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Assessment Of Drying Techniques For Production Of Banana Value Added Products

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ABSTRACT
Horticultural products have high moisture content which makes it vulnerable to microbial and other spoilages due to biochemical reactions. Moisture content of banana is 74% apart from nutritional aspects like carbohydrate, fibre, vitamins and minerals. The content of one of the important minerals, potassium is 396mg/100g in banana and 499mg/100g in plantain. More than 130 countries are cultivating banana in an area of 8.8 million hectares. About 24 % of world banana production is in India. In India, banana cultivated in an area of 4 lakh hectares. In Tamil Nadu, area under banana is 85,000 hectares. In Tamil Nadu, banana production is 36 lakh tonnes. Post harvest loss is up to 30 - 40% and hence preservation is necessary to make it available to the consumers without any loss and to make the farmers to get the better price. Drying increases the shelf-life of the product, so that the products can be available during off seasons also. Solar dryers are used to assess the drying efficiency of banana for the production of banana flour as a method of preservation and value addition. Hence a research was conducted to assess the drying technologies for production of banana value added product like banana flour which can be utilised for further value addition. Solar drying after blanching and curing and preparation of value added products like banana flour resulted in increased yield of 260g/kg of banana which given high net return of Rs.250/kg and highest Benefit Cost Ratio of 3.78 when compared to open sun drying methods with and without pre treatments. Pre treatment such as blanching and curing resulted in a better quality produce. Solar dryer has given higher yield with good quality products. This technology will be very useful FPOs involved in banana because of higher establishment cost and storage facilities.
Key Words – Assessment, Solar Dryer, Banana, Value Added Products

INTRODUCTION

Banana and plantains are grown in about 130 countries. Total annual world production is estimated at 86 million tonnes of fruits. India leads the world in banana production with an annual output of about 14.2 million tonnes. Other leading producers are Brazil, Eucador, China, Phillipines, Indonesia, Costarica, Mexico, Thailand and Colombia.

In India banana ranks first in production and third in area among fruit crops. It accounts for 13% of the total area and 33% of the production of fruits. Production is highest in Maharashtra (3924.1 thousand tones) followed by Tamil Nadu (3543.8 thousand tonnes). Within India, Maharashtra has the highest productivity of 65.70 metric tones /ha. against national average of 30.5 tonnes/ha. Banana is a very popular fruit due to its low price and high nutritive value. It is consumed in fresh or cooked form both as ripe and raw fruit. Banana is a rich source of carbohydrate and is rich in vitamins particularly vitamin B. It is also a good source of potassium, phosphorus, calcium and magnesium. The fruit is easy to digest, free from fat and cholesterol.

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It is also called as Poor man's apple / Common man's fruit. It is an important fruit crop suitable for cultivation in all the tropical and sub tropical countries. More than 130 countries cultivating banana in an area of 8.8 million hectares. Around 24 % of world banana production is in India and it is cultivated in an area of 4 lakh hectares in India. In Tamil Nadu, area under banana is is cultivated in an area of 85,000 hectares.

Bananas are rich in soluble fibre which, dissolves in liquid to form a gel during digestion. Unripe fully matured green bananas or plantain also contain resistant starch, a type of fibre that can not digest. Together, these two types of fibres may help moderate blood sugar levels after meals and regulate appetite by slowing the emptying of your stomach. This means that despite their higher carb content, bananas may not cause major spikes in blood sugar levels in people who don't have diabetes. However, for persons with diabetes, eating a large portion in one sitting may cause blood sugar levels to rise too high, so it's best to stick to one banana at a time. Dietary fibre has been linked to many health benefitsTrusted Source, including improved digestion. Resistant starch or fibre found in unripe bananas, is a prebiotic which escape digestion and end up in large intestine, where it become food for the beneficial bacteria in your gut (probiotics). Regarding pectin, a fibre found in both ripe and unripe bananas may help prevent constipation and soften stools.

Table 1. Nutritive Value of Banana & Plantain (per 100 g)

Nutrients	Banana	Plantain
Water (%)	74.00	65.00
Energy (Kcal)	92.00	122.00
Carbohydrates (%)	23.00	34.00
Protein (%)	1.03	1.30
Fat (%)	0.48	0.37
Potassium (mg)	396.00	499.00
Calcium (mg)	6.00	3.00
Vitamin A (IU)	64.00	1127.00
Dietary Fiber (%)	3.00	2.00

Preservation of fruits and vegetables is essential for keeping them for a long time without further deterioration in the quality. Drying was probably the first ever food preserving method used by man, even before cooking (Alamu *et al.*, 2010). Drying is suited for developing countries with poorly established processing facilities. Drying is a simple process of moisture removal from a product in order to reach the desired moisture content and is an energy intensive operation (Bukya Krishna *et al.* (2018). The prime objective of drying technology apart from extended storage life can also be quality enhancement, ease of handling, further processing and sanitation and is probably the oldest method of food preservation practiced by mankind (Abrol *et al. (*2014).

Processed products, such as chips, banana puree, jam, jelly, juice, wine and halwa can be made from the fruit. The tender stem, which bears the inflorescence is extracted by removing the leaf sheaths of the harvested pseudostem and used as vegetable. Plantains or cooking bananas are rich in starch and have a chemical composition similar to that of potato.

Banana powder after drying is used as the first baby food. It helps in reducing risk of heart diseases when used regularly and is recommended for patients suffering from high blood pressure, arthritis, ulcer, gastroenteritis and kidney disorders.

Drying brings about substantial reduction in weight and volume, minimizing packing, storage and transportation costs and enables storability of the product under ambient temperatures. These features are especially important for developing countries, in military feeding and space food formulation (Vanarsdel, 1965).

Drying Increases the shelf-life of the product, so that it can be available during off seasons. The open air sun drying is one of the oldest and well known processes for preserving agricultural product for a long time. There are certain new techniques are introduced for efficient drying process

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such as hot air drying or dielectric heating. But these processes require a huge amount of energy which is generally obtained from conventional energy sources like fossil fuels. With the depletion of fossil fuels and hike in energy prices, more and more emphasis is being given to utilize renewable energy sources for drying.

To protect the products from adverse climatic conditions like rain, wind, dust, loss of produce to birds, rodents and pests and also to accelerate the time for drying the products, control the final moisture and reduce wastage through bacterial action, different types of solar dryer can be used (Khalil *et al.*, 2007 and Janjaia *et al.*, 2008). Fodor (2006) stated that on a clear day solar radiation available to any location is dependent on the angle of the sun relative to horizon. Solar energy is free, renewable, abundant, and an environment friendly energy source. This reduces drying time due to effective utilization of solar energy. It maintains the quality of the food products and acts as an ideal substitute for fossil fuel based dryers. The two basic limitations faced by the solar dryers are sunshine hours and weather change.

Solar dryers are available in various ranges of size and design and are used for drying of various agricultural products. Solar-energy drying systems used effectively in drying of agricultural produces (Ekechekwu and Norton (2015)) & (Norton et. al. (1997). Olatunbosun Salaudeen (2011) designed and constructed a solar dryer and tested for drying of banana for preparing value added products. Lokesh et al. (2015) reviewed about the solar dryers and stated that the solar dryers are very efficient in utilising for drying of agricultural products.

The relative moisture content higher than 43% causes enzymatic and chemical spoilage in the product. But the oxidation of fats cannot be avoided by drying the product. Most of dried fruits contain 20-25% of moisture. Drying is the process of removing water from the product. Drying the outside parts of product is very simple and evaporation of water can happen very fast by heating up the air and by moving the air fast. This is very much important to transport this water from the product to the outside. This process can be increased by heating up the product. In practice there is a maximum temperature at which the product can be dried, because too high temperature can damage it (structure, taste and smell). During the drying process, also other conditions like contamination of foreign bodies, chemicals, dust and bacteria is also important. For fast and perfect drying, the circumstances must be optimal and process should be controlled. Modern drying systems can do this in very effective and economical manner.

Solar dryers are available in various ranges of size and design and are used for drying of various agricultural products. Various types of Dryers are available as per requirement of farmers. Primarily all the drying systems are classified on the basis of their operating temperature ranges that is High Temperature solar dryer and Low Temperature Solar dryer. A typical solar dryer improves upon the traditional open air sun system in important ways as it si faster, more efficient, hygienic and cheap (Sharma *et al.*, 2009).

The open air drying or sun drying has many limitations and due to the rise of fuel prices, depletion of fossil fuels, the use of modern drying technologies are not economical for drying agricultural product. Hence solar drying systems have been developed as a successful and economical tool for drying agricultural product. Solar drying is achieved by direct sun radiation and greenhouse effect. The solar energy received by the drying chamber is dependent on the sunshine hours, climate, weather, atmospheric clearness, and location. Fodor (2006)] stated that on a clear day solar radiation available to any location is dependent on the angle of the sun relative to horizon. Solar energy is free, renewable, abundant, and an environment friendly energy source. This reduces drying time due to effective utilization of solar energy. It maintains the quality of the food products and acts as an ideal substitute for fossil fuel based dryers. The two basic limitations faced by the solar dryers are sunshine hours and weather change.

MATERIALS AND METHODOLOGY

Banana fruit and plantain have high moisture content which makes them vulnerable to microbial and other spoilages due to biochemical reactions. Bacteriological shelf life of dried products depends on the water activity also known as relative moisture content of the product. Relative

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moisture content is measured in percentage and can be in between 0% to 100%. Dried products have low water activity or relative moisture content. Therefore drying or dehydration activities must be carried out as preventive measures to lower moisture content of the product. Drying is a process of removal of water from the food to inhibit biochemical processes and microbial growth.

Drying Increases the shelf-life of the product, so that it can be available during off seasons. The open air sun drying is one of the oldest and well known processes for preserving agricultural product for a long time. There are certain new techniques are introduced for efficient drying process such as hot air drying or dielectric heating. But these processes require a huge amount of energy which is generally obtained from conventional energy sources like fossil fuels. With the depletion of fossil fuels and hike in energy prices, more and more emphasis is being given to utilize renewable energy sources for drying. Banana powder after drying can be store for a long time and can be utilised as such for marketing and for production other value added products like cookies, cakes etc.,

Hence a research work has been conducted as on farm trial to assess the suitable drying technologies for production of banana value added product especially banana flour which can be utilised for further value addition. Three different technology options were tried as different treatments as shown below.

Table 2. Treatment details regarding drying of banana fruits

Technology Option 1 (Source:TNAU 2018)	Blanching + curing + Solar drying (natural convection model) and preparation of value added product – banana flour
Technology Option II (Source: NRCB 2018)	Blanching + curing + Sun drying and preparation of value added product – banana flour
Farmers Practice	Sun drying without pre treatments
Critical inputs	Banana- 5 kg and KMS

RESULTS AND DISCUSSION

In the present study, solar dryers are used to dry the plantain banana after blanching and curing. Solar dried products were compared with the products of sun drying and drying without any pre treatment as the farmers practice.

After drying the material were made into the fine powder for which different parameters were observed for physical and quality parameters such as colour and appearance, flavour, texture, taste and overall acceptability and yield parameters which were given in the table below.

Table 3. Physical and quality parameters of banana value added product – banana flour

Parameters	**T1 Solar drying**	**T2 Sun drying**	**T3 FP - (Sun drying without pretreatments**
Appearance and colour	9.0	8.0	7.0
Flavour	8.0	7.5	7.5
Texture	8.5	8.5	7.0

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Taste	8.5	8.0	8.0
Overall acceptability	8.5	8.0	7.0

Table 4. Yield parameters of banana value added product – banana flour

Parameters studied	**T1**	**T2**	**FP**
Drying time (days)	1.5	3	3
Dehydration ratio	0.18	0.16	0.12
Yield (g/Kg)	260	200	170
% increase over FP	53	18	-
Gross cost (Rs/Kg)	90	90	90
Net return(Rs/Kg)	250	200	110
BCR	3.78	3.22	2.22
Keeping quality (days)	100 days	100 days	85 days

The results revealed that pre treatment such as blanching and curing resulted in a better quality produce. When compared to sun drying, solar dryer has given more yield with good quality products. Drying time is also found to be reduced 50 %. That is 1.5 days is needed for drying of the produce in solar dryer when compared to three days in open sun drying methods. Pangavhane et al.(2002) have designed a solar dryer consisting of a solar air heater and a drying chamber. They observed that the drying time in a solar dryer was four days as compared to seven days in open sun drying and 15 days in shade drying for production of resins from grapes. A solar tunnel dryer designed for drying agricultural crops, by Bala *et al.* (2002), consisted of a transparent plastic covering the flat plate collector. The drying tunnel is connected in a series to supply hot air directly into the drying tunnel using two DC fans operated by a solar module. Bena and Fuller (2001) described that biomass-generated energy serves as a backup for such direct convection type natural solar dryers, thus improving the dryer efficiency. Lutz *et al.* (1986) had developed a multipurpose solar tunnel dryer consisting of a fan, solar heater, and tunnel dryer. The use of this dryer had reduced the drying time considerably with better end product quality. The solar dryer developed by ElSebaii *et al.*(2009) consisted of a flat plate solar air heater connected to a cabinet, acting as a drying chamber to produce good quality dried products.

Hybrid dryers are usually direct-type solar dryers, but are backed up by an auxiliary energy source, so that during the less sunshine hours and cloudy weather the energy back-up can be utilized to dry food materials without interruption. This usually results in better product quality. Bhattacharya *et al.* (2002) have developed a hybrid solar dryer using direct solar energy and a heat exchanger. The dryer consists of a solar collector, reflector, heat exchanger cum heat storage unit, and a drying chamber. The drying chamber is placed beneath the collector. The dryer is operated during normal sunny days as a solar dryer and as a hybrid solar dryer during cloudy days. Drying is also carried out at night using stored heat energy, in which it is collected during the daytime and with electric heaters located at water tank. The efficiency of the solar dryer is enhanced by recycling about 65 per cent of the

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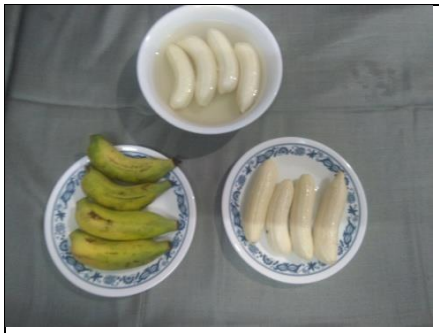
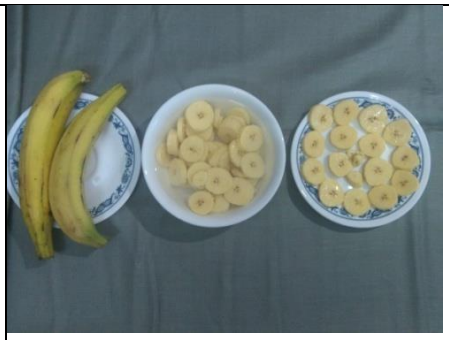
drying air in the solar dryer.
The various advantages are there for using of solar dryers. They are as follows.

- Solar dryer can save fuel and electricity and drying time in solar dryer is reduced in comparison to open drying method.
- Fruits and vegetables dried in solar dryer are better in quality and hygienic than dried in open.
- Products are protected against flies, rain and dust; product can be left in the dryer overnight during rain, since dryers are waterproof.
- It Reduces Losses and Better market price to the products
- Materials required for fabrication of solar dryer are locally available.
- The use of solar dryer involves no fire risks.
- The dryers can be connected in series and hence its capacity can be enhanced as per requirement and it can be dismantled easily so that its transportation is easy from one place to another.
- Better Quality of Products are obtained

In the present study, yield also found to be higher in the solar drying technology option (260g/kg) than the technology option - open sun drying with pre treatments (200 g/kg) and farmers practice (170g/kg). Highest net profit (Rs.250 per kg) and Benefit Cost Ratio (3.78) were also found to be recorded in Solar drying technology option.
This technology can be well practiced by Farmer Producer Organizations (FPOs) who are involved in cultivation, sale and marketing of fruit and vegetables rather than individual farmers because of higher establishment cost and storage facilities in solar drying technology option. The banana flour can also be stored for 100 days without any deterioration in quality. Further the banana flour can be included upto 30 to 70 % in preparation of cookies with minor millets to produce ready to eat products.

CONCLUSION

Solar drying with pre treatments such as blanching and curing is the best technology option for banana flour production. Millet Cookies with banana flour upto 70% can also be prepared for producing ready to eat products with banana. There is chance to increase the BCR from 3.78 to 4.5 when the banana flour is incorporated in the dough for preparing millet banana cookies. Cake preparation with banana flour is also possible to produce a ready to eat product and to increase the net profit. Thus more chances are there in near future in developing entrepreneurship opportunities among the farmers who are involved in cultivation, value addition and marketing of banana and plantain.

	
Banana fig prepared for drying in solar dryer	Banana chips dried at Solar dryer

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Prepared banana chips kept for drying inside the solar dryer

Banana flour prepared from the dried banana inside the solar dryer

Trainings organized to produce millet banana cookies and cakes

References

1. Abrol, G S., Vaidya D., Sharma A and Sharma S., (2014) Effect of solar drying on physio

chemical and antioxidant properties of mango, banana and papaya. National Academy Science Letters, 37(1) : 51 -57
2. Alamu, O.J., C.N. Nwaokocha and O.Adunola (2010) Design and construction of a domestic passive solar food dryer, Leonardo Journal of Sciences, pp:71-82
3. Bala B.K., M.R.A. Mondol, B.K. Biswas and B. L. Das Chowdury, "Solar Drying Of Pineapple Using Solar Tunnel Drier", 4th International Conference on Mechanical Engineering, December 26-28, 2001, Dhaka, Bangladesh / pp. 47-51
4. Bhattacharya, S.C., Leon M.A., Kumar, S. (2002) A comprehensive procedure for performance evaluation of solar food dryers, Renew. And Sust. Energy reviews, Vol. 6, pp. 367-393
5. Bena B.and Fuller R. J., (2002) Natural convection solar dyer with biomass back-up heater, Solar Energy, , 72, 75–83
6. Bukya Krishna, A K Banik, Arghya Mani (2018) Solar drying of fruits and vegetables in Trends and Prospects in Processing of horticultural crops edited by Ivy Chakraporty, Prodyut Kumar Paul, Arghya Mani, Arun Kumar Tiwary and K. Prasad (2018) ISBN – 81-7019 – India pp:179 - 201
7. Ekechukwu O. V and B. Norton, "Experimental studies of integral-type natural- circulation solar-energy tropical crop dryers", Energy Conversion and Management, Volume 38, Issue 14, September 1997, Pages 1483–1500
8. El-Sebaii A.A., Enein Aboul S., Ramadan M. R. I., and El-Gohary H. G. (2002) Experimental investigation of an indirect type natural convection solar dryer. Energy Conversion and Management, 43, 2251-2266
9. Fodor E.V. , The Solar Food Dryer: How to Make and Use Your Own Low-Cost, High Performance, Sun-Powered Food Dehydrator, New Society Publishers, (2006)
10. Janjaia S., N Srisittipokakuna and B.K.Balab (2008) Experimental and modelling performances of a roof integrated solar drying system for drying herbs and spices. Journal of Energy 33 pp: 91 -103
11. Khalil, E.J., Al-Juamily, N Khalifa and T.A.Yassen (2007) Testing of the performance of a fruit and vegetable solar drying system in Iraq. Journal of Desalination. 209 pp:163 -170
12. Lokesh R.Dhumne, Vipin H.Bipte, Prof.Y. M.Jibhkate, Solar dryers for drying agricultural products International Journal of Engineering Research-OnlineVol.3., S2, 2015 IC-QUEST 2015 ISSN: 2321-7758 Proceedings of 4th International Conference On Quality Up-gradation in Engineering, Science & Technology (ICQUEST_2015) Organized by Bapurao Deshmukh College of Engineering, Sevagram, Wardha – 442 102, Maharashtra, India; 11th April.,2015
13. Lutza K & W Muhlbauera (1986), Solar Tunnel Dryer With Integrated Collector, Drying Technology: An International Journal, Volume 4, Issue 4, pp: 583-603
14. Olatunbosun Salaudeen (2011) Design, Construction and testing of a solar dryer, Project submitted to the Department of Agricultural Engineering in partial fulfillment of the requirement for the award of the degree of Bachelor in Engineering in University of Agriculture, Abeokuta, Ogun State, Nigeria
15. Pangavhane Dilip R., Sawhney R.L. and Sarsavadia P.N., "Design, development and performance testing of a new natural convection solar dryer". Energy, 2002, 27, 579– 590.
16. Sharma A., Chen C.R. and Lan N.V. (2009). Solar energy drying systems. Renewable and Sustainable Energy Reiviews, 13 pp: 1185 - 1210
17. Vanarsdel, W.B., (1965) Food dehydration. Food Technology, 19, pp:484 -487