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ICS 65.060.01

Agricultural machinery – Fruit Dryer – Specifications

BUREAU OF PRODUCT STANDARDS

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National Foreword

This Philippine Agricultural Engineering Standards PAES 248:2010, Agricultural machinery – Fruit Dryer – Specifications was approved for adoption as Philippine National Standard by the Bureau of Product Standards upon the recommendation of the Agricultural Machinery Testing and Evaluation Center (AMTEC) and the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development of the Department of Science and Technology (PCARRD-DOST).

Foreword

The formulation of this national standard was initiated by the Agricultural Machinery Testing and Evaluation Center (AMTEC) through the project "Development of Standards for Agricultural Production and Postharvest Machinery" funded by Philippine Council for Agriculture, Forestry and Natural Resources Research and Development of the Department of Science and Technology (PCARRD-DOST)

This standard has been technically prepared in accordance with BPS Directives Part 3:2003 – Rules for the Structure and Drafting of International Standards.

The word "shall" is used to indicate mandatory requirements to conform to the standard.

The word "should" is used to indicate that among several possibilities one is recommended as particularly suitable without mentioning or excluding others.

In the preparation of this standard, the following documents/publications were considered:

PAES 201:2000 Agricultural Machinery – Heated-Air Mechanical Grain Dryer - Specifications

PNS/BFAD 15:2007 ICS 67.080 Philippine National Standard – Dried Mango Products – Specification

PNS/BFAD 16:2007 ICS 67.080 Philippine National Standard – Dried Tropical Fruits - Specification

Belonio, Alexis T. *Agricultural engineering formula*. Department of Agricultural Engineering and Environmental Management, College of Agriculture, Central Philippine University, Iloilo City, Philippines. 2003.

SolarFlex fruit and vegetable dryer. Malnutrition Matters: Food Technology Solutions. SloarFlex Dryers and Heaters. May 2008

Multi-Commodity solar tunnel dryer. Bureau of Postharvest Research and Extension, Department of Agriculture. 2009

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Taduran, Cromwell M. *An assessment of the quality of locally available dried magoes*. Undergraduate Thesis. Agricultural and Bio-Process Division, Institute of Agricultural Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños. April 2003.

Ilagan, Donna Cuevas. *Processing of dried mango (mangifera indica linn,) cubes and slices*. Undergraduate Thesis. Agricultural and Bio-Process Division, Institute of Agricultural Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños. October 2003.

Optimization of the heated air drying of "saba" Banana (*Musa sepientum L. var. compressa*). Undergraduate Thesis. Agricultural and Bio-Process Division, Institute of Agricultural Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños. October 2000.

Factor, Michael Frias. *The drying characteristics of sliced pineapple*. Undergraduate Thesis. Agricultural and Bio-Process Division, Institute of Agricultural Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños. April 2004.

Queja, Rey Manuel Bagalacsa. *Evaluation of the drying performance of a laboratory-scale heat pump dryer using several high-value crops*. Agricultural and Bio-Process Division, Institute of Agricultural Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños. April 2006

Rayel, April Rose Relato. *Optimiztion of heated air drying of apple* (*Malus domestica L. var. Fuji*). Agricultural and Bio-Process Division, Institute of Agricultural Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños. April 2006.

Fernandez, Melanie Magpantay. *Optimization of heated air-drying of jackfruit* (*Artocarpus heterophyllus lam.*). Agricultural and Bio-Process Division, Institute of Agricultural Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños. April 2007.

AMTEC Test and Evaluation Report on Fruit Dryer

1 Scope

This standard specifies the manufacturing and performance requirements for fruit dryer used for drying sliced fruits such as mango, pineapple, papaya, banana, jackfruit, apple, etc.

2 References

The following normative documents contain provisions, which, through reference in this text, constitute provisions of this National Standard:

AWS D1.1:2000 Structural Welding Code - Steel

PAES 102:2000 Agricultural Machinery – Operator's Manual – Content and Presentation

PAES 103:2000 Agricultural Machinery – Method of Sampling

PAES 311:2001 Engineering Materials - Screws for Agricultural Machines – Specifications and Applications

PAES 313:2001 Engineering Materials – Bolts and Nuts for Agricultural Machines – Specifications and Applications

PAES 249:2010 Agricultural Machinery – Fruit Dryer – Methods of Test

3 Definitions

For the purpose of this standard the following definitions shall apply:

3.1
fan
blower
air moving device that is used to force heated air through the mass of materials to be dried at the desired air flow rate and pressure

3.2
fruit
ripened ovary or ovaries of a seed-bearing plant that are edible, usually sweet and in fleshy form

3.3
fruit dryer
device for removing excess moisture from the fruits, generally by forced or natural convection with or without addition of heat (see Figure 1)

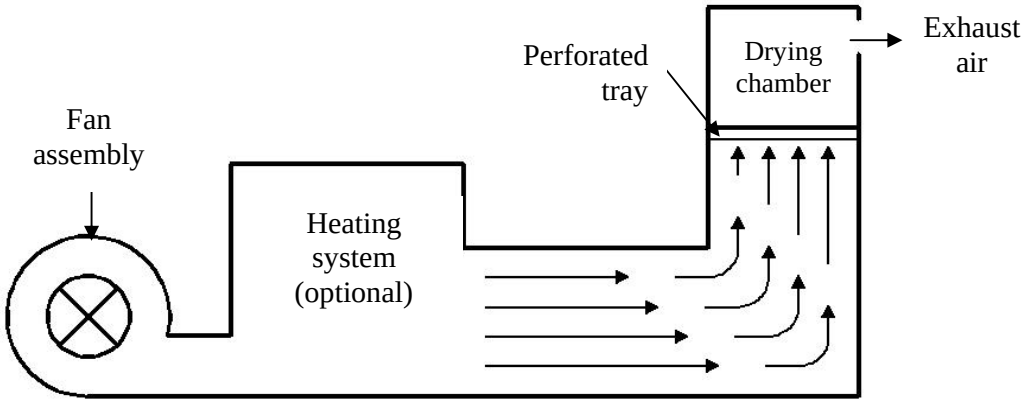

Figure 1. Diagram of fruit dryer

3.4
moisture gradient
difference between the maximum and the minimum moisture content randomly sampled after drying

3.5
plenum
chamber wherein air pressure is developed for uniform distribution of the heated air through the material to be dried.

3.6
safety device
any device that is used to avoid human accident and/or damage to the parts and components of the dryer during the operation and automatically shuts-off the operation of the dryer in case of malfunction

3.7
water activity
ratio of vapor pressure of water in the product to the water vapor pressure of pure water at the same temperature.

Note: Measure of water available for the growth of microorganism

4 Classification

The classification of fruit dryer shall be based according to:

4.1 System Operation

4.1.1 Batch/Tunnel type

Mechanical dryer wherein the sliced fruits in fixed volume are held in the drying chamber in batches until it reaches the desired moisture content.
(see FigureS 2a, 2b and 2c)

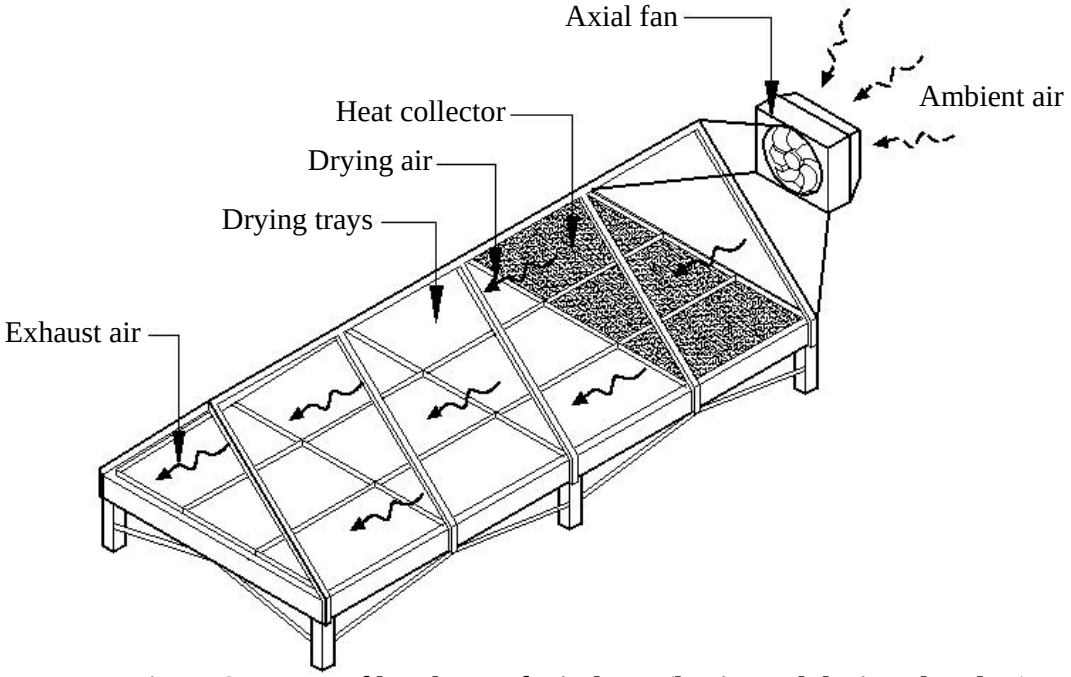

Figure 2a. Parts of batch type fruit dryer (horizontal drying chamber)

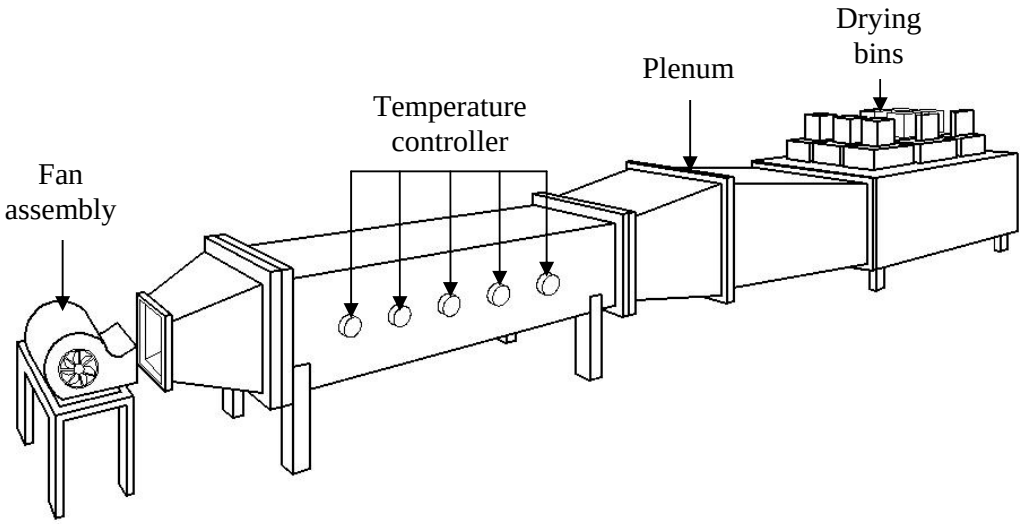

Figure 2b. Parts of batch type fruit dryer (vertical drying chamber)

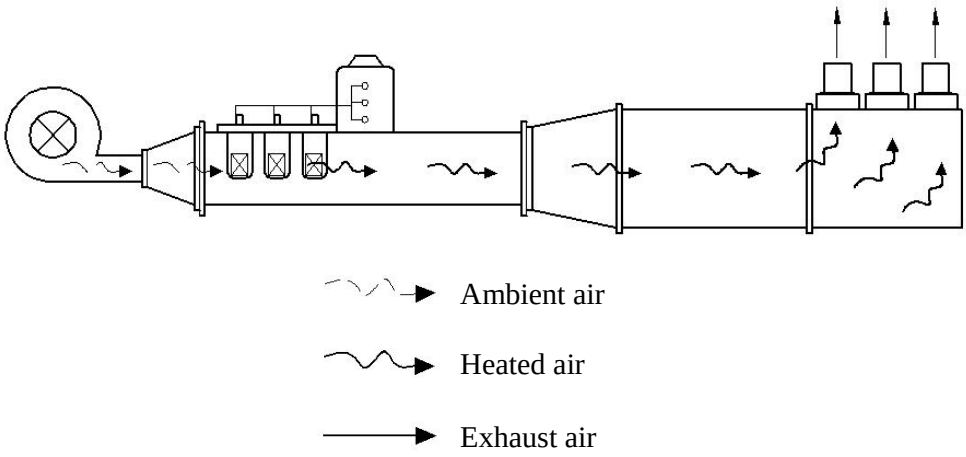

Figure 2c. Flow diagram of batch type fruit dryer (vertical drying chamber)

4.1.2 Tray/Cabinet type

Mechanical dryer wherein fixed volume of sliced fruits are placed on perforated tray(s) in the drying chamber until it reaches the desired moisture content.
(see Figure 3)

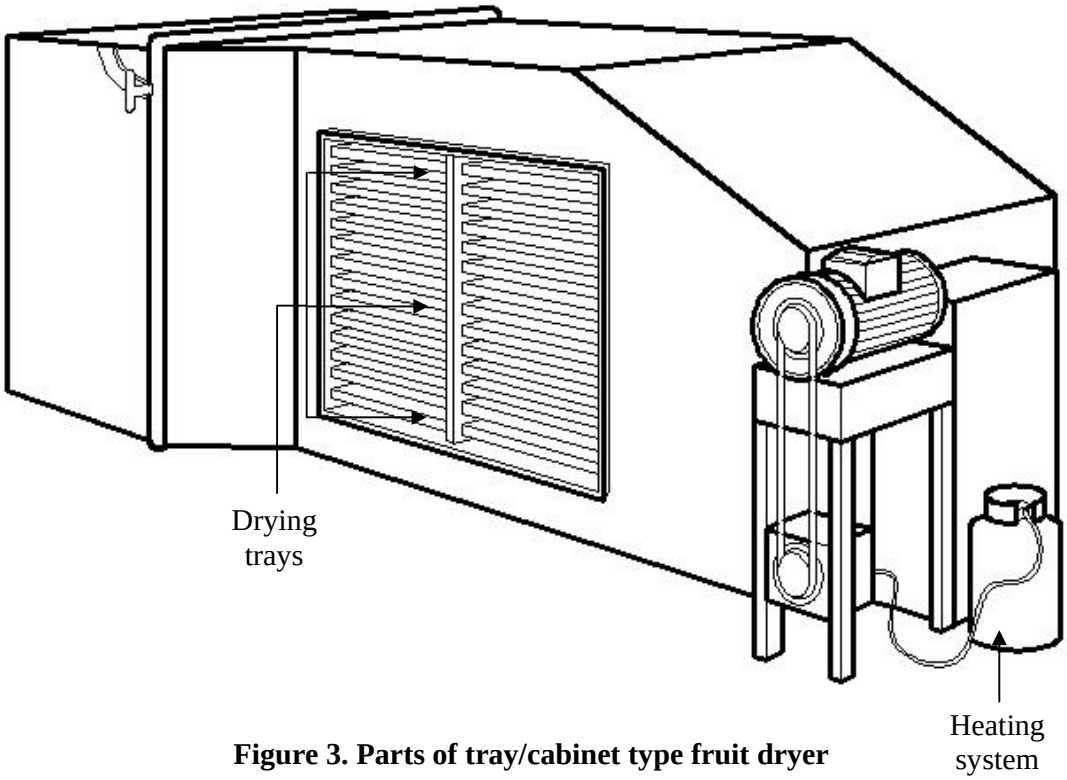

Figure 3. Parts of tray/cabinet type fruit dryer

4.2 Heating System

4.2.1 Method of heating the drying air

4.2.1.1 Fuel burning

This type of fruit dryer heats up the drying air by direct burning of fuel inside the heating chamber.

This shall be further classified according to the following:

4.2.1.1.1 Direct

Dryer in which the products of combustion come into direct contact with the product being dried. (see Figure 4)

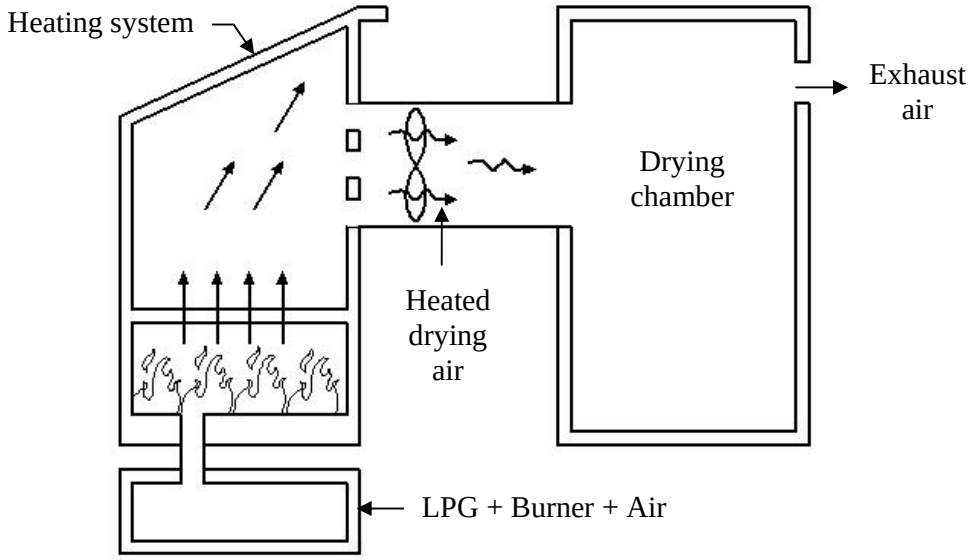

Figure 4. Direct heating system for fruit dryer

4.2.1.1.2 Indirect

Dryer in which the products of combustion do not come in contact with the products being dried. This type uses heat exchanger. (see Figure 5)

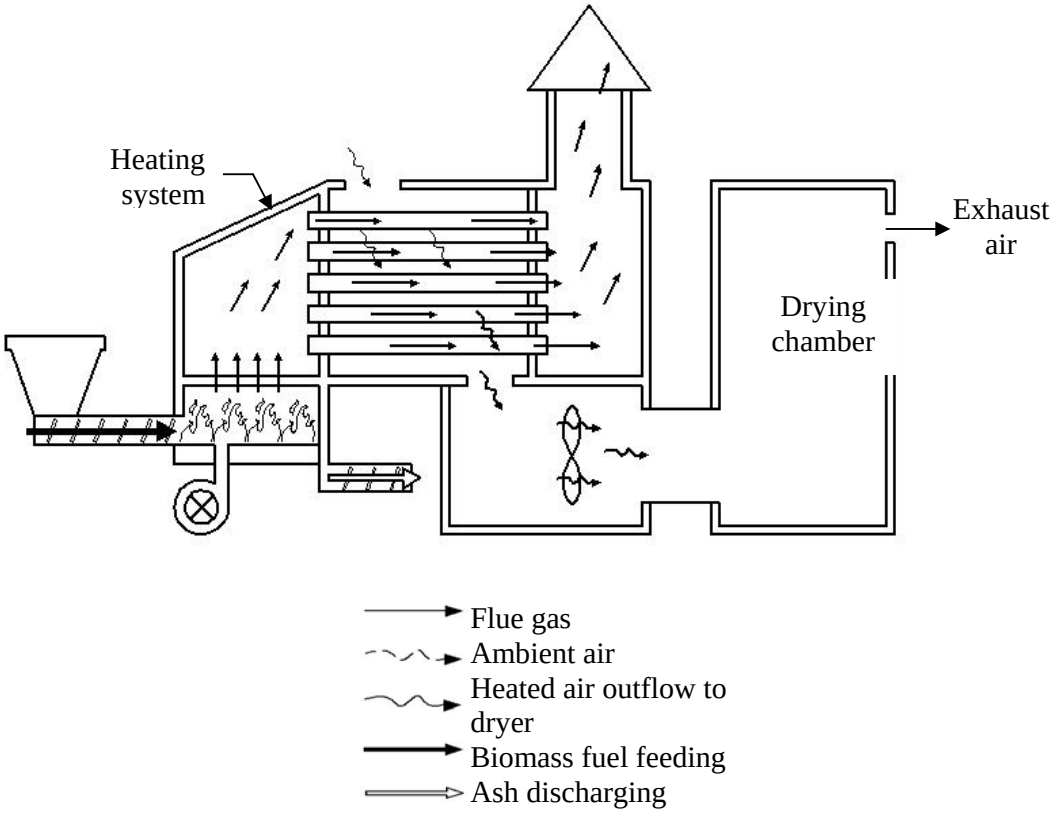

Figure 5. Indirect heating system for fruit dryer

4.2.1.2 Heat pump

Fruit dryer type that heats the drying air through the use of reversed refrigeration system. (see Figures 6a and 6b)

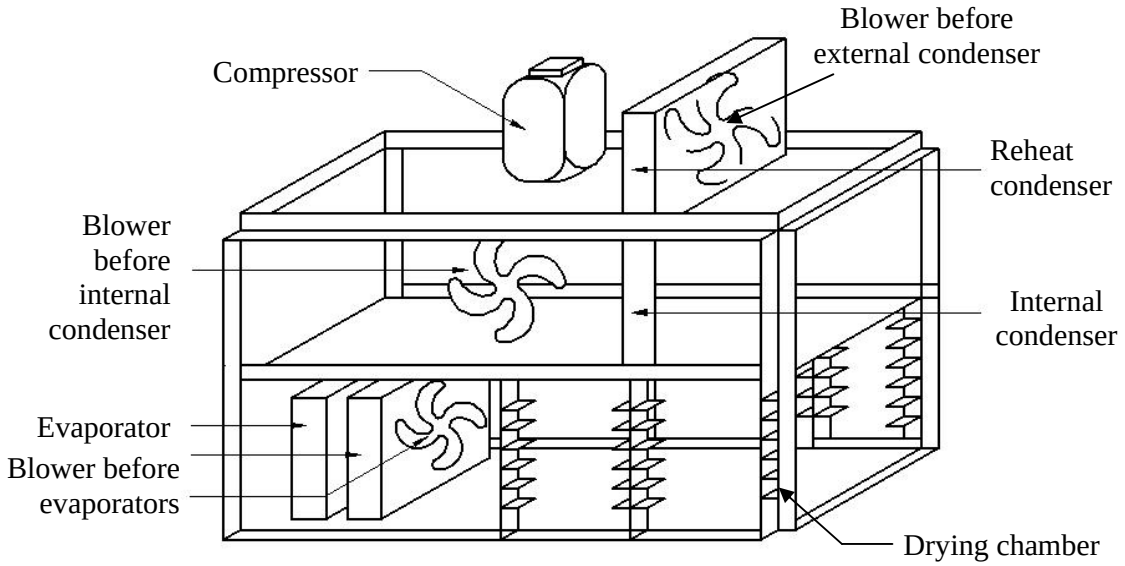

Figure 6a. Parts of heat pump fruit dryer

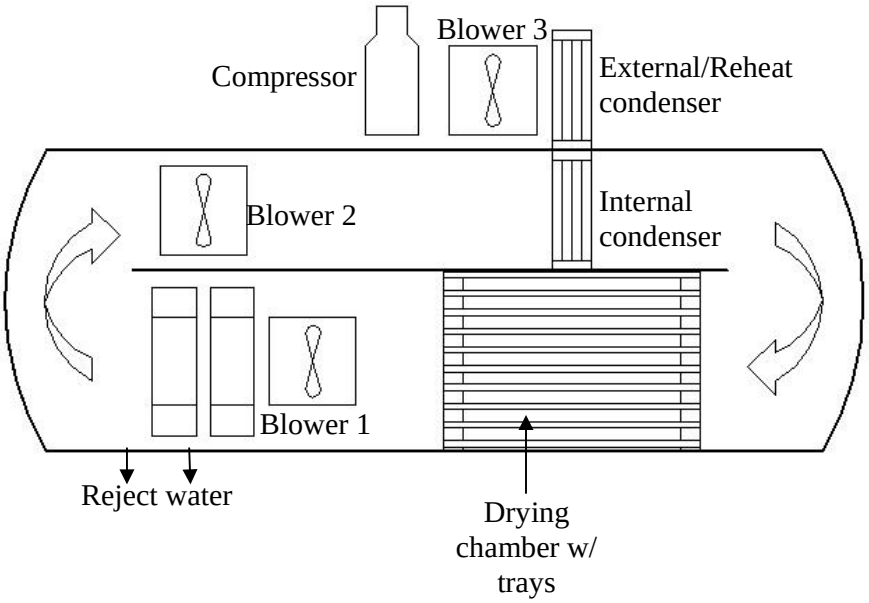

Figure 6b. Flow diagram of heat pump tray type dryer

4.2.2 Fuel Source

4.2.2.1 Conventional energy

Source of energy which includes petroleum-based fuels (LPG and propylene).

4.2.2.2 Non-conventional energy

Source of energy that includes non-petroleum fuels such as biomass and solar energy.

4.2.2.2.1 Biomass energy

Fruit dryer is coupled to an indirect-fired biomass furnace where the drying air is being heated using heat exchangers. (see Figure 5)

4.2.2.2.2 Solar energy

Fruit dryer is coupled to an air type solar collector where the air is being heated and ducted to the drying chamber. Air circulation can be by natural convection or by using blowers. (see Figure 7)

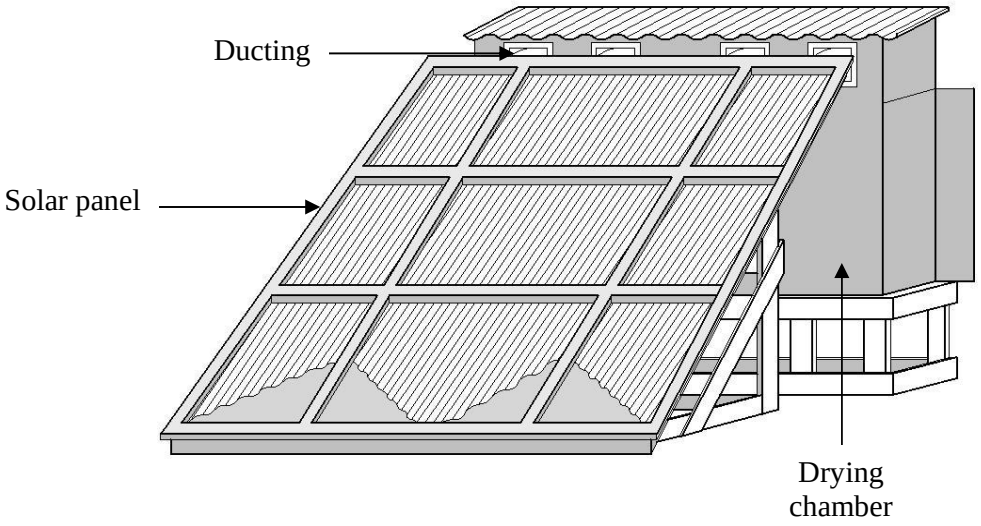

Figure 7. Fruit dryer using solar energy

5 Manufacturing Requirements

5.1 Fruit dryer shall be generally composed of drying chamber, tray cart (if necessary), drying racks/drying bin(s), plenum and/or ducting, blower/fan, heating system, control panel and safety features.

5.2 Stainless steel sheets, steel bars, heavy-duty mild steel, industrial plastics and hard wood shall be generally used for the manufacture of the different components of the fruit dryer.

5.3 Tunnel fruit dryer shall be composed of drying bed, drying trays, heat collector, blower, burner (for supplemental heating on rainy days) and top plastic cover.

5.3.1 Top plastic cover for tunnel fruit dryer shall be made of UV stabilized polyethylene plastic sheets. This shall be used to cover the heat collector and the drying chamber.

5.3.2 There shall be provision to properly secure the plastic cover.

5.3.3 The dryer stand and the floor panel shall be rigid and shall be able to support the maximum drying capacity of the tunnel fruit dryer.

5.4 Solar fruit dryer shall be composed of air type solar energy collector/panel (teflon coated), ducting, fans/blowers, inlet of drying air, drying chamber, drying trays and exhaust for drying air.

5.5 Heat pump fruit dryer shall be composed of a compressor, condensers, evaporators, drying chamber, drying trays and blowers.

5.5.1 There shall be provision for the discharging of the condensed moisture from the sliced fruits.

5.5.2 Blower(s) shall be placed before the evaporator and condenser to effect air circulation inside the dryer.

5.5.3 Thermostats shall be installed in the evaporators and condensers to monitor temperature.

5.5.4 Pressure gauges shall be installed before and after the compressor to monitor the refrigerant.

5.5.5 General parts of the heat pump fruit dryer shall be made of stainless steel and food-grade materials.

5.5.6 The outer frame of the heat pump fruit dryer shall be covered with a minimum of one-inch thick styrofoam as insulation.

5.5.7 Non-ozone depleting refrigerant (e.g. HFC-134a, HFC-236fa, etc.) shall be used as the refrigerant of the heat pump dryer.

5.5.8 Maximum range of drying air temperature to be used in heat pump fruit dryer shall be 60°C to 70°C.

5.6 Walls and floorings of the drying chamber shall be rigid to be able to support the maximum load capacity of the fruit dryer. It shall be made of food grade non-corrosive materials (e.g. stainless steel, aluminum, etc.). Floorings shall be perforated or meshed.

5.7 For tray/cabinet type, tray cart shall be made rigid to be able to support the drying racks/trays. It shall be made of food grade non-corrosive materials (e.g. stainless steel, aluminum, etc.). It shall have rubber wheels for ease in transporting the drying racks inside and outside the drying chamber.

5.8 Drying racks/trays/bins shall be rigid to be able to support its maximum load capacity. It shall be made of food grade non-corrosive materials (e.g. stainless steel, aluminum, etc.) and shall be perforated.

5.9 Turning vanes shall be provided on the fruit dryer to ensure uniform flow of drying air across the drying chamber and to reduce pressure drop.

5.10 Air velocity inside the drying chamber of fruit dryer should be at least 0.2 m/s.

5.11 There shall be provision for the exhaust of the drying air after passing through the sliced fruits to be dried.

5.12 There shall be provision for ease of handling of the drying trays in and out on the walls of the dryer and/or on the tray cart.

5.13 Bolts and screws to be used shall conform to PAES 311 and 313.

5.14 Sizes of the parts of the fruit dryer shall be based on the specifications of the manufacturer.

5.15 Maximum drying capacity and holding capacity shall be based on the specifications of the manufacturer.

6 Performance Requirements

6.1 Final moisture content wet basis of the fruit to be dried shall not be more than 15%.

6.2 Water activity of dried fruits shall not be more than 0.70 at 25 °C.

6.3 Drying temperature and sliced thickness should be dependent on the type of fruit to be dried. (see Table 1)

Table 1. List of fruits to be dried with their recommended sliced thickness and drying temperature

Fruits	Sliced thickness, mm	Drying Temperature, °C
Pineapple	10	60
Papayas	8 to 10	60
Mango	2 to 4	55
Banana	3.3 to 3.9	54 to 57.5
Apple	3	88
Jackfruit	Depends on thickness of pulps	83

Source: Undergraduate theses for fruit dryer from Agricultural and Bio-Process Division, Institute of Agricultural Engineering, College of Engineering and Agro-Industrial Technology, University of the Philippines Los Baños

6.4 When drying sliced mango, appearance/color shall be moderate yellowish brown and hardness shall be in between 4.4g to 6.4g.

6.5 Minimum drying efficiency of the fruit dryer shall be 75%.

6.6 Actual performance factor shall be at least 70% of the total carnot cycle performance factor of the heat pump fruit dryer system.

6.7 The minimum heating system efficiency shall be the following:

Petroleum based fuel (direct-fired)	90%
Petroleum based fuel (indirect-fired)	75%
Biomass fuel (indirect-fired)	50%

6.8 The actual holding capacity of the fruit dryer shall conform to the specification of the manufacturer.

6.9 The dried fruit shall have no traces of foreign matters on its surface, no unacceptable discoloration and no fermented or musty smell.

6.10 The fruit dryer during operation shall have uniform and equally distributed drying air temperature to the drying chamber.

7 Safety, Workmanship and Finish

7.1 All rotating components shall be statically and dynamically balanced.

7.2 The fruit dryer shall have adequate protection from or for all moving parts.

7.3 The fruit dryer shall be free from manufacturing defects and sharp edges and surfaces.

7.4 Metal parts should be machine pressed if necessary. Cut and weld method shall be avoided. All rough surfaces should be smooth.

7.5 Surfaces that are not in direct contact with the fruits to be dried shall be coated with food grade paint material.

7.6 There shall be adequate provision for fire control.

7.7 There shall be provision for access to parts during repair, maintenance and operation.

7.8 The noise emitted by the dryer shall not exceed 92 dB(A).

7.9 All welded parts shall be air-tight and smoothly polished and it shall pass visual inspection criteria (AWS D1.1:2000) for discontinuity of materials.

7.10 Welded joints shall not be less than 4 mm (1/8 inch) side fillet welded. Undercut shall not exceed 2 mm (1/16 inch) for any length of weld.

8 Warranty for Manufacturing and Durability

8.1 Warranty against defective materials and workmanship shall be provided for parts and services except for normal wear and tear of consumable parts such as belts within one year from the date of purchase of the fruit dryer.

8.2 The construction shall be rigid and durable without breakdown of its major components for at least one year from the date of purchase of end-user.

9 Maintenance and Operation

9.1 Every fruit dryer unit shall be provided with basic tools, operation and parts manual containing full information on method of installation and operation. The manual which conforms to PAES 102 shall be provided.

9.2 Manufacturers/distributors shall provide after-sales service, identify fast wearing parts and should ensure availability of spare parts.

10 Sampling

Fruit dryer shall be sampled for testing in accordance with PAES 103.

11 Testing

Fruit dryer shall be tested in accordance with PAES 249.

12 Marking

12.1 Each fruit dryer shall be marked in English with the following information using a stencil or by directly punching it on a plate and shall be positioned at a most conspicuous place:

12.1.1 Registered trademark of the manufacturer

12.1.2 Brand

12.1.3 Model

12.1.4 Serial number

12.1.5 Drying capacity, kg/h

12.1.6 Holding capacity, kg/batch

12.1.6 Rated power/voltage/frequency/phase, in metric units

12.1.7 Name and address of the manufacturer

12.1.8 Name and address of the importer, if imported

12.1.9 Country of manufacture (if imported) / “Made in the Philippines” (if manufactured in the Philippines)

12.2 Safety/precautionary markings shall be provided when appropriate. Marking shall be stated in English and Filipino and shall be printed in red color with a white background.

12.3 The markings shall have a durable bond with the base surface material.

12.4 The markings shall be all weather resistant and under normal cleaning procedures, it shall not fade, discolor, crack or blister and shall remain legible.

Philippine Agricultural Engineering Standards

AMTEC-UPLB – PCARRD Project: "Development of Standards for Agricultural Production and Postharvest Machinery"

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