BioInnovate Africa

icipe
African Insect Science for Food and Health

Adaptation and promotion of refractance window drying technology for production of high quality bioproducts

Project Overview

John H. Muyonga

Project closure meeting, March 22nd 2022

THE REPUBLIC OF UGANDA
Ministry of Trade, Industry and Cooperatives

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

KIRDI KENYA INDUSTRIAL RESEARCH & DEVELOPMENT INSTITUTE

EAST AFRICA NUTRACEUTICALS

Fonus For Better Health & Nutrition

TONNET

Project duration and funding

- Started in December 2017, with target end date of Dec 2020
- Due to restrictions arising from COVID, project end date extended to June 2021
- Project budget was $750,000

Challenge

- Diverse fruits and vegetables produced
  - Unique organoletic, functional and nutraceutical properties
- Seasonality
- Market access challenges
  - Low economic benefits
- Up to 80% loss
- Lack of appropriate preservation technology

Project aims

Development objective

- To create new business opportunities in food value addition and agro-processing equipment fabrication, contributing to job creation and income generation

Expected outcomes

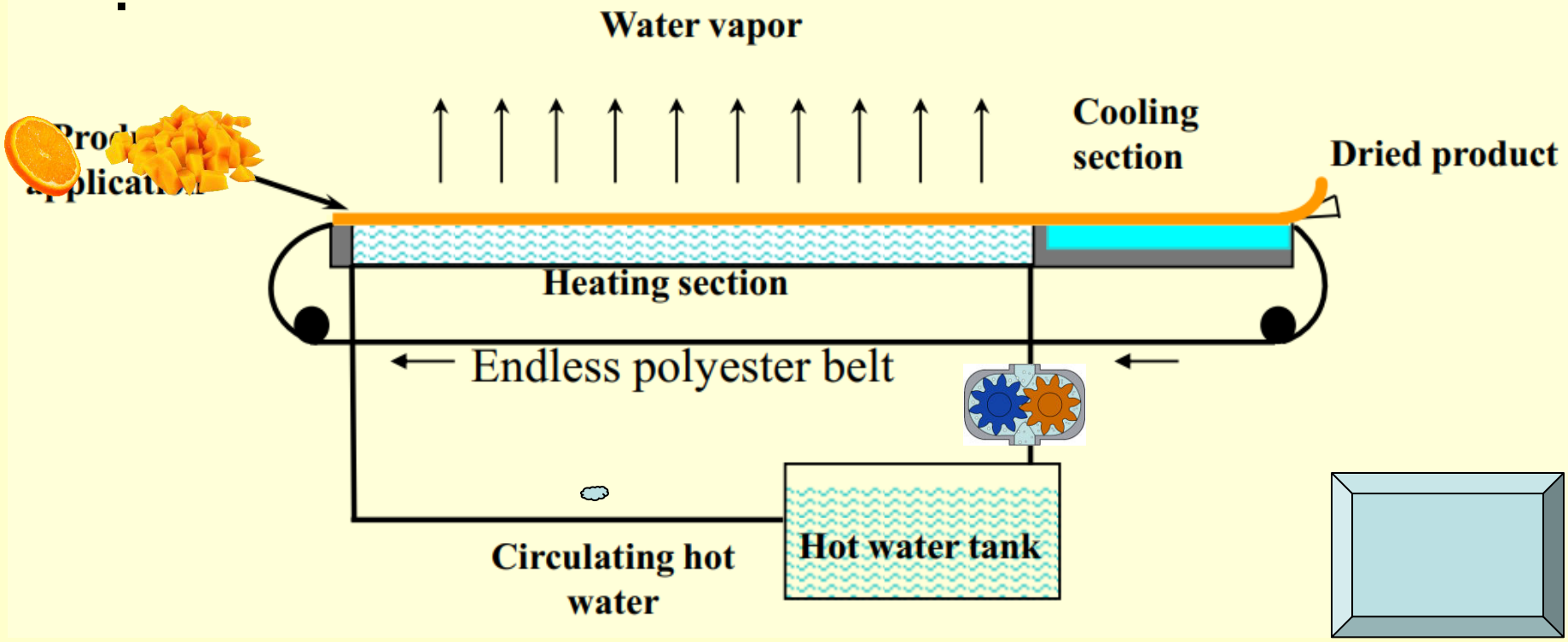
- High value dried products from fruits, vegetables and herbs introduced into Uganda & Kenya markets
- Local fabricators making quality **RWD** equipment suitable for use by local agro-processors
- Increased use of locally produced food ingredients derived from fruits, vegetables and herbs
- Enhanced collaboration among farmers, agro-processors, researchers and support agencies

Why drying

- Widely used preservation technology
- Products are stable under ambient temperature
- Minimizes storage, transportation and packaging costs
- Dried natural products used as ingredients in variety of food products
- Variety of technological options

Why RWDT

- High quality product
- Mechanical simplicity
- Inexpensive
- Energy efficient
- Short drying time


Water vapor
Cooling section
Dried product
Heating section
Endless polyester belt
Hot water tank
Circulating hot water

Commercial RW dryers cost approx 1m US$

Project activities and responsible partners

Activity	Responsible partner
Design of dryers	Mak ABE & KIRDI
Fabrication of dryers	TONNET & KIRDI
Techno-economic evaluation of dryers	FONUS & EAN
Optimisation of drying processes	Mak FTN & JKUAT FST
Evaluation of RWD products	Mak FTN & JKUAT FST
Processors and fabricators capacity assessment	MTIC & KIRDI
Training of farmers and agro-processors	FONUS & EAN
Training of fabricators	Mak ABE & KIRDI
Promotion of RWD use	MTIC, FONUS & EAN
Training of graduate students	Mak & JKUAT

Project outputs

THE REPUBLIC OF UGANDA
THE INDUSTRIAL PROPERTY ACT, 2014

Reg. 43(1)

CERTIFICATE OF GRANT OF UTILITY MODEL

In accordance with the Industrial Property Act, 2014, this is to certify that a Utility Model having the No. **UG/U/ 2020/12** has been granted to **PROF. JOHN H. MUYONGA; DR. JULIA KIGOZI and SHAFFIC SENYIMBA** of **Makerere, Kampala, Uganda; Makerere, Kampala, Uganda and Makerere, Kampala, Uganda** on the **2nd day of November, 2020**.

In respect of an invention disclosed in Utility Model Application No. **UG/U/ 2020/12** filed on the **August 19, 2020** with Priority on: **19/08/2020.**
Being an Invention entitled: **THE ELECTRIC AND BIOMASS POWERED REFRACTANCE WINDOW DRYER APPARATUS**

Dated at KAMPALA this **2nd day of November, 2020**

URSB
UGANDA REGISTRATION SERVICES BUREAU
02 NOV 2020
Ageet Abraham Onyait
REGISTRAR

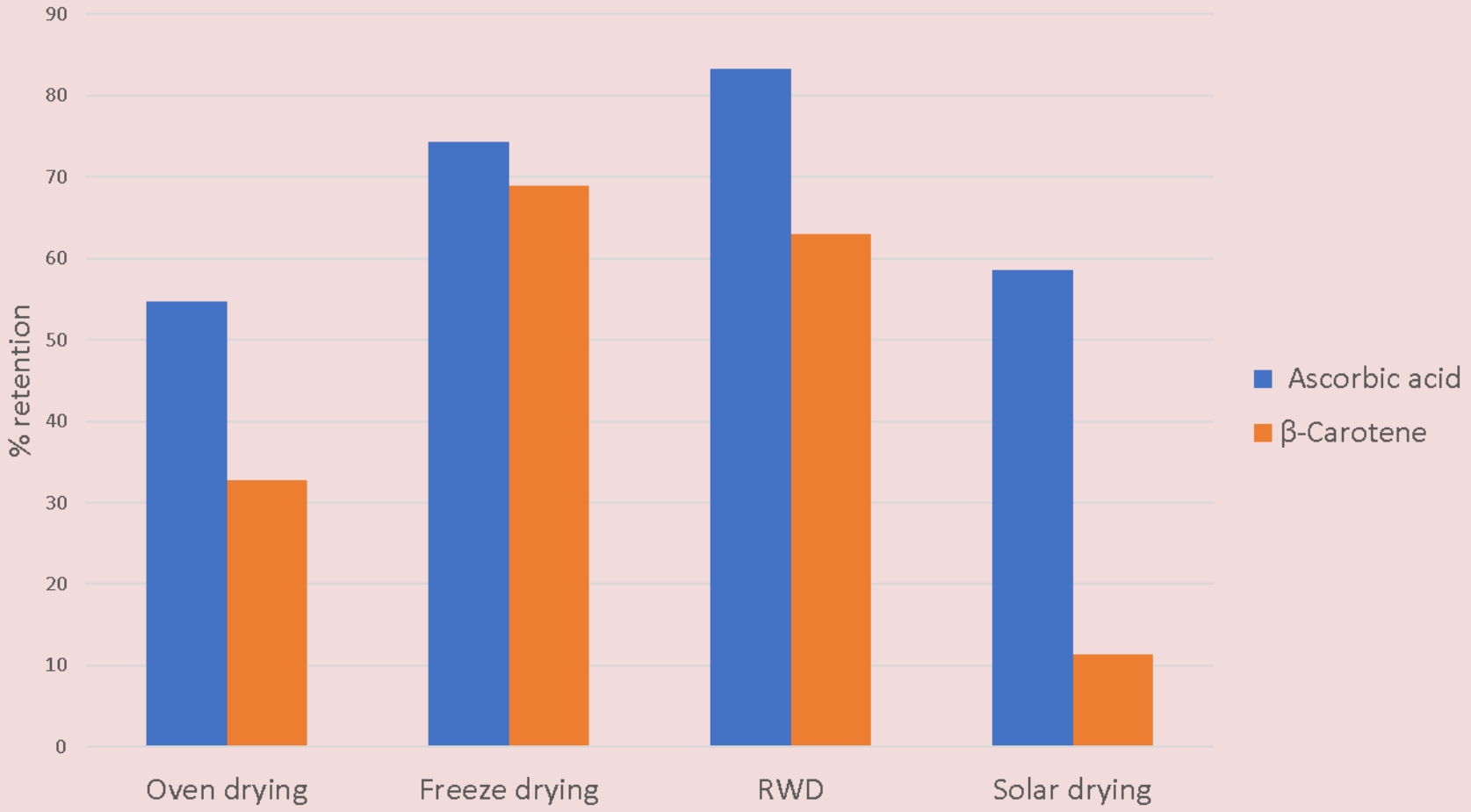
Asst. Registrar of Patents

Developed RW dryers

RW drying conditions for different products optimized

Fruit/Vegetable	Input variables	Response variables	Optimized conditions
Passion fruit juice	Drying temperature and time	Moisture, vitamin C, ß-carotene , total phenolic content and total anti-oxidant activity	82.9 °C and 60 min
Pineapples	Drying temperature and puree/slice thickness	Drying time and vitamin C content	Puree: 86.2 °C and 2.9 mm for 58 mins Slices: 78.9°C and 2 mm for 96 mins
Mango puree	Drying temperature and puree thickness	Vitamin C, β-carotene and duration of drying (time)	74.598 °C and 2.5 mm for 55.6 mins
Jackfruit puree	Drying temperature and puree thickness	Drying time, vitamin C, antioxidant activity and total carotenoid content	93.4°C, 2.56 mm for 62 mins
Cow pea leaves	Drying temperature and time	vitamins A and C, protein and moisture content	72.6℃ and 60 mins

Nutrient retention in jackfruit

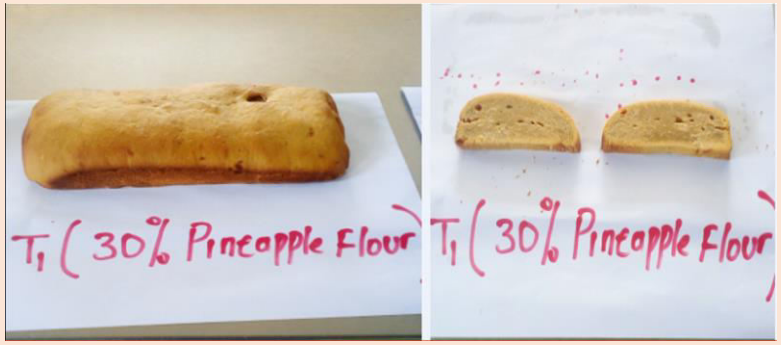


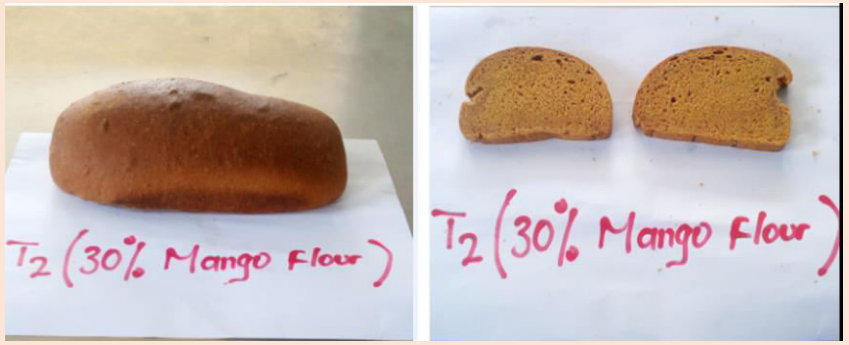
Dried fruit products

Protocols for utilisation of RWD products as ingredients in value added foods

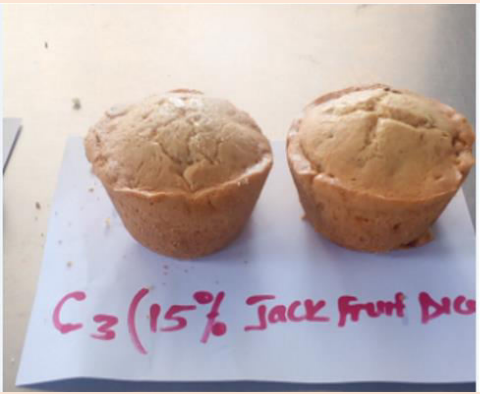
- Bread
- Cakes
- Yoghurt
- Porridge flour
- Reconstituted juice

Bread containing different RW dried fruits





Cakes containing RW dried fruits



Protocols for use of RW dried fruits as ingredients

Schematic diagram for flavouring bread using RWDT dried pineapple dices

Recipe

240g of sugar
90g of Fat
20g of salt
20g of yeast
5g of Calcium
1800g of wheat flour
200g of RWDT pineapple

- Measure out dry cake ingredients according to recipe
- Measure 200g of fruits and add to cake ingredients
- Add fat to the dry ingredients
- Mix the fat and dry ingredients until you get a dough with a good consistency
- Cut and Kneed 560g of dough into baking tins
- Proof the dough for 2 hours
- When the dough is well risen to about half of the tin, transfer to the preheated oven Bake for 40 minutes at 200°C
- Cool bread at room temperature for 50 mins
- Slice and pack

Recipe

Pineapple 2.5% per liter of boiled cool water

OR

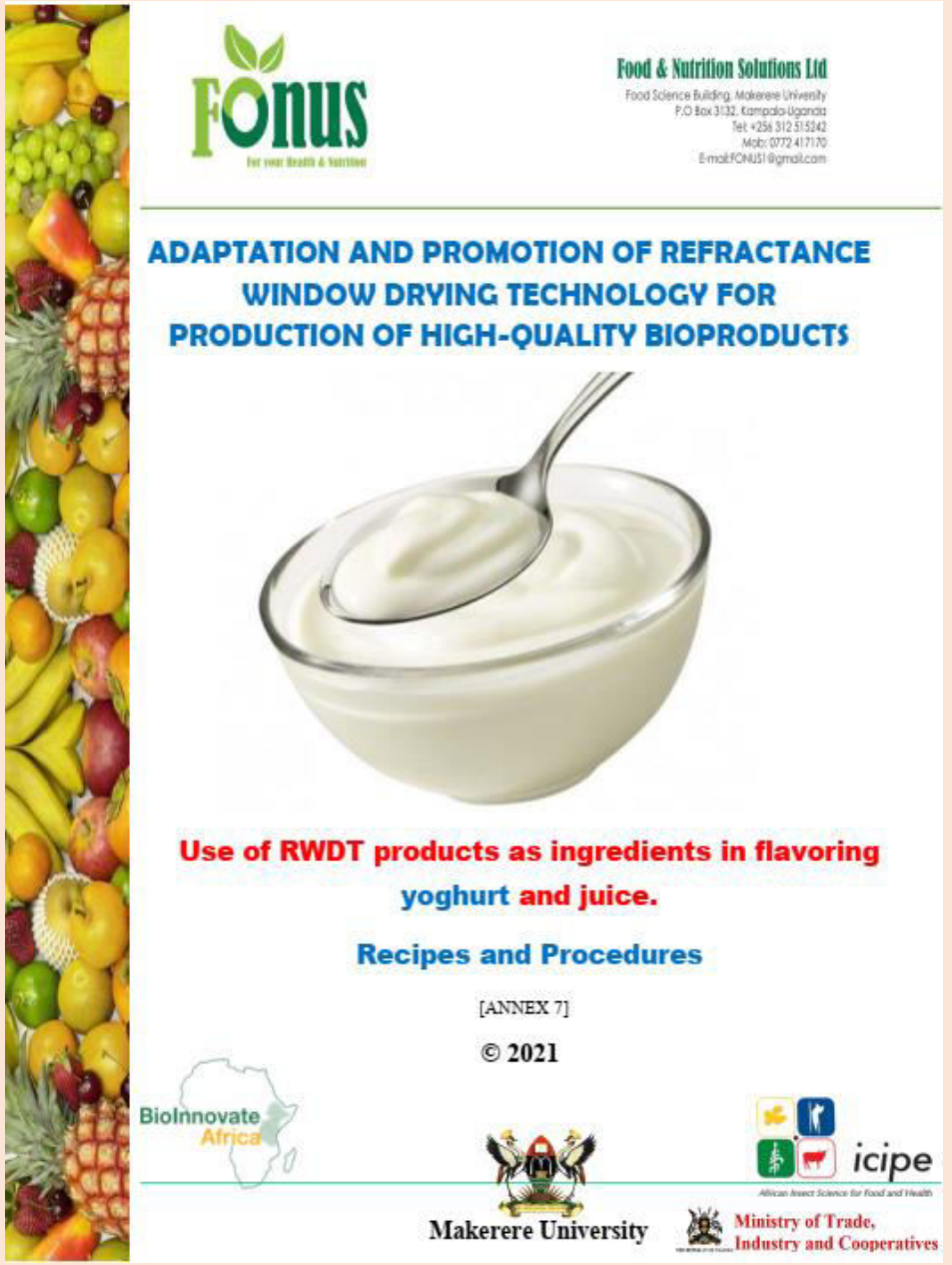
Mango 2% per liter of boiled cool water

OR

Passion fruit 1.5% per liter of boiled cool water

- Measure out 1 litre of plain yoghurt
- Mix 200ml of plain yoghurt into 25g of pre-weighed fruit powder
- Pour the premix into the remaining yoghurt
- Stir for about 5 minutes, be gentle to prevent thinning
- Refrigerate overnight to allow the fruit flavour to permeate into the yoghurt
- Pack yoghurt in clean bottles for distribution or consumption

Guidelines for use of RW dried fruits as ingredients



Training of farmers and agroprocessors

Training covered use of RWD and use of RWD products as ingredient

https://www.youtube.com/watch?v=NJmnSHT51O0

https://youtu.be/NJmnSHT51O0.

Training of fabricators

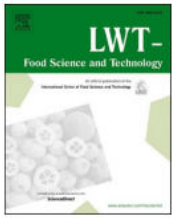
- Sixteen fabricators trained and gained skills in fabrication of different components of the RWD

Twelve journal publications

Contents lists available at ScienceDirect

LWT

journal homepage: www.elsevier.com/locate/lwt



Optimization of refractance window drying conditions for passion fruit puree

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ARTICLE INFO

Keywords:
Refractance window drying
Passion fruit
Optimization
Response surface methodology
Phytochemicals

ABSTRACT

Passion fruits (*Passiflora edulis*) have pleasant flavor, an acidic aroma and high vitamins and phytochemicals content. However, they are highly perishable. In this study, the effect of refractance window drying (RWD) temperature and time on nutrients and antioxidant activity of passion fruits was assessed. Response surface methodology (RSM) was used to optimize the drying temperature and time. Moisture, vitamin C, β-carotene and total phenolic content and total anti-oxidant activity were considered as the response variables. Optimal drying temperature and time conditions were found to be 82.5 °C and 60 min, respectively. The respective values for ascorbic acid, moisture, β-carotene, total antioxidant activity, and total phenolic content under optimal drying conditions were 58.8 mg/100 g solids, 11.1% wet basis, 8.8 μg retinol activity equivalent (RAE)/100g solids, 367.6 mg/100 g solids vitamin C equivalent (VCE) and 352.2 mg/100 g solids gallic acid equivalent (GAE), respectively. All models for prediction of these values were satisfactory and had a non-significant lack of fit ($p < 0.05$). The retention of ascorbic acid, β-carotene, total antioxidant activity, and total phenolic content at the optimal conditions was 90.2, 75.9, 89.7, 88.3%, respectively. Results show that RWD under optimal conditions gives passion fruit powder high nutritional quality.

J Food Sci Technol
https://doi.org/10.1007/s13197-021-05302-2

ORIGINAL ARTICLE

Drying behaviour and optimization of drying conditions of pineapple puree and slices using refractance window drying technology

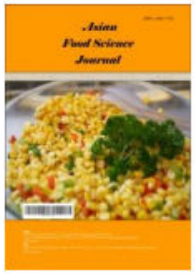
John H. Muyonga[1] · Janet Natocho[1] · Julia Kigozi[2] · Emmanuel Baidhe[2] · Sophie Nansereko[1]

Revised: 6 October 2021 / Accepted: 20 October 2021

Abstract Refractance window drying technology can be used to produce high quality dried fruit products due to its excellent retention of heat sensitive nutrients, organoleptic properties and bioactive compounds. This study optimised conditions for drying of pineapple slices and puree using

Abbreviations

RWD	Refractance window drying
RMSE	Root mean square error



Asian Food Science Journal

20(9): 97-117, 2021; Article no.AFSJ.72518
ISSN: 2581-7752

Exploring the Potential of Jackfruit (*Artocarpus heterophyllus Lam*)

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Authors' contributions

This work was carried out in collaboration between both authors. Author SN designed the study, managed the literature searches, wrote the protocol and wrote the first draft of the manuscript. Author JHM reviewed and edited the manuscript. Both authors read and approved the final manuscript.

Journal of Advances in Food Science & Technology

8(2): 1-10, 2021
ISSN: 2454-4213

ADOPTION OF THE REFRACTANCE WINDOW DRYING TECHNOLOGY IN THE DRYING OF FRUITS AND VEGETABLES IN UGANDA

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Received: 15 March 2021
Accepted: 21 May 2021
Published: 18 June 2021

Original Research Article

ABSTRACT

Farmers in Africa produce a variety of fruits and vegetables with unique nutritional and functional properties that are highly valuable on the international market. The nutritional and functional properties can only be preserved with the use of appropriate drying technologies. Open sun drying and solar drying that are most often used in Uganda require long drying time hence resulting in significant loss of flavor compounds, nutrients, bioactive compounds, and discoloration. With Refractance Window (RW), the fruits and vegetables are conveyed and dried over a bed of hot water using a mylar belt. The dryer therefore offers mechanical simplicity and relatively high drying speed. The advantages of the RW dryer over the conventional method creates an edge for its future development. However, available RW dryers are of very high capacities and cost making them unsuitable for the small-scale processors. In this study, a relatively low capacity (14 - 18 kg/hr of raw material) RW dryer was designed, fabricated, tested and assessed for potential adoption by the processors/farmers. It was noted that potential for adoption is largely constrained by high operation costs associated with electricity

IJSCIA

International Journal of Scientific Advances
ISSN: 2708-7972
Volume: 2 | Issue: 5 | Sep - Oct 2021 Available Online: www.ijscia.com
DOI: 10.51542/ijscia.v2i5.25

Arduino based control of the Food and Water Conveyance Systems of a Refractance Window Dryer

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ABSTRACT

A refractance window dryer with a 14.5kg/hr throughput capacity was developed to effectively dry food product of 3mm on the conveyor belt. For efficient dryer performance an automated system for the conveyor belt movement and water conveyance system was designed. The automated system comprised of an ARDUINO centered control system, an arrangement of sensors, water pump and the conveyor motor. A computer program was written in Arduino environment, successfully compiled and uploaded on to the controller board to process all commands. The system was first simulated successfully in ISIS Proteus environment and connected onto a bread board for testing before attaching the motor onto the main circuit board. Performance tests done at 85°C revealed that there was no movement of the belt as temperature built steadily from 31.19°C until it reached a temperature of 92.0°C in the boiler. The maximum recorded water temperature was 98.06°C and the system had an operating range of 95±3°C. Achieving this led to an automated food conveyance system that was reliable and ensured high product quality. The Arduino based system worked well and is recommended for the refractance window dryer and can be up scaled to a bigger similar machine.

Publications

- Kigozi, J., Ssenyimba, S., Mutumba, R., Baidhe, E., Oluk, I., Tumutegyereize, P., & Muyonga, J. (2021). Adoption of the refractance window drying technology in the drying of fruits and vegetables in Uganda. *Journal of Advances in Food Science & Technology*, 1-10.
- Nyaguti, W. A., Wanjala, G. W.,Kamau, J., & Warui, S. (2021). Techno-Economic Analysis of a Refractance Window Dryer Prototype Developed by Kenya Industrial Research and Development Institute. Current Journal of Applied Science and Technology 40(28).
- Ssenyimba, S., Kigozi, J., Tumutegyereize, P., Muyonga, J. H., & Mutumba, R. (2021). Design and evaluation of a refractance window lab-scale dryer. *Journal of Engineering, Design and Technology*
- Muyonga, J. H., Natocho, J., Kigozi, J., Baidhe, E., & Nansereko, S. (2021). Drying behaviour and optimization of drying conditions of pineapple puree and slices using refractance window drying technology. *Journal of Food Science and Technology*, 1-10.
- Asiimwe, A., Kigozi, J. B., Baidhe, E., & Muyonga, J. H. (2022). Optimization of refractance window drying conditions for passion fruit puree. *LWT*, *154*, 112742.
- Nansereko, S., Muyonga, J., & Byaruhanga, Y. B. (2021). Optimization of drying conditions for Jackfruit pulp using Refractance Window Drying technology. *Food Science & Nutrition*

Publications

- Mutumba, R., Kigozi, J., Tumutegyereize, P., Ssenyimba, S., & Muyonga, J. Performance Analysis of An Arduino Based Calibration and Temperature Control System for A Refractance Window Dryer.

- Mutumba, R., Kigozi, J., Tumutegyereize, P., Ssenyimba, S., & Muyonga, J. Arduino based control of the Food and Water Conveyance Systems of a Refractance Window Dryer.

- Namayengo, F. M., Raymonds, M., Alex, A., & Muyonga, J. H. Techno Economic Analysis of Refractance Window Drying of Fruits: A Case of Small-Medium Scale Agro Processors in Uganda.

- Asiimwe, A., Kigozi, J. B., & Muyonga, J. (2021). Physicochemical Properties, Sensory Acceptance and Storage Stability of Yogurt Flavoured with Refractance Window Dried Passion Fruit Powder. *Asian Food Science Journal*, 38-49.

- Nansereko, S., & Muyonga, J. H. Exploring the Potential of Jackfruit (*Artocarpus heterophyllus Lam*). (2021). *Asian Food Science Journal*. Page 97-117 DOI: 10.9734/afsj/2021/v20i930346.

Menu Search

MONITOR

Magazines

Simple technology to dry your farm produce

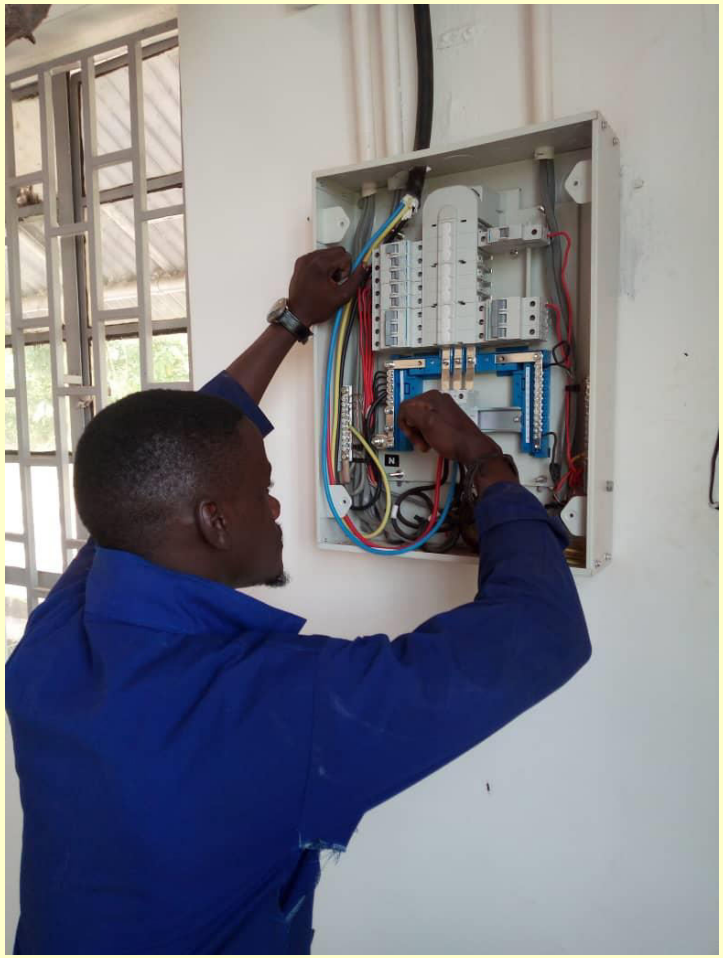
Friday, August 07, 2020 — updated on August 14, 2020

https://www.monitor.co.ug/uganda/magazines/farming/simple-technology-to-dry-your-farm-produce-1916050?view=htmlamp

Makerere University develops Refractance Window Dryer(RWD)

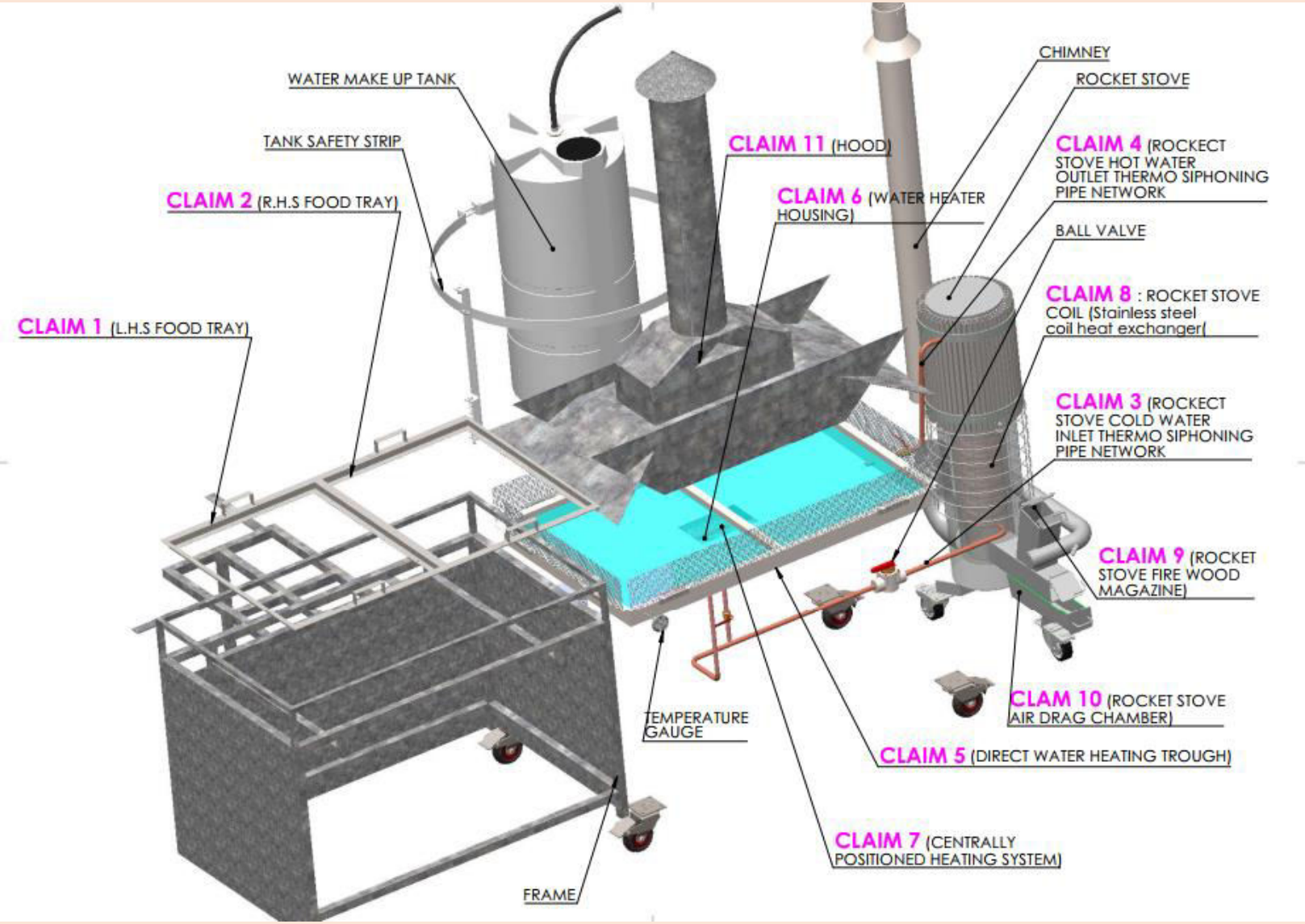
https://www.youtube.com/watch?v=tWJ9EVkjfro

Supported training of 6 grad students (2 PhD & 4 M.Sc.)



Institutional facilities improvement

One utility model and one patent application



Commercialisation arrangements

- Product development with materials dried using RWD as ingredients under development
- MoU between Makerere University and private firm to oversee utilisation of RW equipment at MUARIK for commercial production of value added foods
- Three (two in Uganda and one in Kenya) agro-machinery companies equipped to produce RW dryers under technical guidance of Mak and KIRDI staff
- Engagement with development agencies about financing of farmer groups to procure RWD

Thank you