Vol. 12 · March 2013
Print ISSN 2012-3981 • Online ISSN 2244-0445
doi: http://dx.doi.org/10.7719/jpair.v12i1.211

JPAIR Multidisciplinary Research is produced
by PAIR, an ISO 9001:2008 QMS certified
by AJA Registrars, Inc.

Design and Development of Fish Natural Convection Drying Facility

MANUEL A. BAJET, JR.
ORCHID No. 0000-0002-7545-9719
manuelbajet@gmail.com
University of Northern Philippines
Vigan City, Ilocos Sur,Philippines

ABSTRACT

Fish drying facility was designed, developed and tested to determine its performance, and characterization as a natural convection dryer for stunted tilapia. Parameters in the study were air temperature, relative humidity, drying chamber, moisture content, drying time, capacity and rate. Experimental research design was used and materials includes, lumber painted in black and used as frames, plastic screen mesh, cellophane, black plain sheet and stones.. Findings disclosed that drying rate were noted at the highest during first two hours internal with an average drying rate of 7.20 grams per minute. Average drying rate after the three trials was 2.63 grams per minute. The moisture content of the samples was reduced from 92.68%-75.23% during the 20 hours of drying and weights of fish samples were also reduced from 20 to 15 kilograms. Further, results on relative humidity was higher at the upper trays compared that the lower trays. Return of investment was 72% and has a payback period of 0.05 year.

Keywords - Renewable Energy, Project and Experimental Research, Natural Convection Dryer, Vigan City, Ilocos Sur, Philippines

INTRODUCTION

Tilapia is the second most important fish cultured in the Philippines next to milkfish. In 2002 of the total fisheries production (3,368,519 MT), tilapia contributed 122,417 MT or 3.6%. Increased tilapia production is eminent over the last five years. The continuous study on the development of tilapia species and the use of a number of different culture technologies contributed to this steady increase in tilapia production (BFAR, 2013).

Globally**,** tilapia has become the third most important fish in aquaculture in a worldwide production which exceeded millions of metric that increase annually. These are among the easiest and most profitable fishes to farm due to their omnivorous diet, having their high protein content, palatability, and mode of reproduction, tolerance of high stocking density, and rapid growth. In some regions like Region I, II, and other places in the country, the fish can be raised in the rice fields at planting time and grow to edible size from 5-6 inches of stunted (bansot) tilapia to harvest when rice is ready to harvest. In a normal tilapia culture, most of the farmers manage in a common sight in fishponds and fish fence almost all the major rivers and lakes in the country.

The Cagayan Bureau of Fisheries and Aquatic Resources (BFAR) as of 2008 reported that tilapia production grew and Cagayan Valley (Region II) is the Philippine tilapia capital. Production supply grew 37.35 % since 2003, with 14, 000 metric tons in 2007, and still growing up this day. Growth of tilapia production was due to Government interventions such as accreditation of private hatcheries to ensure supply of quality fingerlings, establishment of demonstration farms, providing free fingerlings to newly constructed fishponds, and the dissemination of tilapia to other provinces in Northern Luzon including Ilocos Sur (Balita, 2009).

Tilapia is commercially cultured in the Philippines. There are Filipino farmers particularly in Region I, II, and other places in the country who raised tilapia in the rice fields at planting time and grow to edible size from 5-6 inches of stunted (bansot) tilapia to harvest when rice is ready to harvest. This practiced by some farmers is to augments income or locally known as diversified farming and at the same time farmers practiced organic way of farming as commonly observed. However, because what they produced are stunted tilapia, farmers cannot sell at better prices in the market.

Based from the popularity of "danggit" or known as dried rabbit fish from Cebu, a technology for stunted tilapia had been locally developed making the product known as "tilanggit" which means produced from juvenile or small sized tilapia. Presently, processing of "tilanggit" has been done at the southern part of the Philippines. Further, Jamandre (2012) had identified market niches of Philippine tilapia were in the form of fillet, dried and whole fish and potential buyers identified were supermarkets, food chains and local household consumers.

Local practices on fish drying as observed was by using net, mats, cloth and directly exposing the fish under the heat of the sun without considering good sanitation practices. This practice makes traditional drying in an open air vulnerable to exposure of the food stuff to rain and dust; exposure to direct sunlight which is undesirable for some food stuffs, infestations by insects, and sometimes attacked by animals.

Solar drying can be considered as an elaboration of sun drying and is an efficient system of utilizing solar energy (Bala, et al, 2012). The tropics and subtropics have abundant solar radiation. Natural convection solar dryers do not require power from the electrical grid or fossil fuels. Hence, the option for drying would be natural convection solar dryers. Many studies in natural convection solar drying of agricultural products have been reported by Excell 1980, Oosthuizen 1995, Bala et al., 2001, and Woods 1995, Sharma et al., 1995 as cited by Bala et al, 2001, several designs are available, and these include 1) cabinet type solar dryer suitable for drying fruits and vegetable 2) indirect natural convection solar dryer for paddy drying and 3) mixed mode AIT drier for drying paddy. These dryers have been widely tested in the tropical and subtropical countries. Also, solar thermal technology is rapidly gaining acceptance as an energy saving measure in agricultural application. It is preferred to other alternative sources of energy such as wind and shale, because of abundant, inexhaustible, and non-polluting properties.

Thus, given the market opportunity for tilapia, Natural Convection Solar Dryer has been designed and tested for its efficiency and quality of produce. On the other hand, the researcher conceived it as an infrastructure support to local tilapia producers and farmers doing diversified farming by raising tilapia while growing rice that leads to increasing their productivity. In many parts of the world, there is a growing awareness that renewable energy has an important role to play in extending technology to the farmer in developing countries to increase their productivity (Waewsak, 2006).

OBJECTIVES OF THE STUDY

This study focuses on design and development of natural convection solar dryer. Specifically, the objectives of this study were: designing and development of natural convection solar drying solar drying system with a cabinet type; determining thermal performance of solar collector; and, determining the efficiency of solar drying system for drying of stunted (bansot) tilapia.

METHODOLOGY

This study used the project method and experimental research design. It focused on the design, performance, and characterization of the natural convection dryer for stunted tilapia. Parameters included in this study were air temperature, relative humidity of the drying chamber, moisture content, drying time, drying capacity and its drying rate.

The natural convection dryer was made out of wood or lumber with cross sectional dimensions of 2" x 3", 2" x 2", 1"x 2",1"x 1" and 1/2" x 1" used for frames. Plastic screen mesh having a one fourth perforation was used for trays and air inlet covering for protection. Plastic cellophane was used for the covering of the dryer. Black painted plain sheet and black painted stones were used as blackbody or the heat collector of the dryer that absorbs the heat from the sun. Tilapia was used as experimental sample while testing the drying efficiency on the natural convection dryer.

RESULT AND DISCUSSION

I. Design and Development of Fish Natural Convection Drying Facility

The prototype fish mechanical dryer has an area of 16 square feet. It has a total height of 7.8 feet. The dryer was 2 x 3 inches of wood for its mainframe, and combination of 2 x 2 and 1 x 2 inches wood for its braces, frame of the solar collector that holds the black painted stones, and other major support, and ½ x1 inches wood for the tray supports.

Figure 1. Fish Natural Convection Facility

Wood was used because it has a very small conductivity unlike some metals like stainless steel, iron and aluminum; therefore wood cannot conduct more heat from the solar collector, which helps prevent heat losses. The thermal conductivity of common structural woods is much less than the conductivity of metals with which wood often is mated in construction. It is about two to four times that of common insulating material. (Waewsak, 2006). Thus, using material in the drying facility is an energy saving too.

The drying chamber has three trays which has 1.6”x2.8” feet, and is placed 7 inches apart with respect to vertical location. The two solar heat collectors have dimensions of 9”x2’10” which use black painted stones as a sun`s heat absorber that heat is faster drying operation. Black painted plain metal sheet is also installed at 28 degree at the lowest portion. To collect the excess water from the fish and drain it out from the drying chamber. Painted plain metal sheet act also as solar heat absorber and that helped in drying the product faster. The upper part of the dryer a semi-circle cross section served as air outlet.

The design of solar dryer was partially pattered from Ukegbu (2013). It was fabricated with a plastic material that conserves energy. The inside of the solar dryer was painted black in other to absorb heat from the sun to dry the samples. Below of the dryer, stones painted black was place in order to trap solar energy for transmission into the dryer to dry the samples. Fish samples were placed on individual net trays that are fixed into the solar dryer. The maximum and minimum temperature readings during the day were taken and the average of both temperatures taken as the temperature of the day. Further, Chaichan (2010) further the study disclosed that black pebbles basement had better thermal storage quality which can reach up to 59^{o}C, while black painted basement increased the absorption of solar radiation thereby increasing system efficiency.

II. Solar Drying Operation of the Fish Natural Convection Drying Facility

The Sample Fish

To make a dried “tilangit”, first, fish were washed and cleaned. Scales, fins and tails were cut, and the gills and intestines are removed. The fish were sliced at the belly portion to removes the entrails and washed again. The fish samples were then soaked in a brine solution made up of vinegar, salt, garlic, black pepper. Soaking was done to marinate the fish overnight to add taste to the fish. Prior to preliminary mix drying or sun drying, draining was done to remove excess water during the soaking or marinating process.

Drying

Tilapia samples were drained for at least three hours after soaking in a brine solution. The drying facility was also exposed under the heat of the sun prior to the loading of tilapia samples for drying. Drying of tilapia fish samples started at eight o'clock in the morning. Trays were loaded with samples all together inside the drying chamber of the fish dryer, the temperature, relative humidity, moisture content, and the drying rate were monitored. Drying time is extended until the collector can no longer produce heat. Drying stops when the solar heat absorber can no longer produce heat energy to dry the samples (fish) or there is no temperature difference between the ambient temperature and the solar heat absorber or at the drying chamber. Samples were collected after 6 pm and placed in a plastic container and sealed to prevent from absorbing outside moisture. Drying was continued the following day using the same facility. Drying of the fish sample lasted at an average of 20 to 22 hours depending the heat of the sun.

Ambient Temperature at Different Drying Duration

The ambient temperature inside the drying chamber was monitored in the three trials. The process was done by recording the temperature every two hours interval. The observation lasted for two days and specifically from 8 o'clock in the morning until 6 o'clock in the afternoon. The table 1 shows the results.

Table 1. Ambient temperature at different drying duration of the Fish Samples

Drying Duration	Ambient Temperature				
	T1	T2	T3	TOTAL	MEAN AVERAGE
0 Hour	26	30.1	35.40	91.50	30.5
2nd Hour	35	34.8	34.20	104	34.66
4th Hour	36	40	35.40	111.40	37.13
6th Hour	40	40	37	117.50	39.16
8th Hour	33.50	34.50	32	100	33.33
10th Hour	28.50	28	30	86.50	28.83
12th Hour	35	34	33	102	34
14th Hour	35.30	36	33.40	105.20	35.06

16th Hour	34.20	36.50	35	105.20	35.06
18th Hour	29.50	34.50	32.40	36.40	32.13
20th Hour	28.20	23	23.50	86.7	28.9

Results in Table 1 specifically the ambient temperature in the drying chamber. Data indicated that it obtained the highest average temperature of 39.16^0C after 6 hours of drying the fish sample at 2 o'clock in the afternoon. The lowest average temperature, after the 10th hour of drying operation is 28.83^0C at 6 o'clock in the afternoon. On the second day it was observed that on the 14th to 16th hour of drying the sample (at 12 noon to 2 o'clock) obtained the highest average temperature of 35.06^0C respectively. While at the 20th hour of drying operation, obtained it 28.90^0C and the sample was already dried.

Air Temperature Inside the drying Chamber

The air temperature inside the drying chamber was done also on three trials. Measured every two hours interval as what is done in taking up the ambient temperature of the mechanical dryer.

Table 2. Air temperature inside the drying chamber
In different drying duration

Drying Duration	Temperature °C			Total	Average Mean
	T1	T2	T3		
O hour	32.00	31.50	33.00	96.50	32.16
2ND hour	38.10	39.50	38.50	116.10	38.70
4th hour	46.00	45,80	45.20	137.00	45.66
6th hour	46.50	45.50	45.00	137.00	45.66
8th hour	37.50	36.00	34.00	107.5	35.83
10th hour	30.60	32.00	33.20	95.80	31.93
12th hour	34.50	34.50	33.00	102.00	34.00
14th hour	36.50	45.00	48.20	129.70	43.23
16th hour	35.80	48.60	47.80	132.20	44.06
18th hour	32.50	34.40	35.50	102.40	34.13
20th hour	31.00	32.00	34.50	97.50	32.50

The results of the air temperature inside the drying chamber of the fish mechanical dryer indicated that obtained highest average temperature at 45.66°C. After 4 to 6 hours of drying, the fish sample at 12 o'clock to 2 o'clock in the afternoon. The lowest average temperature after the 10^{th} hours of drying operation is 31.93 °C at 6 o'clock in the afternoon. At the second day drying, at the 16^{th} hour of drying, the sample obtained the highest average temperature of sample obtained at 46.06°C. At the end of drying operation, the sample fish register at 32.50°C.

Relative Humidity

In monitoring the relative humidity in the drying chamber, digital hygrometer was used. It was placed at the outer of the tray and with respect to its vertical position, it was placed between the trays. Data were recorded at drying time interval of two hours.

Table 3. Average relative humidity in the Drying Chamber

Drying Duration		Relative Humidity (%)		TOTAL	MEAN
	T1	T2	T3		
0 Hour	56.00	60.50	54.50	171.00	57.00
2 Hour	52.00	51.00	53.00	156.00	52.00
4 Hour	46.50	45.00	47.00	138.00	46.16
6 Hour	40.00	38.00	41.00	119.00	39.66
8 Hour	43.00	44.00	46.50	133.00	44.50
10 Hour	63.00	61.50	60.50	185.00	61.66
12 Hour	58.00	61.00	60.50	179.00	59.83
14 Hour	56.00	53.50	58.50	168.00	56.16
16 Hour	55.00	49.50	55.50	160.00	53.33
18 Hour	64.00	55.50	58.50	178.00	59.33
20 Hour	65.50	52.50	60.50	178.00	59.33

Table 3 disclosed results on humidity during the three trials conducted. Data on average relative humidity was taken the result of the total mean. It can be noted that 61.66 percent (%) was the highest relative humidity during the drying of the samples at the 10th hour at 6 o'clock in the afternoon. The lowest average relative humidity is at 6th hour at 5 o'clock in the afternoon operation which was recorded 39.66 percent (%). It was observed during the drying period that trays placed at the top level have the highest relative humidity. This is because, air tends to move upward from the lowest tray to the highest tray all vapor will go upward.

Drying Rate

The fish samples on the trays were removed inside the drying chamber of the Fish Drier in an interval of 2 hours, and the samples were weighted in the use of the grams.

Table 4. Drying Rate of Tilapia dried on the Fish Natural Convection Dryer dries at an hour an interval of 2 hours

Drying Duration	Drying Rate In Grams Per Minute T1	T2	T3	Total	Mean
2	7.5	8	7.5	23	7.66
4	4.3	4.40	4.7	13.40	4.46
6	4.4	4.42	4.5	13.10	4.36
8	2.5	2.70	2.40	7.60	2.53
10	1.8	1.70	1.50	5	1.66
12	2.3	4.50	2.70	7.50	2.5
14	1.8	1.70	1.90	5.40	1.8
16	1.2	1.40	1.30	3.90	1.3
18	.8	.70	.90	2.40	.80
20	.30	.25	.45	1	.33

In Table 4 the three trails, were observed to have the drying rate in grams per minute as relatively very fast at the first hour from 7.66 gram to 4.46 gram. It was observed that it slowed down as the time drying becomes longer or longer exposure to the sun.

Further, data disclosed that the drying rate was very fast during first four hours from 8.00 gpm to 4.46 gram. It rapidly slowed as the time drying increased. There was an increase from 1.66 to 2.55 grams of the drying rate at the first hour of re-drying during the second day. This may be attributed in the storing of the fish samples overnight. The mechanisms of most food stores were in two phases. During in the first phase, the surface layers of the food item dries up and form a hard skin. In this phase, the drying rate or rate of moisture removal was high. On the second phase, the drying becomes slow, the moisture trapped inside has to diffuse outward and there evaporate. The drying rate was reduced. Also, the rate of drying depends on the weather condition on the day of drying time.

Moisture Content

Moisture content was taken by having the tilapia sample weighed and pre-drying for almost 3 to 4 hour before and on the sunrise. The total initial weight of the samples was 20 kilograms. After several hours, to its bone dry weight went down to 14.20 kilograms. Results of the initial moisture content of the tilapia samples were 92.69 percent (%) wet basis.

Table 5. Moisture content loses of the tilapia, dried the dryer at different duration

Drying Duration	Moisture Content Loss%			Total	Mean
	Trial 1	Trial 2	Trial 3		
2 hours	2.05	2.20	1.42	5.67	1.89
4 hours	1.80	1.85	1.32	4.97	1.66
6 hours	2.11	2.00	2.04	6.15	2.05
8hours	2.14	1.10	1.30	4.54	1.51
10hours	0.75	1.10	1.65	3.50	1.17
12hours	2.75	1.65	1.80	6.20	2.07
14hours	2.05	3.00	2.05	7.10	2.37
16hours	1.75	2.00	2.25	6.00	2.00
18hours	1.50	2.25	1.10	4.85	1.61
20hours	0.95	0.60	0.50	2.05	0.68

In drying evaluation, the weight of the samples is 20 kilograms. It was monitored every 2 hours interval and observed of a maximum of 2.37 percent moisture content loss and the corresponding weight. To prevent the samples from absorbing outside moisture, dried tilapia samples were placed in a plastic container and sealed tightly.

Based on the data gathered per loading of tilapia samples into the fish dryer, the moisture content of dried tilapia was almost 75 percent (%) having an initial weight of 20 kilograms, it had a final weight ranged from 14.20 to 15 kilograms. Despite of the moisture content, the tilapia samples after 18-20 hours of drying attained the desired physical characteristics of a dried fish.

III. Financial Evaluation

In this study, the following assumptions were taken into account: a.) annual interest of investment was 10 percent; b.) annual repair and maintenance cost are 25 percent of the designed fish dryer cost; c.) its economic life is assumed for three years, and d.) annual depreciation cost is 1/3 of the cost of the fish dryer.

On the other hand, for drying operations, it is assumed that 60 percent of the whole year the dry season and 40percent wet season in Northern Luzon, Philippines. For this period, there will only be 108 batches of tilapia drying.

Payback Period. The payback period of the fish dryer was determined through the equation,

$$\text{Payback Period} = \frac{\text{Total Cost of Investment Required for the Project}}{\text{Net Annual Cash Inflows}}$$

Return on Investment (ROI). The return on investment of the design Tilapia Solar Dryer was determined through the equation,

ROI = Total Net Income / Total Investment (refers to total annual cost)

Assumptions of Total Annual Cost of Material Input of the dryer. The total annual cost of expenses investment in the sample Tilapia and brine solution.

2160 kilograms of fresh tilapia @ 120 pesos	= Php 259,200.00
Brine Solution	= 1,800.00
Total Cost of Material Input	= 261,000.00

Fabrication Cost of Fish Natural Convection Dryer = Php 10, 947.15

Note: Fabrication cost was prorated based on the economic or useful life of the facility which is equivalent to the annual depreciation cost.

Annual Sales of Dried Tilapia samples**.** Dried tilapia
(15kilos x 108 batches = 1,620 kilos)
1620 kilos @ Php 300.00/per kilo = Php 486,000.00

Table 6. Annual financial operation of the developed fish natural convection dryer

	Particular	Cost (Php)
a.)	Sales (Benefits) (1620 kilos @ P300.00 per kilo)	486,000.00
b.)	Production Cost:	
	Cost of Fresh Tilapia	259,200.00
	Cost of Brine Solution	1, 800.00
	Labor (P150.00/batch)	16,200.00
	Other Production Cost:	
	Depreciation Expense	3,649.05
	Repair and Maintenance	2,189.43
	Interest on Investment Project Cost	109.47
	Total Annual Production Cost	283,147.95
	Annual Net Income	202,852.05

Financial Analysis:

1. Return Of Investment ROI

= Total Net Income / Total Investment (refers to total annual cost)

$$= \frac{\text{P } 202{,}852.05}{\text{P } 283{,}147.95}$$

ROI = 72% or P 0.72

The computation implies that an investor can earn P0.72 for every peso invested in the production of dried tilapia using fish natural convection dryer.

2. **Payback Period**

$$\text{Payback Period} = \frac{\text{Total Cost of Investment Required for the Dryer Project}}{\text{Net Annual Cash Inflows}}$$

$$= \frac{\text{P } 10{,}947.15}{\text{P } 206{,}501.10}$$

Payback Period = 0.05 year

Payback period as computed showed that total cost of the project can be recovered for less than a month of operation.

Computation:

Initial Cost of the Fish Natural Convection Dryer **P 10, 947.15**

Annual Cash Inflow:

Sales	486,000.00

Annual Cash Outflows:

Cost of Fresh Tilapia	P 259,200.00
Cost of Brine Solution	1,800.00
Labor (P150.00/batch)	16,200.00
Interest on Investment/Project Cost	109.47
Repair and Maintenance	2,189.43
Total Cash Outflows	279,498.90

Net Annual Cash Inflows (P486,000 – P 279,498.90) **P 206,501.10**

Note: Depreciation was not included because it is a non-cash expense account.

Table 7. Technical description of the natural convection fish drier facility

Parameter	Value
Area Covered	22.5 square feet
Highest air temperature at drying chamber	45.66 degrees cel
Highest ambient temperature at drying chamber	39.16 degrees cel
Maximum drying rate	7.66 gram per min.
Dryer Capacity	24 kilos
Drying Duration per day	10 hrs.
Solar Collector Area	15 square feet
Total Solar dryer Height	5.5 feet
Fabrication Cost	Php 10,947.15
Return on Investment	72 %
Payback Period	0.05 year

Figure 7 and 8. The actual view of the fish dryer natural convection facility

CONCLUSION

The fish natural convection drying facility was designed and evaluated using the stunted tilapia as experimental samples. Solar heat absorbers are painted black stones as the base of the facility or at the lower level. Results disclosed that highest drying rates were achieved during the first two hours with an average drying rate of 7.20 grams per minute. The average drying rate of the designed fish solar dryer for three trials was 2.63 grams per minute. The total average moisture content removed was 17.46 percent, wet basis since the final average moisture content of the samples was 75.23 percent wet basis from the initial moisture content of 92. 69 percent wet basis.

The moisture content of the samples was reduced from 92.68%-75.23% for the 20 hours of drying. The weights of samples were also reduced from 20 to 15kilograms.

Relative humidity inside the drying chamber of the designed natural convection dryer varies from time to time depending on the weather characteristic. However, relative humidity was higher at the upper level tray since vapor carried by the hot air moves upward.

Lastly, total cost of the project was P 10,947.15 with a computed return of investment equal to 72 percent while the investment can be recovered for less than a month as its payback period.

RECOMMENDATION

The researchers would like to recommend this low-cost fish natural convection dryer to local farmers and fisherfolks as it only requires minimal capital investment in constructing the dryer. Also, engaging in dried tilapia production is a lucrative business for tilapia for its demand is not only in the local market but to foreign market as well.

LITERATURE CITED

Bala, B.K., Nipa Debnath
2012 Solar Drying Technology: Potentials and Developments. Ashdin Publishing. Journal of Fundamentals of Renewable Energy and Applications. Volume 2 (2012) Article ID R120302, 5pages www.omicsonline.com/open-access/2090-4541/2090-4541-2-111.pdf‎ . Retrieved June 15, 2013.

Bala,B.K., Mondol M.R.A
2001 Experimental Investigation on Solar Drying of Fish using Solar Tunnel Dryer. Drying Technology: An International Journal. Volume 19, Issue 2, 2001. www.tandfonline.com. Retrieved June 15, 2013.

Balita
2009 www.balita.ph/2009/07/28/tilanggit-processing-as-viable-livelihood-venture. Retrieved July 25, 2013.

Bureau of Fisheries and Aquatic Resources (BFAR)
2013 www.bfar.da.gov.ph/pages/Programs/prog-getexeltilapia.html. Retrieved June 15, 2013.

Chaichan, M.T and Hussein A. Kazem
2010. Thermal Storage Comparison for Variable Basement Kinds of a Solar

Chimney Prototype in Baghdad- Irag Weather.www.cscjournal.org/csc/ manuscript/journals/IJAS/33pdf. Retrieved August 28, 2013 *aquafishcrsp. oregonstate.edu/Project/?entry=1*. Retrieved August 8, 2013 http//balita.ph 2009/07/28/tilanggit-processing-as-viable-livelihood-venture. Retrieved August 2, 2013

Jamandre, W.E; Upton, H.; Remedios B.; Russell B.
2012 Improving the Supply Chain of Tilapia Industry of the Philippines. www.docstoc.com/.../Jamandre-etal-Tilapia-Industry-Philippines. Retrieved August 5, 2013.

Ukegbu P. O*. and Okereke C. J.
2013 Effect of solar and sun drying methods on the nutrient composition and microbial load in selected vegetables, African spinach (*Amaranthus hybridus*), fluted pumpkin (*Telferia occidentalis*), and okra (*Hibiscus esculentus*).skyjournals.org/SJFS/abstract/.../Ukegbu%20%20and%20 Okereke.htm. Retrieved July 2013.

Waewsak, et. al.
2006 www..awc.org/helpoutreach/faq/faqfiles/conductivity.html.Retrieved August 9, 2013.

Pursuant to the international character of this publication, the journal is indexed by the following agencies: (1) Public Knowledge Project, a consortium of Simon Fraser University Library, the School of Education of Stanford University, and the British Columbia University, Canada; (2) E-International Scientific Research Journal Consortium; (3) Philippine E-Journals; (4) Google Scholar; (5) Index Copernicus; (6) Scholastica; (7) Researchgate; (8) Lacriee of France; and, (9) University Library of Leipzig, Germany.