Embodiment design of *Moringa Oleifera* rotary dryer using VDI 2221 method

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Abstract. In order to find the solution to the current problems of drying process of Moringa Oleifera in East Nusa Tenggara (NTT)-Indonesia such as requiring a large enough space and power, expensive, non-ergonomic and need to turn the leaves over at least once manually using hand during the drying process that can contaminate the process, a new suitable drying method is necessary. Therefore, embodiment design of drying method using VDI 2221 method was studied. The results indicated that a new suitable drying method of moringa oleifera using VDI 2221 method can be made by successfully designing and manufacturing a rotary dryer based on the selection of the best concept from a variety of existing design concepts. In summary from the perspective of engineering design, after testing, the rotary dryer was suitable and can be used to solve current problems of drying process of Moringa Oleifera in East Nusa Tenggara-Indonesia.

1. Introduction

Malnutrition has become a serious problem from toddlers to the elderly. Malnourished children will experience various disorders such as in terms of physical, mental, and intellectual growth which results in increased mortality and reduced learning ability, as well as the body's immune system against various diseases and work productivity [1]. One solution to overcome this condition is by consuming vegetables with high nutritional content values such as *Moringa Oleifera*. *Moringa Oleifera* (leaves) is a type of plant from the *Moringaceae* tribe. Indonesia, especially the province of East Nusa Tenggara (NTT), there are many *Moringa Oleifera* plants that grow evenly throughout the region and this potential has not been fully utilized and researched. According to previous studies [2-5], *Moringa Oleifera* contains vitamins A, B, C, D, E, K, folic acid, biotin and also contains various kinds of amino acids, including amino acids in the form of aspartic acid, glutamic acid, alanine, valine, leucine, isoleucine, histidine, lysine, arginine, venilalanine, triftopan, cysteine, and methionine. With such complete nutrition, *Moringa Oleifera* can be a solution to overcome malnutrition problems from toddlers to the elderly [6].

A drying method of *Moringa Oleifera* is a fundamental post-harvest processing before being used as a material of food, beverages and pharmaceuticals. The existing drying equipment of *Moringa Oleifera*, especially in NTT, has several disadvantages such as: requiring a large enough space and power, expensive, non-ergonomic and need to turn the leaves over at least once manually using hand during the drying process that can contaminate the process. Consequently, it comes a need to study a new design of drying method using a specific engineering method to overcome the existing problems of drying process of *Moringa Oleifera* in NTT. VDI 2221 method was seen as necessary in order to focus on the
phases: clarification of the task, conceptual design and embodiment design which based on the needs and easiness in both design and assembling or fabricating process [7-9]. Therefore, a study in order to design the rotary drying system of *Moringa Oleifera* using the VDI 2221 method is needed.

2. Material and methods

2.1. *Moringa Oleifera*

*Moringa oleifera* is a plant that is easy to grow in tropical and subtropical areas on all types of soil and is resistant to dry seasons with drought tolerance of up to 6 months. *Moringa* plants are plants with a height of 7-11 meters and thrive from the lowlands to an altitude of 700 m above sea level.

2.2. Design methods of VDI 2221

This method is a "systematic approach to design for engineering systems and engineering products" described by G. Pahl and W. Beitz [10].

3. Results and discussion

The design process using the VDI 2221 method has several stages that must be carried out, starting from job descriptions to prototyping. As a starting point in the design of *Moringa* leaves the dryer with a rotary system, need to set their initial specifications by taking into account the requirements of demand or wishes, as seen in Table 1.

| Parameter            | Specification                          | Demand (D) / Wish (W) |
|----------------------|----------------------------------------|-----------------------|
| Geometry             | Design dimensions                      | W                     |
| Force                | High stiffness                         | D                     |
|                      | Emphasis right                         | D                     |
|                      | Using an electric motor                | D                     |
|                      | Material-saving design form            | W                     |
| Energy               | Energy comes from electricity          | D                     |
|                      | The energy used is small               | W                     |
| Material             | Components are not easily damaged      | D                     |
|                      | Material easily obtainable             | D                     |
|                      | Durable material                       | D                     |
| Ergonomics           | Proportional form                      | D                     |
| Assembling           | Easy to assembly                       | D                     |
| Production           | The manufacturing cost is quite cheap  | W                     |

A list of sub-function solution principles must be made to find out what components can be used in realizing the design of a moringa leaf dryer with a rotary system (Figure 1). In listing the principle the solution should have as many variations as possible. If the solution principle has been obtained, then the solution principles need to be re-analyzed in order to facilitate the next concept design stage.
After the principle of the sub-function solution has been developed, it is necessary to make possible combinations, so as to form a system that is most supportive in the form of several variants (Figure 2). Based on the principles of the solutions that have been carried out above, several combinations or variations can be obtained:

1. Variant 1 : A1 → C2 → C3 → B4 → A5 → A6
2. Variant 2 : B1 → A2 → B3 → C4 → C5 → C6
3. Variant 3 : B1 → A2 → A3 → B4 → B5 → A6
4. Variant 4 : C1 → B2 → A3 → A4 → A5 → B6
In this study, based on several variants that have been made, variant number 3 was selected. The reasons for the selection criteria for variant 3 can be seen in the chart of the selection plan (Figure 3).

After doing the design using the VDI 2221, then calculate the element of planning in accordance with the selection of components that have been determined (Table 2).
Table 2. The results of the machine element planning calculations.

| Power Plan | Shaft Planning | V-belt and Pulley Selection | Bearing Selection |
|------------|----------------|-----------------------------|-------------------|
| The force on the machine \((F) = 98 \text{ N}\) | Power plan \((P_d) = 0.1865 \text{ kW}\) | The pulley diameter \((D_1 \text{ and } D_2) = 95 \text{ mm and } 166.25 \text{ mm}\) | Radial load \((F_r) = 9.99 \text{ kg}\) |
| Torque required \((T) = 125 \text{ N.mm}\) | Permissible Shear Tension \((\tau_a) = 7.08 \text{ kg/mm}^2\) | V-belt planning Type A: \(-\text{Motor Power (P) = 0.25 Hp}\) | Axial load \((F_a) = 0\) |
| Power required \((P) = 0.0251 \text{ Kw}\) | Moment of Twist \((T) = 129.75 \text{ kg.mm}\) | -Gearbox output rotation \((n_1) = 35 \text{ rpm}\) | Equivalent load = 9.99 kg |
| Shaft diameter \((d_s) = 15.3 \text{ mm}\) | | -Axle distance \((C) = 600 \text{ mm}\) | Bearing rotation speed factor \((F_n) = 1.18 \text{ rpm}\) |
| Deflection due to torsional moments \((\theta) = 0.030^\circ\) | | The length of the belt used \((L) = 1612.27 \text{ mm}\) | Specific dynamic nominal capacity \((C) = 200.82\) |
| | | The linear velocity of the V-belt \((v) = 0.17 \text{ m/s}\) | Bearing life factor \((F_h) = 23.72\) |
| | | The contact angle \((\theta) = 3.02 \text{ rad}\) | Nominal bearing life \((L_h) = 6.672.890 \text{ hours}\) |
| | | The V-belt tension \((F_1 \text{ and } F_2) = 184.6 \text{ kg and } 75.35 \text{ kg}\) | Bearing life reliability factor = 32.44 year |
| | | The transmission power capacity of a single belt \((P_o) = 0.1821 \text{ kW}\) | |

The final design according to the variant number 3 can be seen in Figure 4.

**Figure 4.** Final design of *Moringa Oleifera* rotary dryer.

In variant 3, the position of the tool selected is horizontal. The horizontal position was chosen because the position is commonly used, both static and dynamic drying. There are several options for the source of rotation which are included in several variants, namely the electric motor, the gasoline motor, and the crank. Based on several considerations, the rotation source used is an electric motor. One of the most important components in a drying process is heating. In selecting a heater, it must meet several criteria, namely easy maintenance, easy access and the current source comes from electricity. Therefore, the heater that is possible to use is fluorescent lamp. In terms of materials to be used, it must meet the requirements for health products. There are 2 materials commonly used in tools for health products, namely aluminum and stainless. From a health perspective, it is recommended to use stainless material.
Therefore, variant 3 was chosen because it uses stainless as the drying material. For the heater layout can be on the side, bottom, and rear. The layout of the heater on the side and rear requires the help of a blower to conduct heat properly. It differs from the heating layout at the bottom because in principle the heat flows naturally from the bottom up. To reduce production costs, variant 3 is selected which has a heating layout at the bottom. During the drying process, a control using a thermocontrol and timer is required. Thermocontrol functions to adjust the temperature during the dryer so that it remains within a predetermined limit, as well as the timer which functions to adjust the drying time until the specified time. Therefore, variant 3 has a very necessary thermocontrol and timer in order to facilitate the drying process. From the results above, it can be seen that the VDI 2221 method has succeeded in making a new design of rotary dryer for *Moringa Oleifera* based on a variety of components according to the available alternative solutions and can be used as an effective solution for existing problems.

4. Conclusion

By implementing the VD 2221 method, the rotational motion to carry out the process of back and forth the leaves automatically can be made. Meanwhile, the dimension of a rotary dryer becomes smaller and lighter compared to the existing dryer. It can be concluded that the design of the *Moringa Oleifera* rotary dryer was successfully made according to the best variant and can be used as an effective solution for existing problems.

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