eISBN 978-967-16145-1-8

Konvensyen Kebangsaan Kejuruteraan Pertanian Dan Makanan 2019
21 Mac 2019, Wisma Tani, Kementerian Pertanian Malaysia, Putrajaya

MSAE2019-PFE03

Evaluation of lab scale Vitato flour processing and drying performance using cabinet dryer

Amir Syariffuddeen, M.A.[1], Faridah, H.[2], Shahrir, A.[1], Aida Hamimi, I.[2], Hazila Khairuunizah, K.[2], and Azman, H.[1]

Engineering Research Centre[1]
Food Science and Technology Research Centre[2]
Persiaran MARDI-UPM, MARDI Head Quarters, 43400 Serdang, Selangor, Malaysia.
**Corresponding Author, Tel: +06 89536557, E-mail: asyariff.mardi@1govuc.gov.my*

Abstract

Vitato sweet potato has a bright orange colour with rich in carbohydrate as well as high content of β-carotene which functioning as Vitamin A in human body. With this high nutrients, Vitato has potential to become an alternative for health ingredient for processing flour and has used as one of the ingredient for premix flour for bakery purposes, such as for baking biscuits, muffins and cakes. An experiment has done to evaluate the processing flow of Vitato flour in the pilot scale. An amount of 25kg of fresh Vitato has used as feedstock and has through several processes of washing, peeling, sorting, slicing, drying and grinding. The performance of drying process on time consumption and moisture reduction profile has investigated. It has recorded time consumption to complete process for production of Vitato flour are 8 hours/ day with 20% recovery of flour, with 14.49kW electricity power, 560 litres of water used with 3 man power operation.

Keyword: Vitato, Flour, Drying, Moisture, Recovery

Introduction

Sweet potato (Ipomea batatas) is a cultivated tubers that come from tropical continent of America which appropriate to grow in sandy lush soils with containing many organic substances (Izalin, 2014). Sweet potato are rich in carbohydrates and known as among the dominant food crops which produce the highest amount of edible per hectar per day (Futega et. al., 2013). Sweet potato also is a food crop that is have play an important role in improving household and national security, health and livelihood of poor family in sub-Sahara African (SASHA/CIP, 2009). In Malaysia, sweet potato has considered as one of the staple food in Malaysia instead of rice, wheat, corn, barley, potato and cassava (Utusan Malaysia, 2016). Sweet potato has become an alternative crop to replace the plantation of tobacco since it has announce as a new revenue resource for farmer especially in Kelantan and Terengganu. Sweet potato has planted twice in a year in small area with estimation of 3000 hectar. A study conduct by MARDI related to the sweet potato has successfully produce new variety of sweet potato named "Vitato". Sweet potato "Vitato" has belong to the family "Convolvulaceae" with its scientific named "Ipomea Batatus" (Senanayake et. al.,2013). It have characteristic as orange-fleshed in colour which particularly rich in β-carotene and most important contain of pro-vitamin A carotenoid (HarvestPlus, 2009). The orange-fleshed of "Vitato" has rich in antioxidant which converted into Vitamin A when reaction occur in human body. Moreover, "Vitato" also rich in Vitamin C and E together with Anthocyanin which can prevent cell and DNA damage, cancer prevention, fetal defects and delay aging. "Vitato" can processed into flour and used as one of the ingredients in a production premix flour for bakery products such as biscuits, muffins and cakes. "Vitato" processed flour can be stored for more than 1 year at room temperature. Commonly, sweet potato flour processing involved several processing such as reported by Hageninama and Owuri (2000) which it started with selection of sweet potato, then cleaning and trimming, washing, slicing, drying, milling and packaging. Ekinyu, (2010) reported that sweet potato flour processing step are choosing the sweet potato, then washing, draining, chipping and slicing, drying, milling, packaging and labelling and storage as final step. In this experiment, a Vitato flour processing has done in pilot scale for lab scale production which involve processes such as washing, peeling, sorting, slicing, drying and grinding. This paper will discussed on evaluation of whole process involve in Vitato flour processing in small scale in pilot plant including the investigation on drying performance, time and power consumption for each process step and also recovery of final products.

Materials and methods

The experiment for processing of Vitato Flour were implemented in the Pilot Plant in Food Science Research Centre, MARDI, Selangor. 25kg of raw Vitato samples has used and purchased from Pasar Borong Selangor, Seri Kembangan, Selangor. The detail of processing were described as below:

1)Selection of Vitato roots

25 kg of Vitato roots use should be undamaged and mature with 4 months for the early maturing varities and 5-6 months for the late maturing varities (Figure 1).

Figure 1: 25kg of matured Vitato

2)Washing process

The Vitato samples has washed using mechanical Nilma Thumbler Washer (Italy) as Figure 2, with specification of 230V, 1.45HP with water capacity used per batch washing process 328 litre. The time consumption for washing process was set for 15 minutes. The electrical energy consumption for the process is calculated and measured.

Figure 2: Washing process of Vitato using mechanical thumbler washer

3)Peeling process

After washing, the Vitato samples are taken to the peeling section and the samples has put in stone grinder for deskinning and peeling process as Figure 3. The water and time consumption along the process are recorded and measured.

Figure 3: Deskinning and peeling process of Vitato using stone grinder machine

4)Sorting and cutting defect of tuber

Then, the deskinning Vitato will be sorting and cutting the defect or damaged part of the Vitato samples (Figure 4). This process was done manually with assisted by the 3 manpower. Time taken along the discarded damage part of samples also has taken and recorded. The samples after sorting and cutting process were weighed also.

Figure 4: Sorting and cutting defect of Vitato manually by man power

5)Slicing to cut-strip

After weighing, the samples will be slicing into the cut-strip form using AB Hallde Maskiner slicer machine (Sweden) as Figure 5 with specification of 415V and 1.3HP. The time consumption, electricity along the slicing process are recorded and the final mass of sample after process also weighed.

Figure 5: Slicing Vitato into cut-strip form using slicer machine

6)Soaking and tossing process

The samples then are soaked in the solvent consist of water and sodium metabisulphate with ratio of 1:7 as Figure 6. This purpose is to preserve the orange-fleshed colour of Vitato. The soaking process are only 1 minutes and then the samples are tossed manually assisted by 2 manpower. Then, the samples are reweighed to get their mass before proceed to drying process.

Figure 6: Soaking and tossing process of cut-strip Vitato using sodium metabisulphate

7)Drying process

The samples then are arranged in the tray in the cabinet dryer with amount 1.5kg samples filled in each tray as shown as Figure 7. The thickness of sample in each tray has set at 1.5 cm and samples then put in hot air circulating cabinet dryer with profile of maximum capacity 150kg, power input 1.5kW/hour. The drying process are set at 70°C. Time consuming, electricity and moisture reduction profile was investigated along the drying process.

Figure 7: Drying process of cut-strip Vitato using cabinet dryer

8)Grinding process

The dried sample of Vitato are grinded using Hammer mill Model UM-50SS (Germany). It is necessary to pass twice the dried material in the mill to produce a finer flour. The residual moisture in the dried slices should be between 5-10%. Over drying of slices will contributed to the formation a lot of dust and loss of material during the milling process. It is recommended to grind dried Vitato immediately after drying to prevent the rehydration. Time consuming and power consumption was investigated along the drying process. Recovery of Vitato flour from initial feedstock also has calculated.

Figure 8: Grinding dried cut-strip Vitato into powder using Hammermill machine

Results and discussion

Table 1 has summarized the parameter involved and has recorded in each step of processing along the Vitato flour production. A 25kg of Vitato roots are selected and has washed using mechanical thumbler washer. All of Vitato was washed in one batch in 328 litre of water. Under processing of 15 minutes with one manpower, it takes 0.36kW of electrical energy for washing the tubers. For peeling process, a batch of 3.5kg of Vitato has subjected to stone grinder. So that, to complete the peeling for 25kg samples, 7 batch of process has been implemented which take 28 minutes with 420 litres of water consumption under operation of one manpower. Then, after peeling process, the samples has be sorted and discarded he damage part of Vitato. This process was done manually and took about 3.5kg sample for a batch with time consuming of 3 minutes per/batch processing. Thus, the process take about 21 minutes with assisting of 3 manpower. The mass after sorting and cutting process were 22.97kg. Thus it indicated about 9% waste has discarded from initial tubers used. The samples has been sliced into cut-strip form with a 2.1kg of samples can be used for a batch processing. This means for 23kg samples after sorting and cutting, it operate 11 batch of processing to complete the slicing process with time of consumption of 6 minutes. Using 2 manpower, the slicer machine has recorded using 130kW of electrical energy. The mass of sample after slicing also has taken and it recorded the mass of 22.60kg. The sliced cut-strip Vitato then are soaked in solution of sodium metabisulphate in order to preserve the orange-fleshed colour of Vitato. The mass after has recorded 24.99 kg and this increment of mass contribute due to the absorption of water during soaking process.

Table 1: Parameter recorded for each process in pilot plant production of Vitato flour

Process	Initial Mass (kg)	Final Mass (kg)	Power Consume (k/hr)	Water Consume (litres)	Duration (min)	Manpower	Remarks
Selection of Vitato	25.00	-	-	-	-	-	-
Washing	25.00	-	0.36	320	15	1	-
Peeling	25.00	22.97	-	420	28	1	i) 3.5kg/ batch in stone grinder (25kg = 7 batch) ii) Time consuming: 28 min (4 min per/batch) iii) Water consuming: 420 litre (60 litre/batch)
Sorting and cutting defect			-		21	2	i) 3.5kg/ batch sorting ii) Time consuming: 21 min (3 min/ batch
Slicing to cut strip	22.97	22.60	130	-	6	2	a) 2.1kg/ batch (23kg= 11 batch) b) Time consuming: 6 min (0.5 min/batch)
Soaking and tossing process	22.60	24.99			1	2	
Drying process	24.99	4.95	1.5	-	420	2	a) Thickness sample per/tray: 1.5 cm b) Tray thickness: 4.0 cm c) Dryer type: Hot Air Circulating Cabinet Dryer d) Capacity: 150kg/batch e) Power: 1.5+0.5kW/ hour f) Temperature: 70°C

Table 1 has summarized the parameter involved and has recorded in each step of processing along the Vitato flour production. A 25kg of Vitato roots are selected and has washed using mechanical thumbler washer. All of Vitato was washed in one batch in 328 litre of water. Under processing of 15 minutes with one manpower, it takes 0.36kW of electrical energy for washing the tubers. For peeling process, a batch of 3.5kg of Vitato has subjected to stone grinder. So that, to complete the peeling for 25kg samples, 7 batch of process has been implemented which take 28 minutes with 420 litres of water consumption under operation of one manpower. Then, after peeling process, the samples has be sorted and discarded he damage part of Vitato. This process was done manually and took about 3.5kg sample for a batch with time consuming of 3 minutes per/batch processing. Thus, the process take about 21 minutes with assisting of 3 manpower. The mass after sorting and cutting process were 22.97kg. Thus it indicated about 9% waste has discarded from initial tubers used. The samples has been sliced into cut-strip form with a 2.1kg of samples can be used for a batch processing. This means for 23kg samples after sorting and cutting, it operate 11 batch of processing to complete the slicing process with time of consumption of 6 minutes. Using 2 manpower, the slicer machine has recorded using 130kW of electrical energy. The mass of sample after slicing also has taken and it recorded the mass of 22.60kg. The sliced cut-strip Vitato then are soaked in solution of sodium metabisulphate in order to preserve the orange-fleshed colour of Vitato. The mass after has recorded 24.99 kg and this increment of mass contribute due to the absorption of water during soaking process.

Drying process for Vitato cut-strip has been done by using cabinet dryer and the arrangement of sample were by filling 1.5kg of sample in the 6 different location tray. The location of the tray are divided by two compartment which is 3 tray in the left compartment (upper, middle and bottom) and other 3 tray in the right compartment (upper, middle and

bottom) as shown in previous Figure 7. From Figure 8, it displayed the moisture reduction distribution during drying process. It has summarize that the moisture reduction distribution in non-uniform and this suggested due to the different hot air velocity that has received by each tray. This phenomenon also contributed by the different location of the tray with the tray in the bottom left reached targeted moisture ≤10% after 3.5 hours faster than other tray. Moreover, this location are the closest to the hot blower so that it received highest speed hot air flow compared to the other tray location Then, it has followed by tray in middle right (4 hours), bottom right (4.5 hours), middle and upper left (5.5 hours) and lastly upper left (6.5 hours) to complete and reached moisture ≤10%. Since the targeted moisture to complete the drying process was ≤10%, it has shown that the optimum time to complete drying is close to 7 hours with each tray reached uniform moisture of ≤10%.

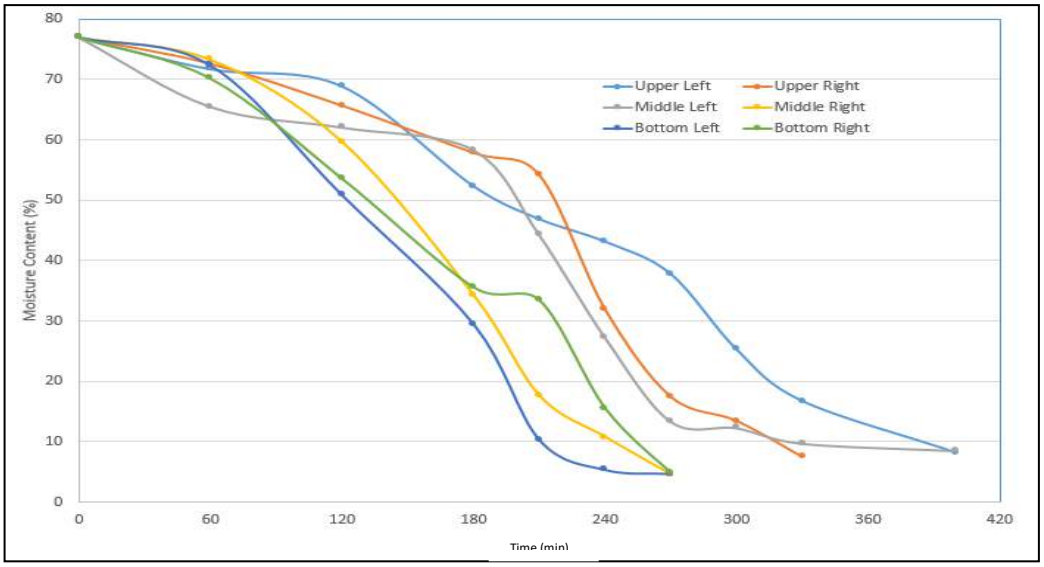

Figure 8: Profile of drying cut-strip Vitato

Instead of measuring moisture reduction, mass reduction also has recorded during drying process. This has been done by put 20 grams of sample in each tray and recorded the mass reduction until it reach the mass that represent moisture content of 10%. Based on Figure 9, it can be seen that each tray has reached the mass of 6.6 grams, which is represent for 10% targeted moisture after 5 hours with sample located in bottom and middle right exhibited 3.5 hours to reached 10% of moisture content. However, this result are contradicted with the moisture reduction profile and this suggested due to the small amount sample used and the location and container used for filling the sample were not represent entire sample in the each tray.

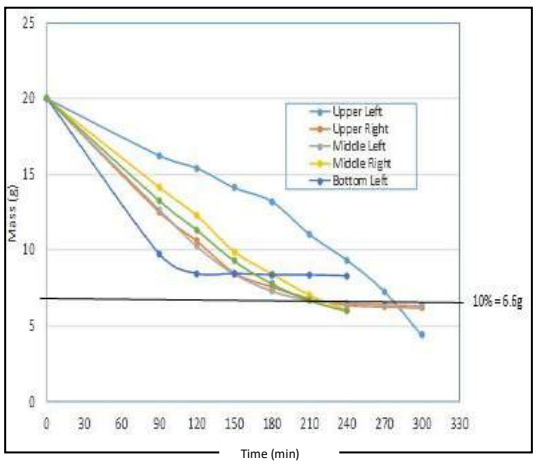

Figure 9: Mass reduction during drying of Vitato cut-strip

Table 2: Characterization of dried Vitato after drying and grinding process

Mass dried Vitato after drying process (kg)	4.95
Percentage Drying recovery (dried mass/ initial mass x100%)	20.00
Dried Vitato water activity, Aw	0.40
Mass flour after grinding (kg)	4.63
Percentage product recovery (flour/ initial mass x100%)	18.50
Vitato flour water activity, Aw	0.28

As refer to Table 2, after entire sample has reached targeted moisture of ≤10%, the mass of the dried Vitato sample are 4.95kg and this contributed to the 20% of drying recovery. The water activity of dried Vitato was 0.40Aw. Then, the dried sample has grinded and produced 4.625kg which is represent of 18.5% flour recovery with water activity of 0.28Aw. Summary for whole process flow, starting from selection of tubers until production of flour, it exhibited that the lab scale processing of Vitato flour managed to produce 18.5% of flour recovery with total time consumption 8 hours with maximum 3 man power, using 14.49kW of electricity with using 560 litres of water per/batch/day processing. Cost calculation for operation has found only RM 3.49 per/batch/day or RM 76.78 per/month as shown in Table 3.

Table 3: Parameter and cost calculation involve in production of Vitato flour using lab scale approach

Parameter	**Unit**	**Monthly/ cost (22 days working day)**	**Cost operation per/day**	**Cost operation per/month**
Time Operation	8 hours/ day	176 hours/ month	-	-
Man Power (trained worker/ MARDI staff)	3 person (maximum)	-	-	-
Electricity	14.49kW/ day	318.78kW/ month	RM 3.17	RM 69.76
Water	560 litres/ day	12, 320 litres/ month	RM 0.32	RM 7.02
	Total cost		RM 3.49	RM 76.78

Conclusion:

Production of Vitato flour via lab scale has been implemented using 25kg of fresh-harvested Vitato. All stage processes has been done using minimal facilities with assisted of minimum trained worker which is MARDI staff. Based on the results, it has found the product recovery are 18.5% with minimum cost operation of RM 3.49 per batch process that involve 8 hours one day operation. It has suggested the using of advance equipments such as semi or fully automated sorting and cutting machine, or improve the existed accomodations into larger capacities. Also using the advance dryer such as Fluidized Bed Dryer so that it will shorten the time operation, increase the production of product and also cut the operation cost.

References:

Eugene Ekinyu (2010), Multiplication of OFSP and non-OFSP varieties in NEU Uganda, Sweetpotato Platform Meeting, Namulonge,1 July 2010

Futega G. O., Tomlins K., Bechoff A., Henshaw F.O., Idowu M.A. and Westby A., (2013), A survey of traditional processing of sweet potato flour for amala, consumption pattern of sweet potato amala and awareness of orange-fleshed sweet potato (OFSP) in South West Nigeria, Journal of Food, Agriculture & Environment Vol.11 (3&4): 67-71.

Hagenimana V and C Owori (2000), Process of producing sweetpotato flour. Research for Development, Department for International Development, UKAID. http://r4d.dfid.gov.uk/PDF/Outputs/CropPost Harvest/R7036_sweetpotato_flour.pdf.

HarvestPlus 2009. Provitamin A sweet potato. http//ww.harvestplus_sweet_potato_strategy.pdf (accessed on August 30th, 2010).

Nur Izalin, M.Z., Siti Meriam, A., and Hasri H. (2014), Penghasilan tepung pracampuran hasilan bakeri berasaskan ubi keledek VitAto(Development of premix flour for VitAto sweet potato based bakery products), *Buletin Teknologi MARDI, Bil. 6(2014): 9 – 16*

SASHA/CIP 2009a. Sweet Potato for Health and Profit Initiative.http//www.cipotato.org/sasha/index.html (accessed on January 12th, 2010).

Senanayake SA, Ranaweera KKDS, Gunaratne A, Bamunuarachchi A (2013). Comparative analysis of nutritional quality of five different cultivars of sweet potatoes (Ipomoea batatas (L) Lam) in Sri Lanka. Food Sci Nutr; 1: 284-291.

Utusan Malaysia, article entitled “Nilai Ubi Keledek”, 29 December 2016