energy from vibration, these includes monomorph, bimorph, stack and membrane. Piezoelectric materials are popular for energy harvesting from ambient vibrations due to their high power densities and ease of applications (Ozpak, Y. 2014). Ryan Robert Knight (2007) presented a work that focuses on two types of common piezoelectric mechanical designs and their electromechanical coupling. Guojun Wang (2010) developed a piezoelectric energy harvesting system that fits within a pair of shoes for unobtrusive, electrical energy generation from the compression and tension energy normally absorbed by the shoes during walking.

Most of the reviewed literature, the device geometric optimisation and circuit techniques are the gaps that limit the study to evaluate a highly efficient piezoelectric energy harvester. The choice of appropriate material in such purpose to achieve highly efficient output for energy harvesting has not been investigated thoroughly by other authors.

This study will conduct a series of processing of the basic requirements for energy harvester in order to fulfil the gaps aforementioned above. A material selection will be performed to obtain the right material for energy harvesting, optimisation of the energy source, and a new idea of harvesting will be implemented to develop the reliability and capability of the device.

Objectives

This study aims to:

1. Design an optimal footstep power harvester and develop a new concept of harvesting circuit.
2. Evaluate the design with respect to optimal dimension of the transducer and enhanced power output of the harvesting circuit.
3. Verify the performance and output of the prototype through actual experiment.

Significance

This study will contribute extend knowledge in the area of energy harvesting such as optimisation of the energy source which is a way in for the improvement of the output. The footstep power harvester will be of assistance to the community particularly in areas of inadequate electricity.

This study will also serve as a lead to every individual in providing their own additional source of electricity without too much reliance in external grid. The study of harvesting renewable energy adds a scholarly research particularly in engineering field. It involves scientific knowledge and application of scientific principles as a basis of future technologies.

Theoretical/Conceptual Framework

1. Piezoelectric Conversion

Piezoelectric materials have the capability to generate electricity in response to an applied mechanical stress (direct effect) and the capability to produce mechanical stress when an electric field is applied (converse effect).

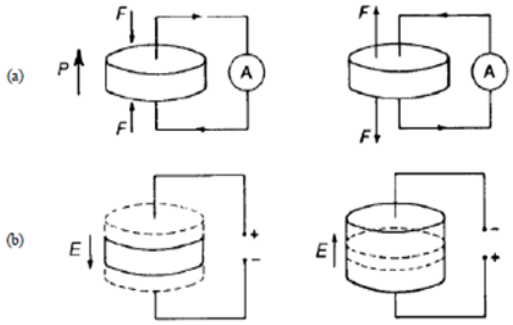


Figure 1: (a) Direct effect (b) Converse effect.

Figure 1 illustrates the direct and converse effect, where P indicates the direction of polarization of the piezoelectric disc, F indicates the applied force, and E indicates the application of an electric field.

Figure 2 illustrates the piezoelectric effect with the help of a compression disk.

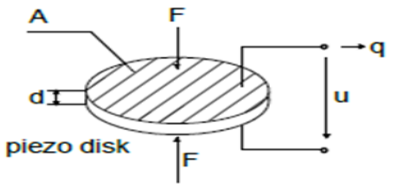


Figure 2: Piezoelectric Effect

Charge

$q = d_{33} F$ (1.1)

Voltage

$u = (d_{33} \cdot d \cdot F)/(e_{33} A)$ (1.2)

where

d_{33} and e_{33} are piezo constants

F is applied force
d is thickness
A is electrode area

A compression disk looks like a capacitor with the piezoceramic material sandwiched between two electrodes. A force applied perpendicular to the disk causes a charge production and a voltage at the electrodes. (Wagner, J. & Burgemeister, J. 2012)

1.1 Piezoelectric Transducers

PZT-5A and PZT-5H piezoceramics are the most commonly used engineering piezoceramics. Their typical three-dimensional piezoelastic properties can be found on the Figure 3. (Wagner, J. & Burgemeister, J. 2012)

2. Harvesting Circuit

For harvesting the developed energy in the piezoelectric element, certain IC components will be used to charge and store charges in mobiles or batteries. A step down switching and voltage regulators will be used, namely, LT1074 and LT1083.

	Reference model			Parametric studies		
	Top electrode (silver)	PZT-5A	Bottom electrode (brass)	Silicon	Glue layer	PZT-5H
Diameter (mm)	7	9	12	12	12	9
Thickness (μm)	30	100	100	100	50	100
ρ (kg/m^3)	1049	7750	8490	2330	1170	7500
d_{31} (m/V)		-1.71×10^{-10}				-2.74×10^{-10}
d_{33} (m/V)		3.74×10^{-10}				5.93×10^{-10}
d_{15} (m/V)		5.84×10^{-10}				7.41×10^{-10}
s_{11}^E (m^2/kg)		1.64×10^{-11}				1.65×10^{-11}
s_{33}^E (m^2/kg)		1.88×10^{-11}				2.07×10^{-11}
s_{12}^E (m^2/kg)		-5.74×10^{-12}				-4.78×10^{-12}
s_{13}^E (m^2/kg)		-7.22×10^{-12}				-8.45×10^{-12}
s_{44}^E (m^2/kg)		4.75×10^{-11}				4.35×10^{-11}
s_{66}^E (m^2/kg)		N/A				N/A
K_{11}^T		1730				3130
K_{33}^T		1700				3400
ε_0 (F/m)		8.85×10^{-12}				8.85×10^{-12}
E (GPa)	83		97	202	2.4	
ν	0.37		0.31	0.33	0.34	

Figure 3: Table of Specifications of PZT Materials

2.1 LT1074 Step – Down Switching Regulator

The LT1074 is a 5A (LT1076 is rated at 2A) monolithic bipolar switching regulator which requires only a few external parts for normal operation. The power switch, all oscillator and control circuitry, and all current limit components, are included on the chip. The topology is a classic positive "buck" configuration but several design innovations allow this device to be used as a positive-to-negative converter, a negative boost converter, and as a flyback converter.

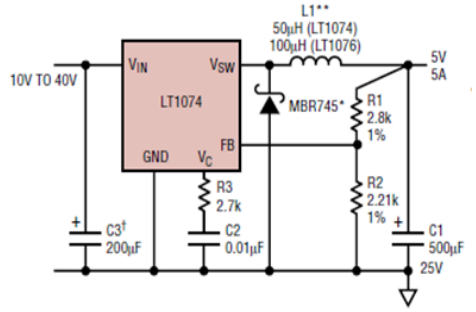


Figure 4: Step – Down Switching Regulator

The switch output is specified to swing 40V below ground, allowing the LT1074 to drive a tapped inductor in the buck mode with output currents up to 10A. (Linear Technology, Step-Down Switching Regulator)

2.2 LT1083 Voltage Regulator

The LTR1083 series of positive adjustable regulators are designed to provide 3A, 5A and 7.5A with higher efficiency than currently available devices. All internal circuitry is designed to operate down to 1V input to output differential and the dropout voltage is fully specified as a function of load current. Dropout is guaranteed at a maximum of 1.5V at maximum output current, decreasing at lower load currents.

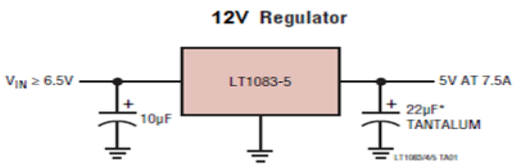


Figure 5: Voltage Regulator

On-chip trimming adjusts the output voltage to 1%. Current limit is also trimmed, minimizing the stress on both the regulator and power source circuitry under overload conditions. The LT1083 series devices are pin compatible with older three-terminal regulators. A 10µF output capacitor is required on these new devices; however, this is usually included in most regulator designs.

The LT1083 develops a 1.25V reference voltage between the output and the adjust terminal. By placing a resistor R1 between these two terminals, a constant current is caused to flow through R1 and down through R2 to set the overall output voltage.

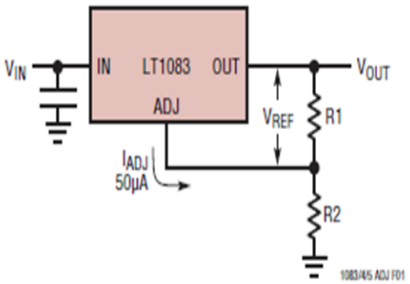


Figure 6: Voltage Regulator Output

$$V_{OUT} = V_{REF}\left(1 + \frac{R2}{R1}\right) + I_{ADJ}\,R_{2}. \qquad (1.3)$$

Normally this current is the specified minimum load current of 10mA. Because I_{ADJ} is very small and constant when compared with the current through R1, it represents a small error and can usually be ignored. (Linear Technology, Low Dropout Fixed Regulator)

METHODOLOGY

Research Design

The design constitutes piezoelectric transducers and harvesting circuit. Two bent PZT – 5H will be used as a material for energy conversion in a shoe together with an aluminium alloy frame for housing. The harvesting circuit consists of a switching regulator and a voltage regulator to normalize the collection of charges from the energy source.

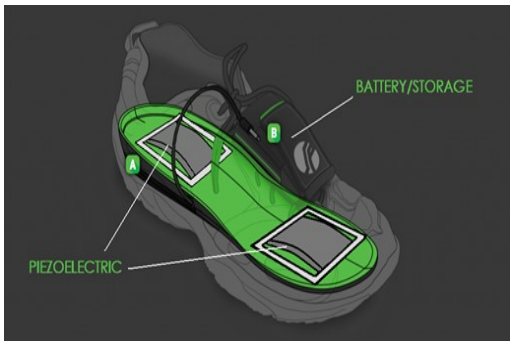


Figure 7: Design Concept

Research Strategy and Design

A quantitative research will be performed in the study to examine the relationship between the variables needed for evaluation. The data needed for validation of the design are expressed in quantity because these will support the problem statement in the study.

The study also exercises an experimental design to investigate the relations between control and manipulation of independent variables and its effects to the dependent variables.

Data, Measurement and Analysis

The data are set into two groups of variables from the transducer to the harvesting circuit. The model dimension and voltage amplitude of the transducer are the dependent variables, where the applied pressure, frequency, and internal properties are the independent. Also, the harvesting circuit has the output voltage, current, and power, which are dependent to the load resistance.

The data to be collected in the study are the dependent variables in each group.

These are the model dimension, voltage amplitude, output voltage, current, and power.

For every data, several measurements will be carried out. A Frequency Domain for the piezoelectric transducers, and a Time – Dependent for harvesting circuit.

After the collection of data, the design will be evaluated through statistical method using Regression Analysis or Correlation which is more appropriate to use for all the data collected in analyzing the degree of relationship of the variables.

Research Methods

Systematic methods for the validation of the design are outlined in this section. With the aid of COMSOL Multiphysics and LT Spice software, the modelling and circuitry of the design will be simulated and evaluated. Several measurements will be performed to establish precise results in the study. In that case, a statistical analysis will carry out the interpretation of the results in the experiment.

Collection, Measurement, Process, and Analysis

The data will be collected through construction and simulation of the model in COMSOL Multiphysics and LTSpice. The measurement of the data from the transducer will be done through value tracing from the post results of frequency domain response. In the harvesting circuit, the data will be measured by marking the average data point from the post results.

The data will be processed by recording the measured values in a table and plot in a graph. The data will be analyzed through determination of the mean and standard deviation of the resulting data in order to obtain the coefficient of correlation.

Modelling and Simulation

This section covers the design evaluation through simulation. It includes mathematical equations that are necessary for design electrical and mechanical parameters. The simulation of piezoelectric transducers will be performed in COMSOL Multiphysics and the harvesting circuit will be evaluated in LT Spice.

Working Equations

Piezoelectric Transducer
Terminal Voltage

$$V = (d_{33} \cdot d \cdot F)/(e_{33} A) \quad (3.1)$$

Harvesting Circuit
Ohm's Law

$$V = IR \quad (3.2)$$

Regulator Output Voltage

$$V_{OUT} = V_{REF} \left(1 + \frac{R2}{R1}\right) + I_{ADJ} R_2 \quad (3.3)$$

Piezoelectric Transducer Materials

The material PZT – 5H will be used as the transducer of the prototype for the production of electrical energy. The properties are shown.

PZT-5H

Diameter (mm)	9
Thickness (μm)	100
ρ (kg/m^3)	7500
d_{31} (m/V)	-2.74×10^{-10}
d_{33} (m/V)	5.93×10^{-10}
d_{15} (m/V)	7.41×10^{-10}
s_{11}^E (ms^2/kg)	1.65×10^{-11}
s_{33}^E (ms^2/kg)	2.07×10^{-11}
s_{12}^E (ms^2/kg)	-4.78×10^{-12}
s_{13}^E (ms^2/kg)	-8.45×10^{-12}
s_{44}^E (ms^2/kg)	4.35×10^{-11}
s_{66}^E (ms^2/kg)	N/A
K_{11}^T	3130
K_{33}^T	3400
ε_0 (F/m)	8.85×10^{-12}
E (GPa)	
ν	

Figure 8: PZT – 5H Properties

The aluminium metal will be used for the framing of the transducer. Its properties are shown below.

Property	Value
Atomic Number	13
Atomic Weight (g/mol)	26.98
Valency	3
Crystal Structure	FCC
Melting Point (°C)	660.2
Boiling Point (°C)	2480
Mean Specific Heat (0-100°C) (cal/g.°C)	0.219
Thermal Conductivity (0-100°C) (cal/cms. °C)	0.57
Co-Efficient of Linear Expansion (0-100°C) ($x10^{-6}$/°C)	23.5
Electrical Resistivity at 20°C (μΩ.cm)	2.69
Density (g/cm^3)	2.6898
Modulus of Elasticity (GPa)	68.3
Poissons Ratio	0.34

Figure 9: Aluminium Properties

The weight of the prototype can be computed from the given data and optimal dimension of the prototype.

Volume (frame) = (10 x 6 x 1.5) – (8cm x4.5cm x 0.5cm) = 72 cm^3

Volume (transducer) = (8 x 4 x 1) = 32 cm^3

Weight = (72 cm^3 x 2.7 g/ cm^3) + (32 cm^3 x 7.5g/cm^3) = **434.4 g**

Simulation of Piezoelectric Transducer

Before the simulation begins, the geometric parameters of the prototype, excluding the harvesting circuit, will be shown. Some parameters are held variable for optimisation purposes. The top view and side view of the model are shown in the figures below.

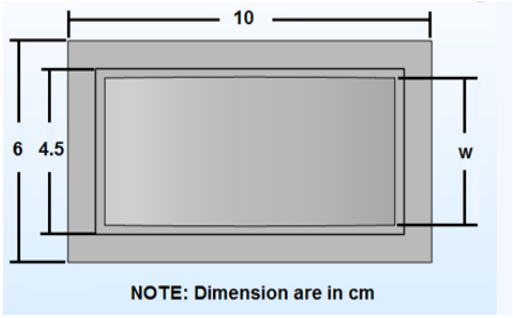
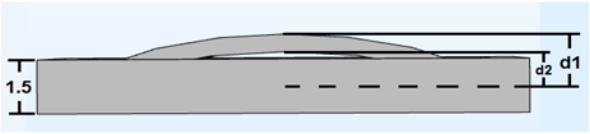


Figure 10: Top View of the Model from COMSOL Multiphysics



The transducer will be evaluated through Frequency Domain to determine the characteristic of the voltage when there is a change of motion. The frequency range is set from 0.5Hz to 2.5Hz.

The optimization module involves numerical solutions for finite element analysis. In this study, the solver for optimization is the Nelder – Mead Method. The objective function for evaluation is the Terminal Voltage, and the type of optimization is maximization.

Results of Piezoelectric Transducer Simulation

The results for optimization and frequency domain are shown below. A table and plots are provided for the numerical results of optimization, and a graph is presented for the frequency domain of the optimal dimension of the transducer.

Table 1 Results from Optimization Study at f = 1.5Hz (Jogging), m = 50 kg

Electric Potential Result								
At w = 3.5cm			At w = 4cm			At w = 4.5cm		
d_1-(cm)	d_2 (cm)	V_{AC} (V)	d_1-(cm)	d_2 (cm)	V_{AC} (V)	d_1-(cm)	d_2 (cm)	V_{AC} (V)
1.8	0.8	17.6	2.0	0.8	19.3	2.2	0.8	20.8
1.8	0.9	15.8	2.0	0.9	17.7	2.2	0.9	19.3
1.8	1.0	14.1	2.0	1.0	17.3	2.2	1.0	17.9
1.8	1.1	12.3	2.0	1.1	15.5	2.2	1.1	16.4
1.8	1.2	10.5	2.0	1.2	12.9	2.2	1.2	14.9
1.8	1.3	8.8	2.0	1.3	11.3	2.2	1.3	13.4
1.9	0.8	19.3	2.1	0.8	20.9	2.3	0.8	22.3
1.9	0.9	17.6	2.1	0.9	19.3	2.3	0.9	20.8
1.9	1.0	15.8	2.1	1.0	17.7	2.3	1.0	19.3
1.9	1.1	14.1	2.1	1.1	16.1	2.3	1.1	17.8
1.9	1.2	12.3	2.1	1.2	14.5	2.3	1.2	16.4
1.9	1.3	10.5	2.1	1.3	12.9	2.3	1.3	14.9

The table shows the results from optimization module. It contains the possible optimal dimension of the transducer. Three different widths are evaluated together with their corresponding co-parameters d_1, d_2, and voltage. The difference between d_1 and d_2 is the thickness of the transducer. As shown in the table, as the thickness reduces the voltage decreases, i.e, the voltage is directly proportional to the thickness as stated in equation (3.1).

From the results, the maximum voltage appeared is 22.3V which has a corresponding dimension of w = 4.5cm, d_1 = 2.3cm, and d_2 = 1.8cm. But, the width is too long and this may increase the electrode area. Note that the voltage is inversely proportional to the electrode area. Hence, the most optimal dimension for the transducer may be in w = 3.5cm and w = 4.0cm.

The results from tables are translated into a plot to show clearly the variation of dimensions with respect to voltages. The parameter d_2 is treated as the independent variable, the voltage is the dependent variable, and the parameters d_1 and w are set to constants. The parameter d_2 is an increasing variable, so it means that the thickness of the transducer is shrinking because d_1 is fixed. When this happens, the voltage will also decrease. It is also clear that the most optimal dimension for the transducer is w = 4.0 cm and thickness = 1cm, since in this level the voltage is optimized.

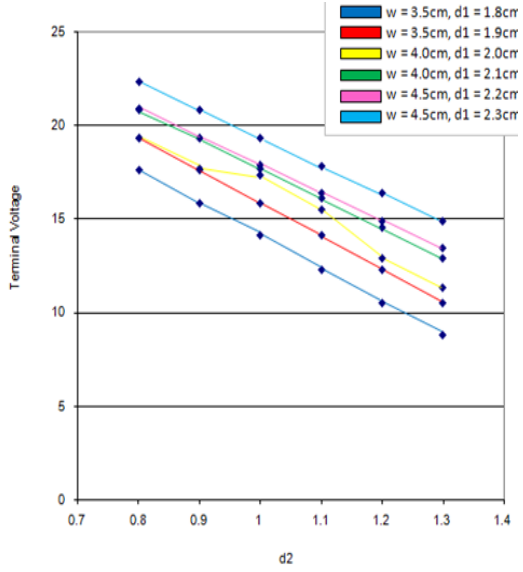


Figure 12: Optimization Results

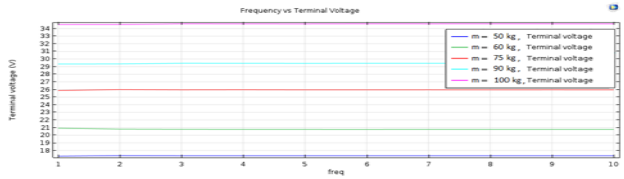


Figure 13: Frequency Domain Result from Optimized Model

The optimal transducer is then evaluated in a frequency domain study by applying increasing load from 50 kg to 100 kg and changing state of motion from walking to fast running. In the result, it implies that as the load increases the terminal voltage also increases rapidly. It proves the equation (3.1) that the voltage is directly proportional to the applied load. However, by changing the state of motion has no significant effect on the terminal voltage. It can be seen that the output voltage is almost constant as the frequency amplifies. Hence, the increase in load has a significant effect on the change of voltage.

Simulation of Power Harvesting Circuit

The harvesting circuit is composed of a voltage regulator for the supercapacitor storage and a switching regulator for the load. Certain electronics components have been added for the requirements of each regulator as specified in datasheets. The circuitry of walking and running situation are the same but only the frequency of the source.

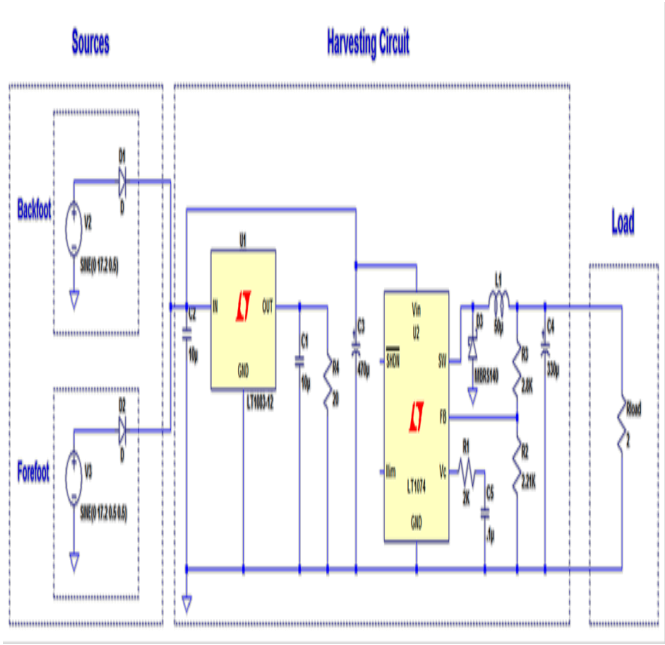


Figure 14: Schematic Circuit Diagram (Walking) using LTSpice

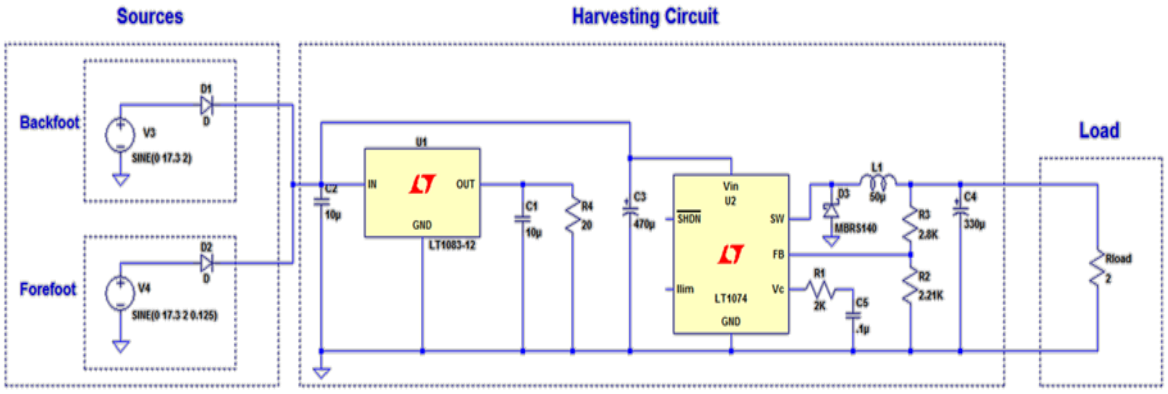


Figure 15: Schematic Circuit Diagram (Running) using LTSpice

For the walking situation, the frequency of the voltage of the transducers is about 0.5Hz because the average footsteps when walking is one step per foot in 2 seconds. To easily understand, 1 Hz is one step per foot in one second. The source voltage is set to 17.6V, the output voltage from a 50 kg load, because the harvesting circuit regulates its output from an input ranging within 10 to 40V. So, no matter how much the input as long as it is within the range it would not affect the output. The source from the forefoot is delayed for 0.5 second because it will only start rising when the backfoot is at the maximum level, that is, the backfoot will be maxima at ¼ of its cycle or 0.5 second.

For the running situation, the source frequency is the only parameter being altered. The source voltage is the same with the former. The frequency is set to 2Hz because the average footstep when walking is 2 steps per foot in one second. The source from the forefoot is delayed for 0.125 second because it will only start rising when the backfoot is at the maximum level, that is, the backfoot will be maxima at ¼ of its cycle or 0.125 second.

Results of Harvesting Circuit Simulation

Walking Situation

The figures below are the graphical results from time – dependent simulation with varying load resistance when walking. Each figure is the voltage and current characteristic with its corresponding load resistance and time needed for one (1) cycle.

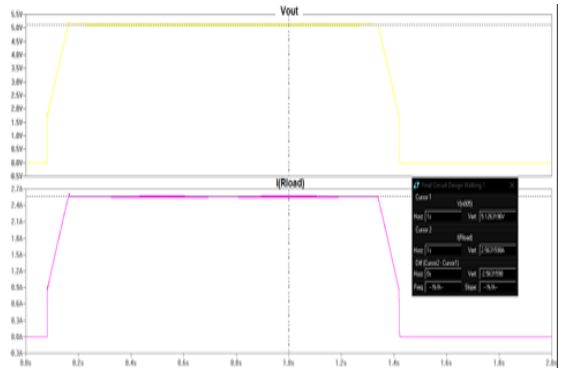


Figure 16: Voltage and Current at Rload = 2Ω

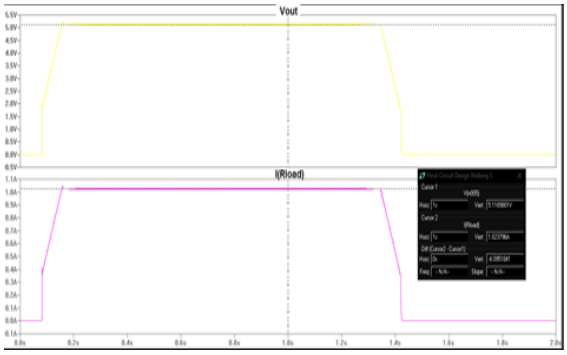


Figure 17: Voltage and Current at Rload = 5Ω

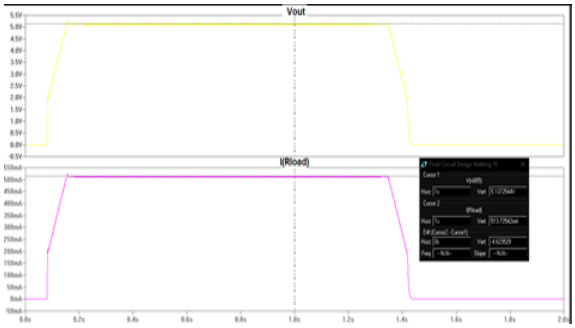


Figure 18: Voltage and Current at Rload = 10Ω

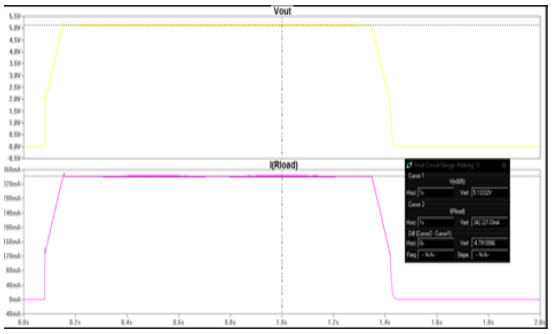


Figure 19: Voltage and Current at Rload = 15Ω

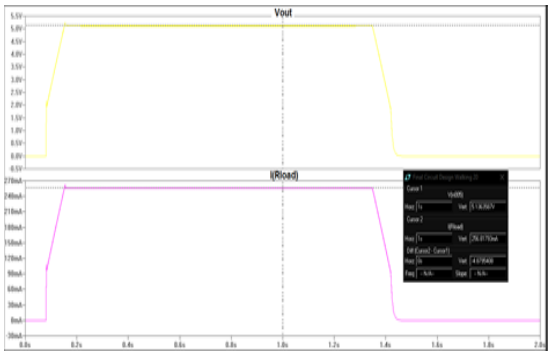


Figure 20: Voltage and Current at Rload = 20Ω

As shown in the figures above, the voltages and currents have the same characteristic. The regulated output waveforms produced are from the combination of two input sources, backfoot and forefoot, respectively. The output voltages of different load resistances have the same value of about 5V. This means that the switching regulator is functional that it can produce desired voltage for the load. However, the current are significantly decreasing as the load resistance increases. A simple explanation about the decrease of the current is that it is inversely proportional to the resistance. The results show that to produce sufficient mobile charging the load resistance must be between 2Ω and 5Ω

Also, the results show that walking can generate maximum power of 13.13W in one second.

Running Situation

The graphical results in running situation have the same voltage and current characteristic from the walking situation. But, the difference between the two situations is the time needed for one (1) cycle. The figures are shown below.

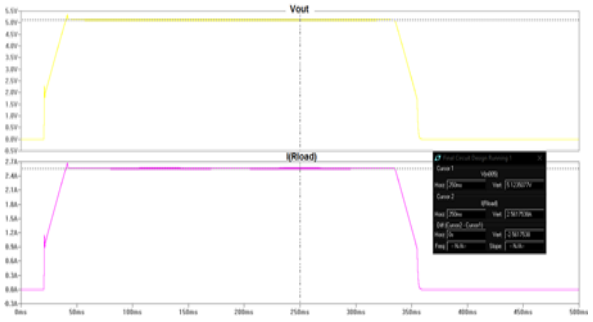


Figure 21: Voltage and Current at Rload = 2Ω

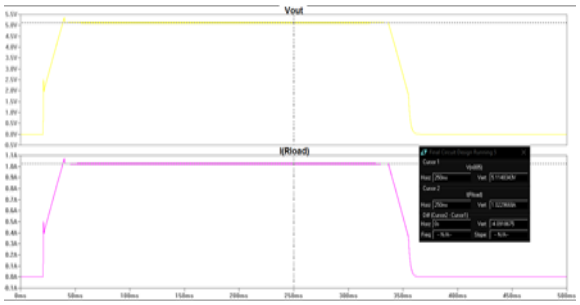


Figure 22: Voltage and Current at Rload = 5Ω

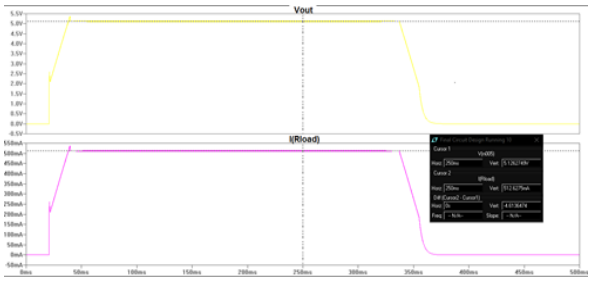


Figure 23: Voltage and Current at Rload = 10Ω

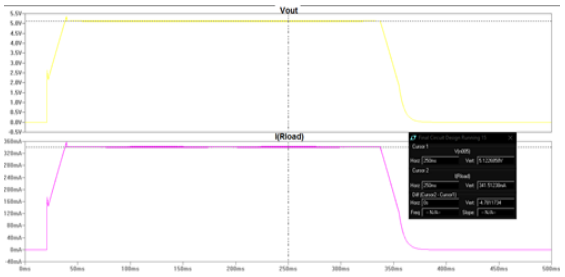


Figure 24: Voltage and Current at Rload = 15Ω

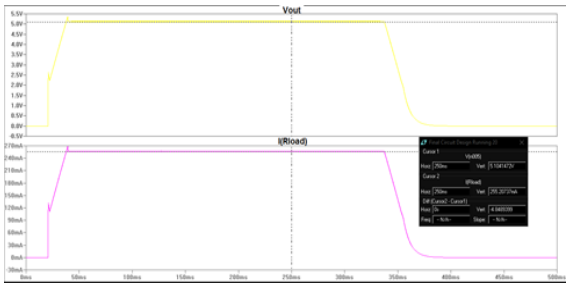


Figure 25: Voltage and Current at Rload = 20Ω

The resulting magnitude of the voltage and current of each load resistance have almost the same values as the former results. The results show that the change of motion has no significant effect on the magnitude of voltage and current. On the other hand, the energy produced when running will give twice as much as when walking. It can be seen from the results that, when running, one cycle takes only 500ms. Therefore, running can produce maximum power of 26.26W in one second.

Tables for Simulation Results

The data collected from the measurements are processed by recording in tables. Two tables are presented below, one for the transducer and one for the harvesting circuit.

Piezoelectric Transducer

As shown in the table below, the applied load to the transducer is varied from 50 kg to 100 kg. The states of motion are also classified into walk, fast walk, jogging, run, and fast run.

Table 2: Voltage Measurement at Different Motion with Applied Loads

Motion	Applied Load				
	A 50 kg	B 60 kg	C 75 kg	D 90 kg	E 100 kg
	V_{AC}	V_{AC}	V_{AC}	V_{AC}	V_{AC}
Walk(0.5 Hz)	17.2	20.5	26.5	29	35.5
Fast Walk (1 Hz)	17.25	20.75	25.75	29.2	34.6
Jogging (1.5 Hz)	17.3	20.75	26	29.25	34.5
Run(2 Hz)	17.3	20.75	25.85	29.25	34.5
Fast Run (2.5 Hz)	17.3	20.75	26	29.25	34.7

The results show that the increase in weight has a significant effect in the voltage generated by the transducer. This implies that as you weigh up, the voltage increases rapidly. In addition, the change in motion has no significant effect in the voltage generated. It is because the object is moving at almost constant velocity, meaning no acceleration or no additional force.

Harvesting Circuit

The table shown below is categorized into two situations: Walking and Running. The electrical outputs are shown with their corresponding load resistance.

Table 3: Voltage, Current, and Power Measurement

Load Resistance (Ω)	Walking			Running		
	V	I	P	V	I	P
R = 2	5.1	2.5	13.	5.1	2.5	13.
R = 5	5.1	1.0	5.2	5.1	1.0	5.2
R =	5.1	0.5	2.6	5.1	0.5	2.6
R =	5.1	0.3	1.7	5.1	0.3	1.7
R =	5.1	0.2	1.3	5.1	0.2	1.3

The results show that as the load resistance increases, the output voltage almost remains constant. That is because the component used in the circuit is independent from the load resistance. However, the current and power are much decreasing as the load resistance increases. The reason is both are inversely proportional to the resistance when the voltage is constant.

CONCLUSIONS

The design of an optimal footstep power harvester circuit has successfully designed and tested in COMSOL multiphysics software. It shows that the current and voltage output was generated through different motion with corresponding load variation. Since power was produced through simulation, it shows that when used either in walking or running, it can give power source which is enough to charge up cellular phones or hand held gadgets.

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CONVEYOR-BASED CAN CRUSHER

MICHAEL G. CALAGO
University of Southeastern Philippines
COLLEGE OF TECHNOLOGY
Iñigo Street, Obrero, Davao City

ABSTRACT

The main purpose of the study is to fabricate a can crusher having a conveyor based which operates a crushing mechanism to crease and crush empty cans, and especially for crushing beverage cans to ease handling for recycling. The study designed and developed a conveyor based can crusher it is concerned with the design, fabrication, testing, and revision of the functionally completed model of conveyor based can crusher. This study employed developmental research and was conducted to electronic and electrical practitioners, instructors and students from University of Southeastern Philippines. Through their actual observation and direct testing of the machine, the results of the study showed that the device had a good performance and yielded high acceptability level in terms of flexibility, functionality and safety. It was moderately acceptable with regards to its cost. Based on the findings, the researchers concluded that the new device is highly functional and beneficial. It is hereby recommended that parallel studies be undertaken to enhance the conveyor based can crusher.

KEYWORDS

Recycling, conveyor, can crusher, developmental research, Davao City, Philippines

INTRODUCTION

Recycling of cans, and in particular beverage cans, has increased rapidly over recent years as garbage disposal has become a greater problem and recycling has become economically feasible. Since beverage cans occupy a relatively large volume with relatively little weight, handling of cans can be eased by compacting the cans. To further increase ease of handling and to aid in automated handling of cans for recycling, it is advantageous to crush each can into substantially the same shape. So that the crushed cans may be baled, the cans should be crushed so that they are flattened from the sides rather than smashed downward from the top to obtain a flatter can.

Uncrushed metal cans occupy a considerable amount of space, making it difficult to store or transport large quantities of metal cans. Thus, it is desirable to flatten metal cans before they are stored or transported elsewhere so that more metal cans can be placed in a given space. Furthermore, crushing metal cans presents the material in a form in which is more readily salvageable for reuse and recycling.
As the need for crushed cans has increased, devices for crushing the cans have been developed. It can be seen then that a can crusher is needed which crushes cans in a repeatable flattened shape and which leaves the crushed can intact for recycling. It can also be seen that a crushing device is needed which is tripped by cans being fed to the crusher rollers and which rotates the rollers until all cans which are fed into the crusher are crushed.

The first can crusher was of course the human foot. People often stomped on cans to flatten them down either for recycling or for greater space in the garbage can. This could sometimes hurt if the foot did not come down properly on the can, so entrepreneurs eagerly sought a variety of alternatives that could be used with the hand. However, we could hardly escape automating the can crusher so that one merely inserts cans and presses a button to crush them.

The present study is directed to a can crusher for crushing empty cans, and especially for crushing beverage cans to ease handling for recycling. Without wishing to limit the present innovation to any theory or mechanism, it is believed that the can crusher of the present innovation facilitates the compaction of metal-cans for recycling purposes. The study intends to fabricate a conveyor based can crusher. This technology introduces a conveyor system mainly used for transporting beverage can and a crushing mechanism is

built within conveyor which makes the study different from other can crusher technology.

Lim, K. L., & Sng, H. K. (2014) developed a belt conveyor system with a distributing belt conveyor unit having upper and lower movable frame assemblies that are pivotally connected to a gear unit that simultaneously moves the lower movable frame assembly in opposition to the movement of the upper movable frame assembly, therein allowing the belt to track smoothly when transferring the articles between one branch belt conveyor unit and two or more branch belt conveyors units. The construction of the distributing belt conveyor unit allows for easy removal of the belt.

Robot manipulators are commonly employed in the wide range of the tasks such as, transportation, material handling, loading, welding, milling and drilling, material assembling, part sorting, packaging and measuring in manufacturing processes. Industrial manipulators are essentially open kinematic chain arm like devices and are generally composed of ternary links interconnected to each other by revolute and prismatic joints (Gomez, 2012).

In contrast, Weaver, F. N., & Weaver, F. N. (2011) fabricated a chain link conveyor for use in material handling equipment such as a feed cart. The chain link conveyor comprises a series of sprockets and a pair of spaced apart chains trained around the sprockets. Each chain includes a series of interconnected links. Each link comprises a pair of sidebars and an interconnecting cross bar along with a pair of hooks that function to connect consecutive links and also function to form a sprocket centering gap that receives and guides respective sprockets through the link as the links moves over the sprockets. Various implementations of the chain link conveyor can be made. In one implementation the chain link conveyor is disposed in a feed cart.

Self-transporting conveyor system suitable was developed for handling the discharge of a rock or concrete crusher. The system includes a pair of stacking conveyors and a pair of transfer conveyors all of which are assembled together for towing by a single highway tractor. The conveyors can be set up at a desired site using available equipment, such as a loader, so that the cost of a special crane is avoided. Each stacking conveyor includes a self-contained hydraulic power supply that allows it to hydraulically fold up for transport, and unfold for operation, and enables it to hydraulically pivot back and forth during operation to build a kidney-shaped pile (Conner, 2001).

As Kranzberg (1986) stated in his Law of Technology, “Technology is neither good nor bad nor is it normal”. Understandably, existing technological devices not simply be regarded as bad or inutile, but rather treated based on the fact after sometime its degree of utilization will diminish such that not be left as it is. Technology must develop new concepts and products or it can go for innovation.

An electrically actuated can crusher having housing, a motor mounted within the housing and a shaft rotatable by the motor and downwardly driven thereby having a crush plate thereon was constructed by Dodd, R. N. (1986). The housing also includes a bottom crush plate allowing a can to be crushed to be placed in the housing between the crush plates. The housing includes an access door which, when in the open position, deactivates the motor. In this manner, when the door is closed, the motor can be activated to lower the shaft crush plate to crush a can placed there between. The shaft crush plate may include a lever movable in a slot in the housing to align the shaft crush plate in its movement and a reversing switch may be provided in the lever and slot to reverse the direction of movement of the shaft crush plate after crushing of a can.

Stephen H. Kaminski (1977) fabricated a manually operated, wall-mountable, beverage can crusher having a compact hollow housing of rectangular cross-section, a ram mounted for sliding movement within the housing, and an ejection spring secured to the rear wall of the housing and operative to urge crushed cans forwardly out of the housing as the ram is raised. The ram is raised and lowered by means of a lever arm pivoted to the top of the housing and connected to the top of the ram through a thrust link pivoted at both ends. The lever arm includes a cover plate which completes closure of the housing when the arm is lowered, and also includes a channel section which partly surrounds the thrust link for compactness of construction.

Synthesis

The statements on the literature emphasizes the importance of the can crusher technology in the field of recycling and various literatures introduces different mechanism and circuitry.

OBJECTIVES OF THE STUDY

The main purpose of this study is to design and develop conveyor based can crusher. Its objectives are: to design and develop conveyor based can

crusher; determine the construction cost of the device; evaluate the level of acceptability in terms of functionality; and to revise defects found during try-outs.

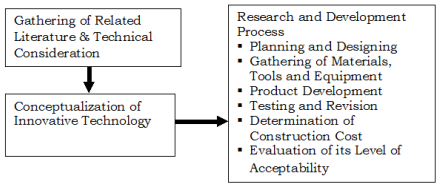
The research paradigm of the study consists of three parts, the input throughput and output. Under the input of the conceptual study are alternative ideas from related studies and literature, supplies and materials, tools and equipment and labor. In the throughput of this study is composed of innovating and designing, constructing, revising, case preparation, circuit preparation and installation. The output of the completed project study "conveyor based can crusher".

MATERIALS AND METHODS

In every research undertaking a certain level of ethical procedure is observed to ensure its validity. In this study, the safety of the respondents was also considered in conducting the actual research procedure.

The researcher utilized the developmental research method, particularly the Research and Development Process at the College of Technology of the University of Southeastern Philippines, Davao City, school year 2014-2015. Specifically, the processes involved in this study were planning and designing of the project set-up, gathering of materials, tools and equipment, product development which includes lay outing the circuit, assembling, and actual setting-up of the mechanism, interfacing of all major parts, and testing and revising. As applied to this study, the researcher developed a conveyor based can crusher.

Descriptive-evaluative research type was also employed in determining the construction cost and in evaluating the level of acceptability of the research output in terms of functionality. The respondents were the 30 Electronic Technology students and professors of the College Technology, University of Southeastern Philippines, Davao City. They were purposively selected considering their expertise on this particular field. The data gathered tallied and treated statistically using weighted mean. The flow chart (Figure 1) shows the developmental process that guided the researcher in developing the conveyor based can crusher from conceptualization, developmental phase of the device up to the evaluation phase.



1. Figure Research Flow Chart

Materials used in the fabrication is locally available. The device was developed using the tools and equipment found in the Electronic Technology Department of USeP-CT. Aside from fabrication, these tools were likewise used in adjusting, checking and evaluating the technology. The diagram and circuitry of the device is shown in figure 2.

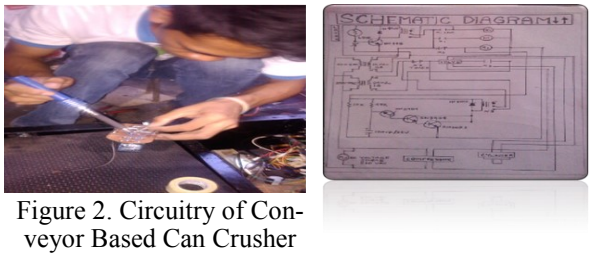


Figure 2. Circuitry of Conveyor Based Can Crusher

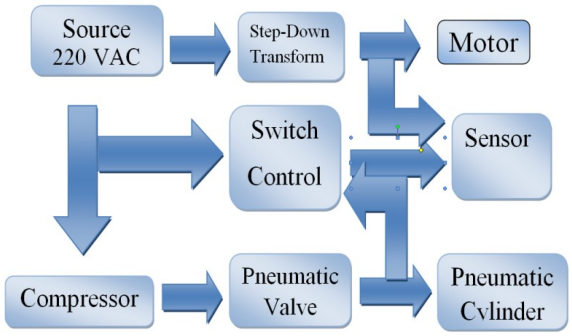


Figure 3. Block Diagram of the Conveyor Based Can Crusher

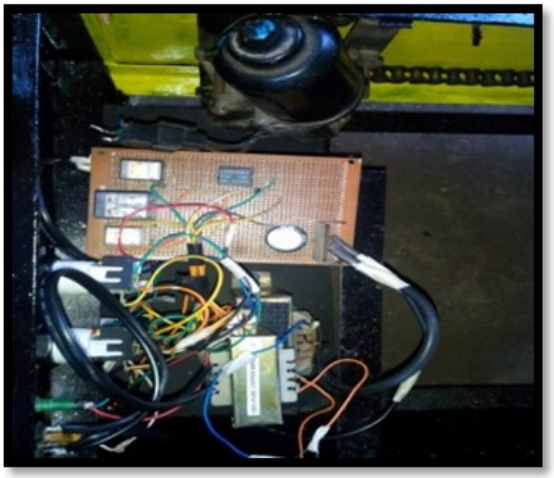


Figure 4. Interfacing of Parts

RESULTS AND DISCUSSION

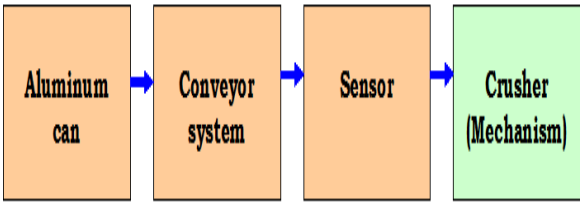
Operation Procedure

The operation of this device starts with the empty beverage can placed in the conveyor. When the push button switch is pressed the conveyor starts to rotate thereby the empty beverage can moves forwards the sensor. When the sensor detects the presence of the beverage can, it sends signal to the crusher mechanism. The crusher automatically stops the conveyor and crushed / pressed the beverage can. After the beverage can is crushed / pressed the conveyor restarts the process.

Figure 5. Completed Conveyor Based Can Crusher

Interrelationships. The innovative designed of conveyor based can crusher composed of four major parts, three of which represent the three circuits of the whole project.

Figure 6. Interrelationships of parts



Fabrication Cost of the Multi-functional Floatless Relay

The bill of materials used to construct the device has amounted to Php 16,737.00 and the labor cost was Php 6,694.80 with a total cost of Php 25, 105.50. Considering the technical and economic advantages, and safety features, the cost is considered as commercially competitive. This implies that a different conveyor based can crusher can be innovated, designed, and constructed using locally available components / materials.

Table 1 Tabulation of Project Cost

Sources	Cost
Supplies and Materials	16,737.00
Labor Cost (40%)	6,694.80
Overhead Cost (10%)	1,673.70
Total	**25, 105.50**

Level of Acceptability of the Device in terms of Functionality

To validate the worthiness of the device, the electronic technology practitioners, professors and students evaluated its acceptability in terms of functionality. As reflected in table 2, the level of acceptability of the device in terms of functionality is generally assessed by the respondents as *very much acceptable* with an average weighted mean of 4.54. On the other hand, the lowest acceptability rating on the functionality of the device has a weighted mean of 4.40 and interpreted as *highly acceptable*. These findings implied that the conveyor based can crusher is *highly functional*.

Table 2 Level of acceptability of the conveyor based can crusher in terms of functionality

Parameter The machine...	Mean	Interpretation
a) serves the purpose as can crusher.	4.57	Very much acceptable
b) is convenient to the user.	4.57	Very much acceptable
c) is easy to manipulate.	4.6	Very much acceptable
d) conveyor runs in normal speed.	4.40	Very much acceptable
e) can crushed various beverage cans.	4.63	Very much acceptable
f) has a sensor that detects the beverage can.	4.53	Very much acceptable
g) employs safety guards to its moving parts.	4.43	Much acceptable
h) has conveyor system.	4.57	Much acceptable
Average	**4.54**	Very much acceptable

Legend:

4.5 – 5.0	Very Much Acceptable
3.5 – 4.49	Much Acceptable
2.5 – 3.49	Acceptable
1.5 – 2.49	Least Acceptable
1.0 – 1.49	Not Acceptable

Structure

The Figure 7 shows the structure of the project which includes its features, parts with their respective function and interrelationships, capabilities, and limitations.

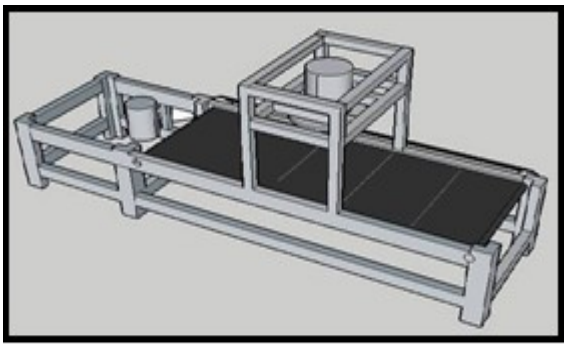


Figure 7. Structure of the Project

Features

a. Functional. The constructed conveyor based can crusher is functional during the testing and some revisions were made.
b. Practically safe. The conveyor based can crusher utilized dc supply voltage moving parts are well protected / guarded.
c. Flexible. The machine can be utilized in crushing various beverages can.

Try-out and Revision

The project had shown various features in the design of coveyor-based can crusher. In the try-out of the fabricated technology the researcher run into some defects during testing. One of the defects found was the arm crusher cannot accurately pressed beverage can and second was the conveyor runs fast. In order to addressed this problems revision were made. The alignment of the sensor and crusher mechanism was the first priority in order to solved the problem in accurate pressed then replacement of gears in the gear box was followed to solved the problem in motor speed.

SUMMARY

The study was concerned with the designed and development conveyor based can crusher. This study was conceptualized because of the widespread and emerging technologies nowadays. Crushing aluminum soda cans for easier storage in recycling bins. While most recyclers don't require you to crush cans, if you do recycle a lot, your normal bin may fill up quickly. The crusher gives you extra space by flattening either single or multiple cans.

The project study sought to innovate, design, construct, test, and revise a conveyor based can crusher and then later validated by electrical, electronic experts for its functionality.

The findings of the project study reveals that a conveyor based can crusher could be innovated, designed, and constructed to be used in the household, establishment, and schools for recycling purposes. In the development of the project, defects were found and were later revised. The conveyor based can crusher has been tested and evaluated by experts and was validated to be standard in terms of its functionality. This implies that a different conveyor based can crusher can be innovated, designed, and constructed using locally available components / materials.

CONCLUSIONS

Based on the findings, it was found out that a conveyor based can crusher can be innovated,

designed, and constructed technically through the use of locally available supplies and materials with the use of our existing technology; the device can be tested, evaluated, and revised and it can used in classrooms, houses, and various establishment for recycling purposes.

RECOMMENDATIONS

Based on the findings, the researchers concluded that the machine is highly functional and beneficial. It is hereby recommended that the newly constructed device be replaced with a wider range sensor to cover greater space, and parallel studies be undertaken to enhance the conveyor based can crusher.

ACKNOWLEDGEMENT

The researcher would like to extend their sincerest gratitude and deepest appreciation to the administration of the University of Southeastern Philippines, particularly the College of Technology for allowing the researchers to present their research entitled design and development of conveyor based can crusher.

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DESIGN OF A HIGH EFFICIENCY DC-DC BUCK-BOOST CONVERTER FOR SMALL SCALE WIND TURBINE SYSTEM

Engr. GILLERT M. BONGCAC, MoE
Jose Rizal Memorial State University
Main Campus, Dapitan City, Philippines
phyton_gil@yahoo.com

ABSTRACT

This study presents a high efficiency DC-DC buck-boost converter for a small scale wind turbine system. The design was modeled and simulated using LTspice software and verified using actual experiment. The performance of the output power and power losses of the buck-boost converter was evaluated using LTspice software and verified using actual experiment. The efficiency was calculated based on the measured results. Result show that the design DC-DC buck-boost converter yields a high efficiency and lower power loss at the input voltage below 5V.

Keywords: DC-DC Buck-Boost Converter, High efficiency Converter, Buck-Boost Converter

INTRODUCTION

Nowadays, the use of technology using renewable source energy played a vital role in the betterment and comfortable of humankind in the field of industry to be facile and hassle-free. Mobile devices such as cellphones, tablet, PSP, MP3 player, MP4 player are everywhere to be found but often, people find themselves lacking of battery supply for their gadgets. This usually happen when an electric power source is nowhere to be found, or there is no available electrical outlet where a low battery can be recharged. Consequently, converting wind energy to electrical energy enables the user to store energy in a battery. In this research, the wind is converted to electricity with DC-DC buck boost converter. Using DC-DC buck boost converter enable converters topology stable and free from over voltage and low voltage. The purpose of this study is to maintain the output voltage steady and free from adversely damaged using a design dc-dc buck boost converter.

An input protection system prevents inputs higher than rated values, which may adversely damage the Buck-Boost DC-DC converter. These inputs include over voltage transients, average voltage, and current output by the Precor EFX 561i elliptical generator (Chu S. 2014). In order to control the output voltage of the buck-boost converter, the controller is designed to change the duty cycle of the converter. The mathematical model of buck boost converter and fuzzy logic controller are derived to design simulation model (Jaber F. 2011). A voltage regulator is a power electronic circuit that maintains a constant output voltage irrespective of change in load current or line voltage. Many different types of voltage regulators with a variety of control schemes are used. With the increase in circuit complexity and improved technology a more severe requirement for accurate and fast regulation is desired. This has led to need for newer and more reliable design of dc-dc converters (Kasat S. 2004). One factor that we can utilize a huge quality of wind power is to improve the design of wind energy system performance. The battery will not charge as it is lower than the rated charging voltage. Wind power depends purely on the wind speed, as the wind speed is not constant the wind power is always varying. For charging a battery the voltage has to be constant. The battery will not charge even if there is a considerable amount of voltage available. The most important part of the converter design is to choose proper inductor value and capacitor value as the output purely depends on the value of inductor and capacitor used. For getting a proper DC voltage filtering is important hence inductor and capacitor plays an important role in getting a stiff DC (Shweta C. and Chayapathy V. 2014). The system has to work in continues current mode so as to charge the battery connected. For operating in continuous current mode the inductor value mist be chosen very high. If their values are low, then the high switching frequency is needed to obtain the same voltage level. This increases the cost of the switch involved. Furthermore, the boost converter acts with the fixed step HCC algorithm to track the maximum power operating point (Maro J. et.al 2015). A block boost converter is proposed for DC chopper and the output current reference of the chopper is decided for the maximum power point tracking of wind turbine. A PFM converter is an alternative DC-DC power converter that uses a variable frequency clock to drive power switches and transfer energy from input to output. Because the drive signals frequency is directly controlled to regulate the output voltage, this architecture is referred to as PFM. DC-DC converter with constant-on-time or constant-off-time control is typical example of this architecture (Yokel O. et.al 2013).

A suitable number of turbines are connected in parallel to a DC-DC converter to raise the voltage level. These groups are then connected in parallel to a DC-DC converter which makes up the transmission voltage. In these DC-based wind farms, there is a need of DC-DC converters, both converters for the single turbines and for converters with higher power designed to handle a group of turbines or a whole wind farm. A key component for the realization of a DC-based wind farm is the high-power DC-DC converter (Lena Max, 2007). The uneven power production from the individual wind turbines creates design as well as control difficulties for the wind farm with series-connected wind turbines. It is found that the proposed control scheme manages to safely operate the wind farm, even when large deviations in the individual power production of the turbines exist (Stefan Lundberg, 2006). The chosen electrical system for a wind farm uses a boost converter as a voltage adjuster and a full-bridge converter as a DC transformer. Simulations are made with different fault locations for a simplified system. Depending on the type of fault, different parts of the transmission system have to be shut down (Olof M. 2002).

In the previous studies of related literature conducted, the most difficult part in their research is how can they generate a constant voltage source of different quality of wind speed—high and low wind speed. In this matter to achieve a constant voltage in gaining a constant power output, we will consider a proper selection and correct placement and design of DC-DC boost converter to increase the performance of the circuitry. Some study didn't consider the aspects of selecting a parameter's component to increase the system performance such as schottky diode, capacitors and different kinds of switch. As they found out in the previous research that full-bridge converter is most advantageous among the three topologies—the series resonant converter, single active bridge converter and full bridge converter (Lena Max, 2007).

To address this gap, we will take a look on designing the DC-DC buck boost converter by selecting good parameters such as schottky diode, capacitor and kinds of switching. Achieving this goals, the enhance design of DC-DC buck boost converter will be realize for the different application for home gadgets and even some appliances in home. In this matter, the existing gaps of having a constant performance of DC-DC boost converter will finally be acquired.

Objectives

This research is aim to;

a. To design DC-DC buck-boost converter with high power efficiency from small wind turbine system.
b. Evaluate the performance of the DC-DC buck boost converter in terms of switching speed using LTspice software.
c. To verify the performance of power losses, switching speed and power output using LT spice.

Significance

This study played a significant contribution to human race as they can harness energy power without paying a small amount of bills in the electric corporation. When there is no electric outlet available to charge our smart-phones and power bank due to brownouts or loss of electricity wind energy is the key answer of the problem. This paper will help other researchers to investigate and evaluate their study in producing an improved model of small-scale wind energy system. In reality we paid large electric bills in electric company for our appliances at homes inasmuch as this study is a helpful tool and practices to shorten our electric consumption.

METHODOLOGY

Research Design

The prototype of this research is a DC-DC buck boost converter use to buck boost (step down) and boost (step up) the power output of design booster. DC-DC buck boost converter can help the study more efficient and effective in power output to be steady state. Component like capacitor, inductor and IC's can help to steady or maintain the desire power output of the system. We will design a circuitry of the system using an integrated circuit (IC's) LTC3331 and schottky diode as one major parameters that affects its performance of the whole system. Performances of IC's and schottky diode are further discuss in the previous Chapter 1 (Theoretical and Conceptual framework).

Research Method

In this thesis, we will implement an experimental method both simulation and actual testing performance to measure and analyze the data.

Collection of Data, Measurement, Process and Analysis

To investigate the initial results of the prototype to be collected and needed in the investigation, the required data are simulated using LTspice Software. To analyze the variable data—dependent and independent variables, independent variables are controlled while simulated to have a better analysis of the experiment. In verifying the results, actual experimentation should be done in testing the design and evaluate/compare the simulated result to actual testing and get the percentage error.

To analyze the result very well, simulated results using LTspice Software should be recorded in a table and graphs as well. The graphs played a vital importance in analyzing the data, through data graphs we can analyze the characteristics of each results by comparing one another. The graphs should also be plotted to determine the data's characteristics.

In analyzing the data, simple regression can be used to evaluate and explain its characteristics. This method deals with analyzing two or more variables to be analyze linearly. In this matter, as we know that we have more than two dependent variables and one controlled independent variables to be analyze.

Procedure in conducting the Experiments (Simulation and Actual)

Simulation and actual procedures are important aspects in this research to evaluate the system and can derive a better analysis.

For Simulation Process

The following are steps in Simulation Process:

1. Go to LTspice Software, Click Component and construct the circuit shown below.
2. Click products of the components to find the Integrated circuit (LTC3531) in LTspice software
3. Put a value of each component like resistor, diode and inductor.
4. Set the value of input voltage as 2.5V, 3.0V, 4.5V, 5.0 and 7.5V.
5. Set the Value of input voltage as 9V, 12V, 15V, 20V and 30V.
6. Run the program as simulated.
7. View the voltage and current graphs and observe its characteristics.
8. Click PrtSc in your pc for documentary purposes.
9. Record the measured data in the table.
10. Compare the simulated value for understanding its characteristics.

For Actual Measurements

1. Prepare the needed equipment and facilities in the experiment.
2. Set up the ammeter, voltmeter and multi-tester or Oscilloscope for the experiment.
3. Measure the output current, output voltage and power output.
4. Calculate the expected current, voltage and power output manually.
5. Record the gather data.

MODELLING AND SIMULATION

In this section, the circuit design of DC-DC buck boost converter is validated. The mathematical equations that helps the simulation to validated are important parameters to evaluate the system. LT Spice Simulator Software are used to simulates the parameters in DC-DC buck boost converter.

The results are recorded for the analysis of the study in the provided table below.

Research and Design Flow Chart

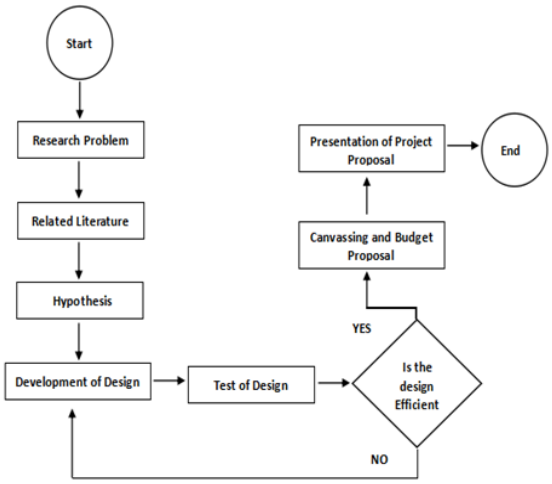

Figure 1: Research Flow Chart

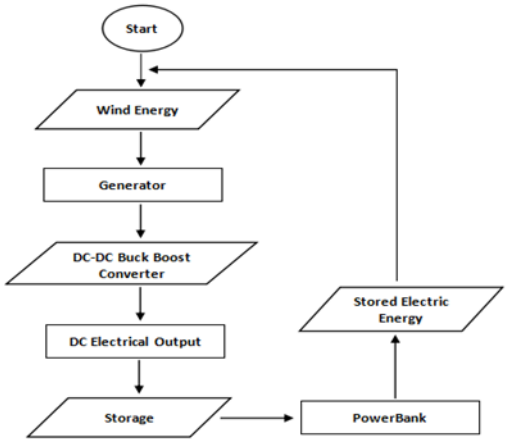

Figure 2: Design Flow Chart

Working Equations

Ohm's Law

$$P=IV$$

$$V=IR$$

$$I=\frac{V}{R}$$

Where P=power, I=current, and V=volts.

Inductor Selection

Data sheets often give a range of recommended inductor values. If this is the case, choose an inductor from this range. The higher the inductor value, the higher is the possible maximum output current because of the reduced ripple current. Normally, the lower the inductor value, the smaller is the solution size. Note that the inductor must always have a higher current rating than the largest value of current this is because the peak current increases with decreasing inductance. For device datasheets, where no inductor range is given, an inductor that satisfies both buck and boost mode conditions must be chosen.

Input Capacitor Selection

The minimum value for the input capacitor is normally given in the datasheet. This minimum value is necessary to stabilize the input voltage due to the peak current requirement of a switching power supply. The best practice is to use low-equivalent series resistance (ESR) ceramic capacitors. The dielectric material must be X5R or better. Otherwise, the capacitor loses much of its capacitance due to dc bias or temperature.

RESULTS AND DISCUSSIONS

Simulation of DC-DC Buck Boost Converter

Figure 3 is the circuit to be simulated using LT Spice software. Voltage output and current output were measured and graph as shown in figure 4.

The Efficiency is then calculated in table 1 using, Eff= (Pout/Pin)*100. The power input is calculated using input voltage and current while the output power is from output voltage and output current.

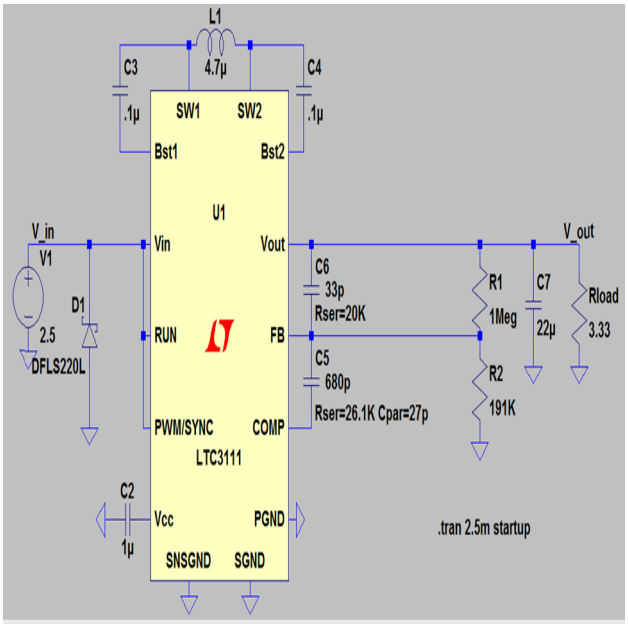

Figure 3: Schematic Circuit Diagram of Proposed Design

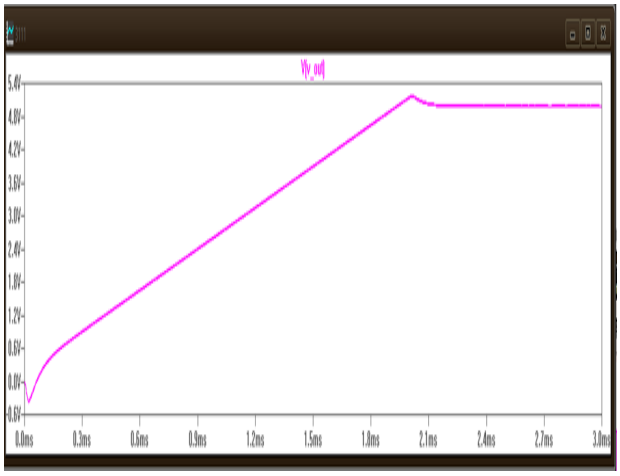

Figure 4: The output voltage the design at 7.5V input voltage

Table 1 Results on the DC-DC Buck-boost converter with varying different input voltage

Voltage Input (Volts)	Power Input (Watts)	Voltage Output (Volts)	Current Output (A)	Power Output (Watts)	Efficiency (%)
2.5	5.0	3.903	1.172	4.57	91.4
2.75	5.5	4.184	1.256	5.25	95.58
3.0	6.0	3.026	2.0	6.052	99.58
4.5	9.0	4.618	2.0	9.236	97.43
5.0	10.0	4.902	2.0	9.804	98.41
7.5	15.0	5.046	1.818	9.174	61.16
9.0	18.0	4.99	2.0	9.98	55.54
12.0	24.0	4.98	2.0	9.96	41.50
15.0	30.0	4.98	1.49	7.420	24.73
30.0	60.0	4.98	1.499	7.420	12.37

Figure 4 shows the voltage output stability of 4.98V at 2.1millisecond after power on. It shows that the switching speed of 2.1ms for the design is very fast.

In table 1, the design exhibits high efficiency at input voltage lower than 5V. When the input voltage is above 5V, its output power deteriorates which lower the efficiency and increases the power losses of the design. This trends means that the design should operate in low voltage specification to have highest power efficiency and lower power lost.

CONCLUSION

Based on the findings, the DC-DC Buck-Boost converter design exhibits a high efficiency on the lower input voltage and therefore can manage a small scale wind turbine system with a very minimal power loss.

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DESIGN OF A HIGH SPEED MOSFET STATIC TRANSFER SWITCH FOR A LOW VOLTAGE APPLICATION

Engr. Gillert M. Bongcac, MoE
Jose Rizal Memorial State University
Dipolog Campus, Dipolog City, Philippines
phyton_gil@yahoo.com

ABSTRACT

This study presents a MOSFET design of static transfer switch (STS) which was simulated using MultiSim. The simulated design result has at switching time of 0.01ms.. When the voltage of the TEG primary source reaches its maximum setting, the battery secondary source switches automatically. The overall performance and the simulated output shows and confirms the functionality of the design presented in this study. The design presented in this study is effective in transfering load to another source fast enough.

Keywords: Static transfer switch using MOSFET, Electronic Static transfer switch, Automatic transfer switch

workingINTRODUCTION

A Static Transfer Switch (STS) is a system that is able to automatically shift the load to another power source when the primary power supply may fail or may have lost its power. This process takes about 4 milliseconds, quick enough that it would seem like the power is not interrupted. In result the load will not have to shut down and restart when the power source will transfer. Then when the primary source is charged and its power is enough to again supply for our load, the Static Transfer Switch (STS) will again go to work, switching from the back-up sources back to the primary source with the same quickness.

However, in using this system, there are some problems that commonly arise like. a) The transferring of the source is not quick or fast enough. In result the load may lost its power and would need to be restarted (Mokhtari, 2005). b) It is very uncommon to find an STS system that uses a Metal-Oxide-Semiconductors Field Effect Transistor (MOSFET) as the main component. c) Most STS systems found on the market are designed for voltages 110 and up. MOSFETs are more suitable for high switching speeds and low power application, usually up to 1000V and 100A. (Aguinaga, 2008).

To cope-up with these problems, this study designs an STS system, using MOSFETs as the primary component for a very fast transfer switching of sources with low voltage source.

Objectives

The study aims to:

1. Design a low voltage Static Transfer Switch (STS) using MOSFET.
2. Design a high speed STS for a fast transfer voltage source..
3. Verify the design operation using simulation software (Multisim.).

RESEARCH DESIGN AND METHODOLOGY

Research Design

The STS will be designed using MOSFET technology. Experimental research using simulation software which is the Multisim and the experiment will be utilized to design, simulate and test how the system functionality of the MOSFET Static Transfer Switch (STS) design.

Experimental Design Process

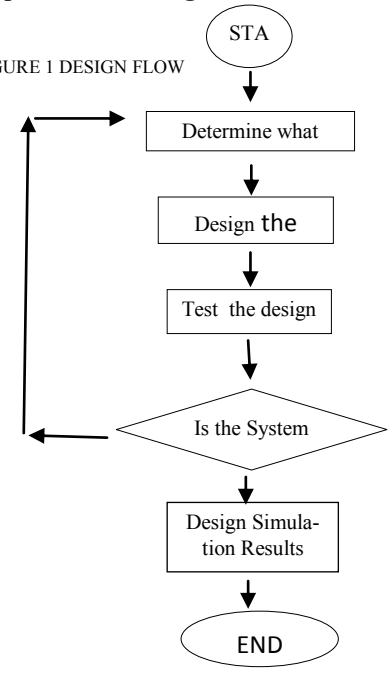


FIGURE 1 DESIGN FLOW

Research Method

For this STS design, we will be using MOSFET technology. MOSFETs are ideal for switching because, they respond fast and efficient.

To test our designed circuit, we will be using a circuit simulator, Multisim. The simulator will show to us what we need to know and whether and how will our circuit would work.

The data that we need to collect are how fast would the Switching is from;

V1 – V2
V2 – V3
V3 – V1

In order to collect the data that we need, we would use the Circuit simulator, Multisim.

RESULTS AND DISCUSSIONS

Circuit of MOSFET Static Transfer Switch (*STS*)

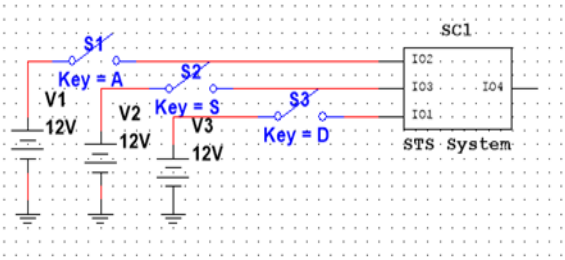
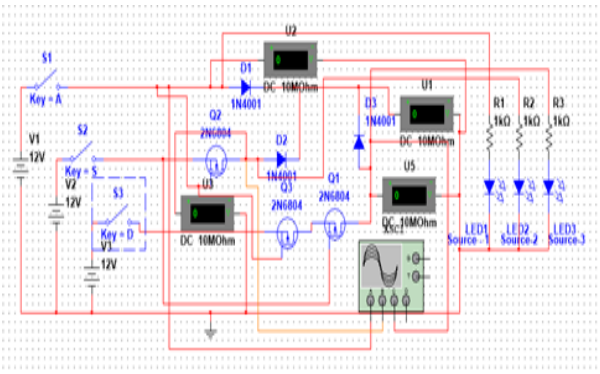


Figure 2. Proposed Circuit of MOSFET STS

Power Sources:
V1 – Thermoelectric Generator (TEG)
V2 – Battery (BATT)
V3 – Power Supply (PS)



Simulation Testing
Figure 3. MOSFET STS Circuit for Simulation Testing

Simulation Testing 1. Simulate with only TEG not working:

In this simulation all power sources are working except the primary source, TEG. When the TEG is not working the system will automatically shift to the secondary source, the Battery. The diagram below show how fast the switching happens.

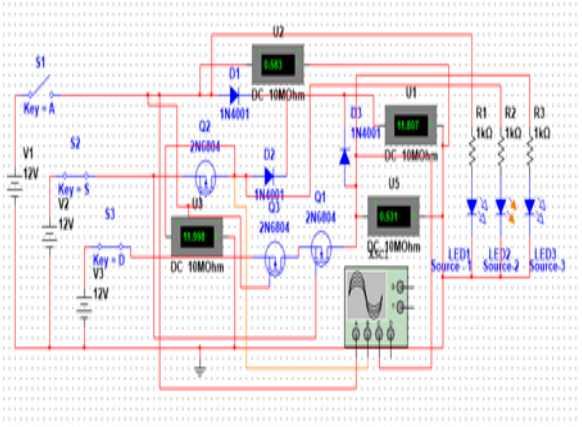


Figure 4. Simulate with only TEG not working

The figure 4 shows the battery or secondary source and power supply or the third source is switched to supply the system.

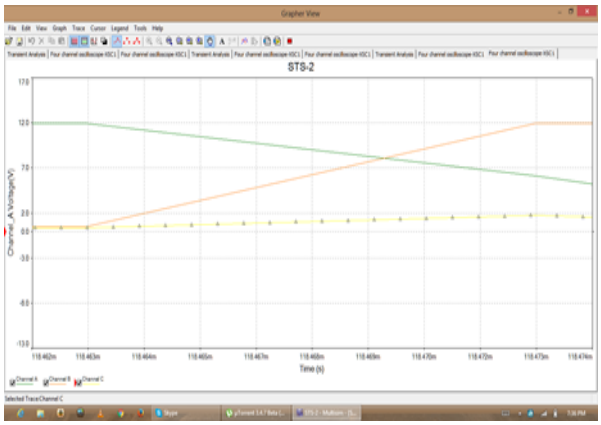


Figure 5. Transient Analysis

The figure 5 shows, the graph of switching from TEG to Battery. When the TEG source reaches to 8.4V it will switch automatically to the back- up source which is the battery with the switching time of 0.01ms.

Simulation Testing 2. Simulate with TEG and Battery not working:

The figure 6 shows, that the Power Supply or the third source is switched to supply the system.

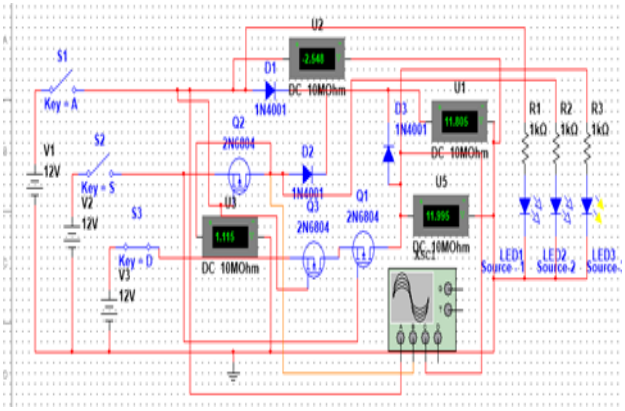
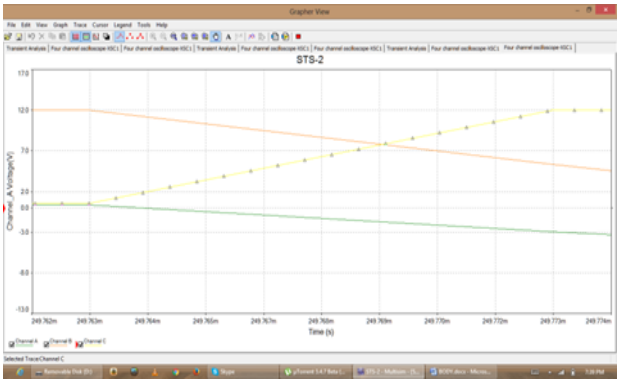


Figure 6. Simulate with TEG and Battery not working



The figure 7 shows, the graph with time switching from Battery to Power Supply. When the Battery reaches to 8.4V, it will switch automatically to the back-up source which is the Power Supply, with the switching time of 0.01ms.

Simulation Testing 3. Simulate with TEG source working again:

In this simulation, the power supply was the one supplying the load, but then the TEG is working again. It shows how fast the switching from the power supply back to TEG.

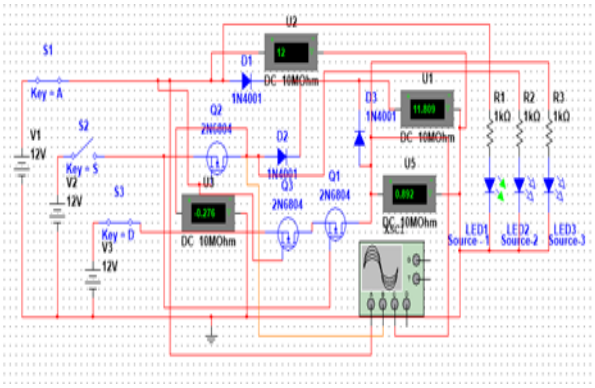


Figure 8. Simulate with TEG source working again

The figure 8 shows, that the TEG or the Primary source is switched to supply the system.

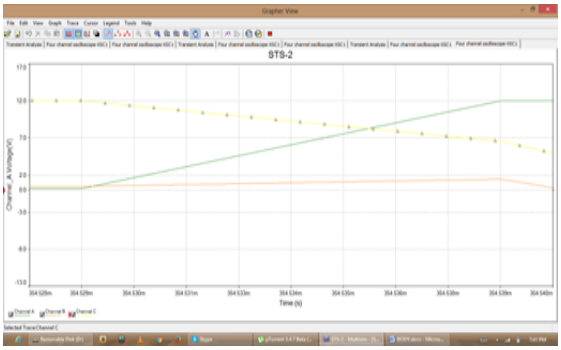


Figure 9.Transient Analysis

The figure 9 shows, the graph with time switching from Power Supply to TEG. When the Power Supply again reaches to 8.4V, it will switch automatically to the TEG, with the switching time of 0.01ms.

Summary of simulation

The table 1 shows all the result of each simulations done by the Static Transfer Switch System.

Table 1. Overall results of simulation

Simulation	SOURCE			SWITCHHING		
	TEG	BATTERY	POWER SUPPLY	FROM	TO	TIME
1.TEG not working, Battery and Power supply working	0.32V	12V	12V	TEG	Battery	0.01 ms
2. TEG and Battery not working, Power supply working	0.32V	0.32V	12V	Battery	Power Supply	0.01 ms
3. TEG source working again, Battery and Power Supply not working	12V	0.32	12V	Power Supply	TEG	0.01 ms

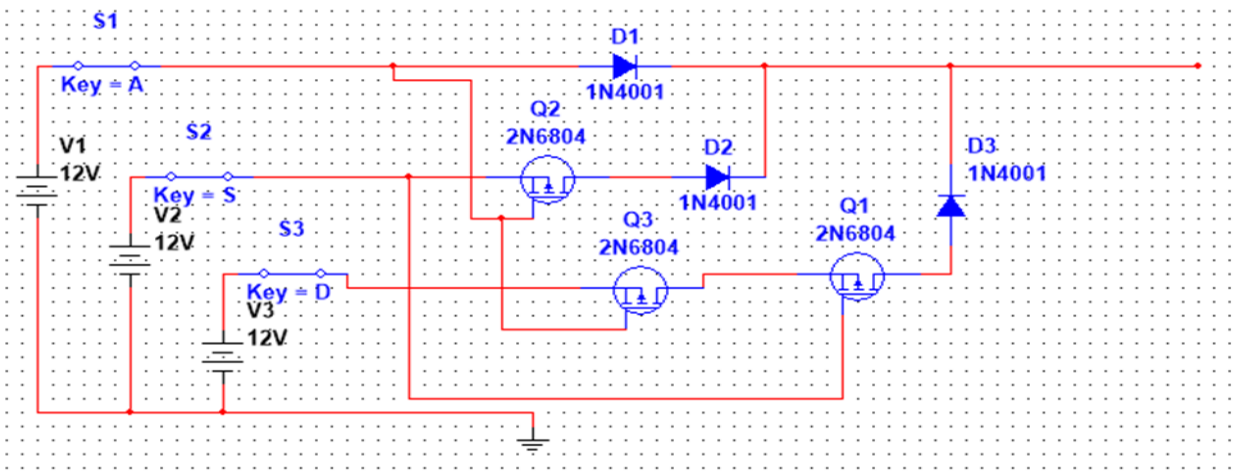


Figure 10. Final Circuit of MOSFET STS

Discussion and interpretation of results

The Results has 3 simulation testing. Each of the simulations has a corresponding trancient analysis. Each analysis shows how fast the switching happens, from one source to another. It can also observed in the graphs, the source that supplies the load fails and its voltage drops from 12V on the same time. It can also observed that the other source that will assume in supplying the load rises from 0V to 12V. Each switching process takes about 0.01ms to happen. On that same process, the MOSFETs functions as it was designed, to switch from the source to another. In simulation 1, the power source switches from the TEG to the Battery. In its tnancient analysis, it shows the voltage of the TEG drops at the time of 118.463ms and the Battery reaches 12v at the time 118.473ms. By at this time, the battery is now the one that is supplying power to our load and the switching time is about 0.01ms. In simulation 2, the power source switches from the Battery to the Power Supply. In its tnancient analysis, it shows the voltage of the Battery drops at the time of 249.763ms and the Power Supply reaches 12v at the time 249.773ms. By at this time, the Power Supply is now the one that is supplying power to our load and the switching time is about 0.01ms. In simulation 3, the power source switches from the Power Supply to the Battery. In its tnancient analysis, it shows the voltage of the Power Supply drops at the time of 354.529ms and the TEG reaches 12v at the time 354.539ms. By at this time, the TEG is now the one that is supplying power to our load and the switching time is about 0.01ms.

The switching time of the design is 0.01ms, which makes the it a high speed STS and all of the components work as it expected. The output of the design is desame as the input, since this design is only a switching. When the voltage of the Primary source, which is the TEG, reaches to 8.4V the Secondary source, which is the Battery, will switched automatically.

Based on the result of simulations, it was found out that the designed is working as a high speed transfer switch based on table 1 with the switching time of 0.01ms .

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

From the overall performance of the design, the following conclusions are derived:

1. The simulated output shows and confirms the functionality of the design presented in this study.
2. This study concludes that the design presented in this study is effective in transfering load to another source fast enough.

Recommendations

It is recommended for the future studies the following:

1. To find a component in place of the MOSFETs that switches faster and performs better.
2. To design a more efficient and reliable STS system.
3. To test in other simulation software and compare the results

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