

Acta Technologica Agriculturae 1
Nitra, Slovaca Universitas Agriculturae Nitriae, 2024, pp. 10–16

THE EFFECT OF DRUM DRYER TEMPERATURE AND ROTATIONAL SPEED ON THE CHARACTERISTICS OF FINGER MILLET (*ELEUSINE CORACANA*) BASED WEANING FOOD ENRICHED WITH COMPOSITE FLOUR

Dadang D. HIDAYAT¹, Diang SAGITA^{1*}, Shilfie R. UTAMI², Raden C. E. ANDRIANSYAH³,
Ari RAHAYUNINGTYAS¹, Doddy A. DARMAJANA¹, Ainia HERMINIATI¹, Yusman TAUFIK²

¹National Research and Innovation Agency, Research Centre for Appropriate Technology, Subang, West Java, Indonesia, zehidayat@gmail.com (D.D.H.), arirahayuningtyas@gmail.com (A.R.), doddyandy@gmail.com (D.A.D.), aini001@brin.go.id (A.H.)

²Pasundan University, Faculty of Engineering, Department of Food Science and Technology, Bandung, West Java, Indonesia, shilfie.utami@mail.unpas.ac.id (S.R.U.), yusmantaufik@unpas.ac.id (Y.T.)

³National Research and Innovation Agency, Research Centre for Food Technology and Processing, Gunungkidul, Yogyakarta, Indonesia, rade015@brin.go.id

*correspondence: diang.sagita@gmail.com

Finger millet or red millet is a source of carbohydrates, protein, and phytonutrients that have not been widely used. This has the potential to be used as an ingredient in making bread and porridge. However, the protein content of millet is insufficient for infant feeding and deficient in essential amino acids like lysine, so other ingredients are needed. This study contrasted composite flour dried at various temperatures and rotational speeds with millet-based supplementary feeding. Finger millet flour, red bean, skimmed milk powder, sugar, and salt were used to produce the weaning meal in that sequence. The dough-to-water ratio is 1 : 4. Organoleptic, physical, and chemical interactions were all considered. The experiment used a randomised block design with three replications and a 3 × 3 factorial pattern. The study discovered that drum dryer temperature impacted chemical, physical, and sensory responses ($p < 0.05$). Temperature had a more significant influence on moisture content than rotational speed. Temperature above 120 °C results in lower moisture content at rotation higher than 1.0 min⁻¹ and meets the criteria for instant porridge (lower than 4%). Lower moisture content at higher temperatures leads to increased protein concentration, but carbohydrates and fats remain relatively constant. The samples more preferred by the panellists were samples processed at higher temperature with rotation above 1.0 min⁻¹. So, this value is recommended, apart from fulfilling the standard criteria, processing with higher rotational speed can increase the output capacity of the process.

Keywords: dehydration; millet; red beans; sensory analysis; weaning food

The majority of weaning meals contain wheat, which can cause food allergies, celiac disease, and other allergens including asthma, stomach cramps, and hay fever. Therefore, it is necessary to construct weaning foods by substituting wheat with alternative readily digested and fibre-containing substances. Millets are equivalent to main cereals nutritionally and are an excellent source of protein, minerals, and phytochemicals. Millets are an abundant source of sulphur-containing amino acids, vitamin B, and minerals such as magnesium, manganese, iron, copper, phosphorus, and zinc (Prasanna et al., 2020). There are many types of millet in the world, and the most commonly used in Indonesia is millet with the Latin name *Setaria italica* L. (called millet in Indonesia) (Qosim et al., 2016), while other types of millet such as finger millet (*Eleusine coracana*) are still rarely used.

In recent years, small millet's nutritional profile has garnered increasing interest. Red millet (*Eleusine coracana*) is one of the small millets that is not being utilised to its full potential. Finger millet has the largest carbohydrate content compared to other forms of millet, such as Pearl millet, Foxtail millet, Barnyard millet, Proso millet, and Kodo millet, but the lowest protein and fat content. Finger millet has

a lower calorific value than other miller but a greater calorific value than Foxtail millet and Barnyard millet (Pontieri et al., 2020).

Millet is a key ingredient in many traditional foods and beverages, such as bread and porridge, and is a significant source of carbohydrates, proteins, and other vital phytonutrients (Habiyaemye et al., 2017). However, millet's protein content is insufficient for baby feeding and deficient in several key amino acids, such as lysine, which is necessary for children's growth. Despite having a relatively high iron concentration, millet has limited bioavailability (Sihag et al., 2015). In addition, millet has low quantities of β -carotene, vitamin C, zinc, calcium, salt, and potassium, which are essential for child and newborn nutrition (Tumwine et al., 2018).

The addition of vegetables and skimmed milk powder is a promising option to improve both the macro and micronutrient profile and functional properties of millet flour (Okonya and Maass, 2014). This is because vegetables are rich in β -carotene, zinc, calcium, sodium, and potassium, while skimmed milk powder is rich in protein with balanced essential amino acids and high digestibility (Hoffman and Falvo, 2004). According to studies on the use of millet

in functional meals (Kale and Vairagar, 2018), dough formed from millet porridge can fulfil the nutritional and sensory requirements for a weaning food.

Using a drum dryer to dry the weaning meal slurry is one option. There are three types of dryers with drums: single-drum, twin-drum, and double-drum dryers. The operation mechanism distinguishes drum dryers from open-system dryers and vacuum dryers. Moreover, there are four types of cylinder dryers concerning the feeding mechanism (Mujumdar, 2006), namely cylinder dryers with nip feed systems, splash feeds, dip feeds, and roller feeds. Single and double-drum dryers are the most common models used for drying. Drum dryers are only utilised for drying powder-producing materials. For heat-sensitive materials, a vacuum drum drier can lower the drying temperature (Mujumdar, 2006). The drum dryer type has a more effective output rate than other drum dryer types; it is more versatile and efficient (Mujumdar, 2006; Okos et al., 2018). Due to exposure to high temperatures, the drum drier was used to dry purees, soup mixtures, premixed morning cereals, and even heat-sensitive items (Mujumdar, 2006).

Based on this explanation, no research has been found regarding the development of finger millet-based weaning food enriched with composite flour. Therefore, the study aimed to describe the properties of millet-based complementary feeding mixed with composite flour dried in a drum dryer at different temperatures and speeds.

Material and methods

Material preparation

The weaning food sample was developed by combining several flours, including finger millet, red bean, skimmed milk powder, sugar, and salt, at the Research Centre for Appropriate Technology, National Research and Innovation Agency in Subang, West Java. Finger millet and red bean flour were sourced from Bantul, Yogyakarta, while skimmed milk powder, sugar, and salt were acquired at Subang local market. The moisture content, ash content, and protein content of finger millet were 9.65%, 2.19%, and 11.38%, respectively, whereas those of red bean flour were 11.52%, 2.10%, and 18.40%, respectively. The weaning food dough was made of red millet and red beans using the formulation chosen in a study conducted by other researchers (Anandito et al., 2016). The weaning food formula contains 39.5% finger millet flour, 31.2% red bean flour, 17.71% skimmed milk powder, 10.41% refined sugar, and 1.0% salt. The ratio of dough to water was 1 : 4.

Equipment

The equipment used to prepare the materials for weaning food consisted of a steam jacket kettle, a double drum dryer developed by Hidayat et al. (2021), a disc mill (FFC-23 model, PT. Toko Mesin Maksindo, Indonesia) with a capacity

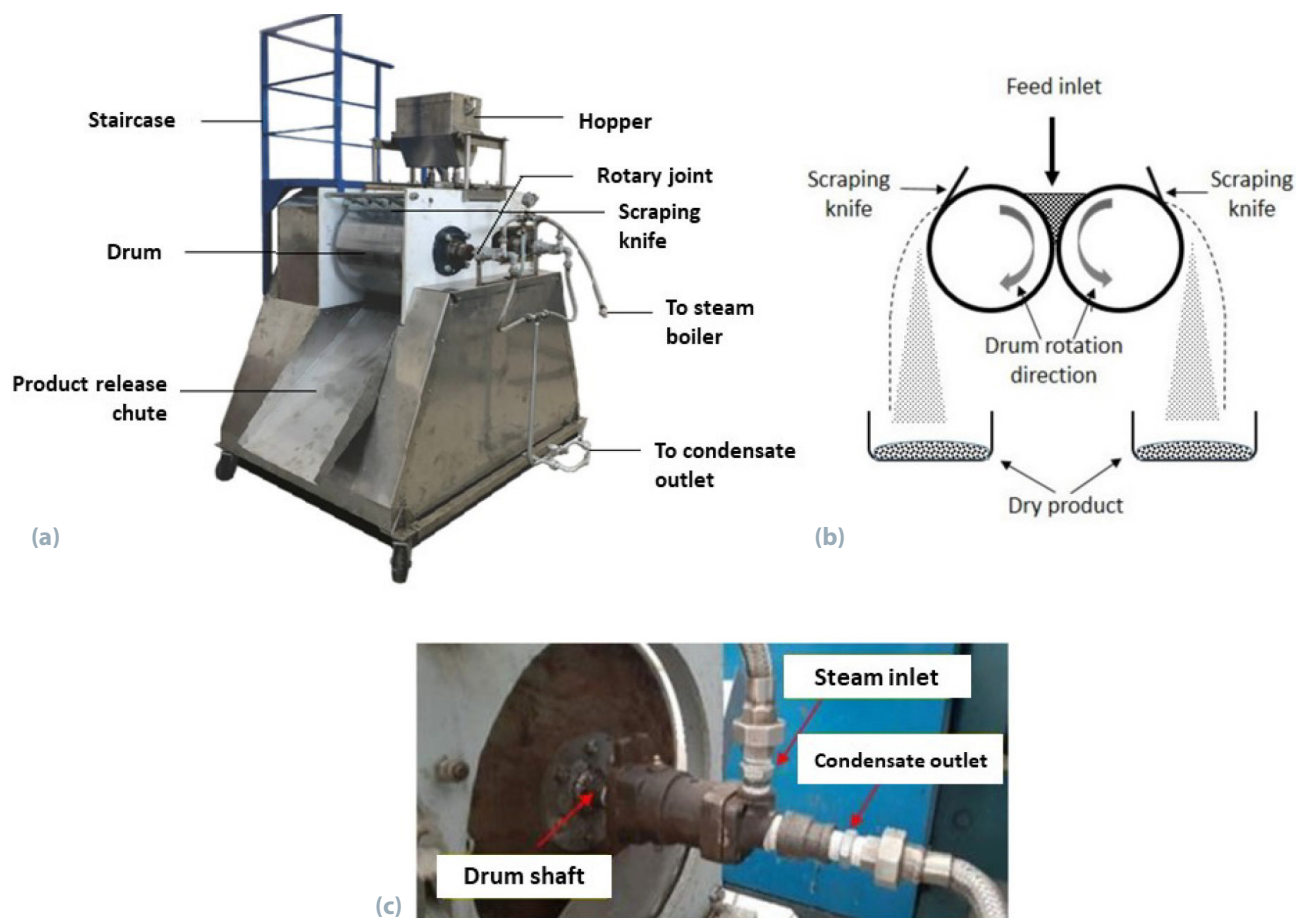


Fig. 1 Drum dryer used in this experiment: (a) Detail description; (b) Flow of processed material (Córdova et al., 2020); (c) Flow of steam as a heat source

of 100 kg·h⁻¹, a vibrating screen, and a sealer. The laboratory and auxiliary equipment utilised to analyse materials and products included the analytical balance with a precision of 0.1 mg (OHAUS Instruments Co. Ltd., Shanghai, China), stirring rod, burette, stative, beaker, petri dish, oven, desiccator, Buchner funnel, vacuum pump, Kjeldahl flask, measuring flask, round bottom flask, Erlenmeyer measuring cup, dropper pipette, sized pipette, goitre pipette, bath, condenser, boiling stone, evaporator cup, furnace, plastic basin, mixing ladder, and scissors.

Drum dryer description

A drum dryer used in this study was a double drum dryer developed by Hidayat et al. (2021). Figure 1 depicts the overall description of the double drum dryer.

The material of the drum was ferro casting ductile 450 covered with hard chrome, measuring 400 mm in length, 500 mm in diameter, and 20 mm in thickness. The usable surface area of the drum for drying was 1.26 m². A 3.73 kW variable speed motor was used to alter the speed of drums between 0 and 3 min⁻¹. Depending on the type of raw material utilised, drum dryer capacity could exceed 10 kg per batch. The gelatinised dough (porridge) was poured into the double drum dryer. A nip, the gap between the two cylinders, was 0.5 mm, and a surface of the liquid pool between the two cylinders was kept at a level of 10 cm above the gap. The drums were internally heated by steam at 200–400 kPa. Steam to heat the drums internally was coming from the 9000 W steam boiler.

Experimental procedure

Weighing the ingredients served as the first step in preparing weaning meals. A mixture of salt, powdered sugar, and skimmed milk powder was added to the finger millet and red bean flour. The dry mixture was then mixed with water in the ratio of 1 : 4 and then heated to 75 °C for 10 min in

a water-jacketed kettle. Following gelatinisation, the drum dryer was used to dry the dough. Drying was done at the drum surface temperature of 100 °C, 120 °C, and 140 °C with the rotation of 0.5 min⁻¹, 1.0 min⁻¹, and 1.5 min⁻¹. Following drum dryer's drying process, the flakes were crushed and sieved through an 80-mesh filter. After that, the analysis of the weaning food flour was performed. Three different kinds of analysis were carried out, which consisted of chemical, physical, and organoleptic responses. Figure 2 shows the flow chart of making weaning food-based finger millet.

Chemical responses

Chemical responses to the resulting weaning food included the analysis of water content using the gravimetric method (AOAC, 1995), the analysis of ash content using the gravimetric method (AOAC, 1995), the analysis of carbohydrate content using the difference method (Sudarmadji et al., 2010), the analysis of protein content using Kjeldahl method (AOAC, 1995), and the analysis of fat content using Soxhlet extraction method (AOAC, 1995).

For moisture content measurement, the sample was first weighed as much as 2 g (*W*), and then it was placed in a ceramic cup. After that, the cup containing the sample (*W*₁) was heated in the oven at 105 °C for 3 h. The sample was then put in a desiccator for 15 min and weighed until a constant mass was obtained (*W*₂). The moisture content wet basis was calculated using Eq. (1).

$$M_c = \frac{W_1 - W_2}{W} \times 100\% \quad (1)$$

where: *M_c* – moisture content; *W* – the initial mass of the sample (g); *W*₁ – the mass of the cup containing the sample before drying in the oven (g); *W*₂ – the mass of the cup and sample after drying in the oven (g)

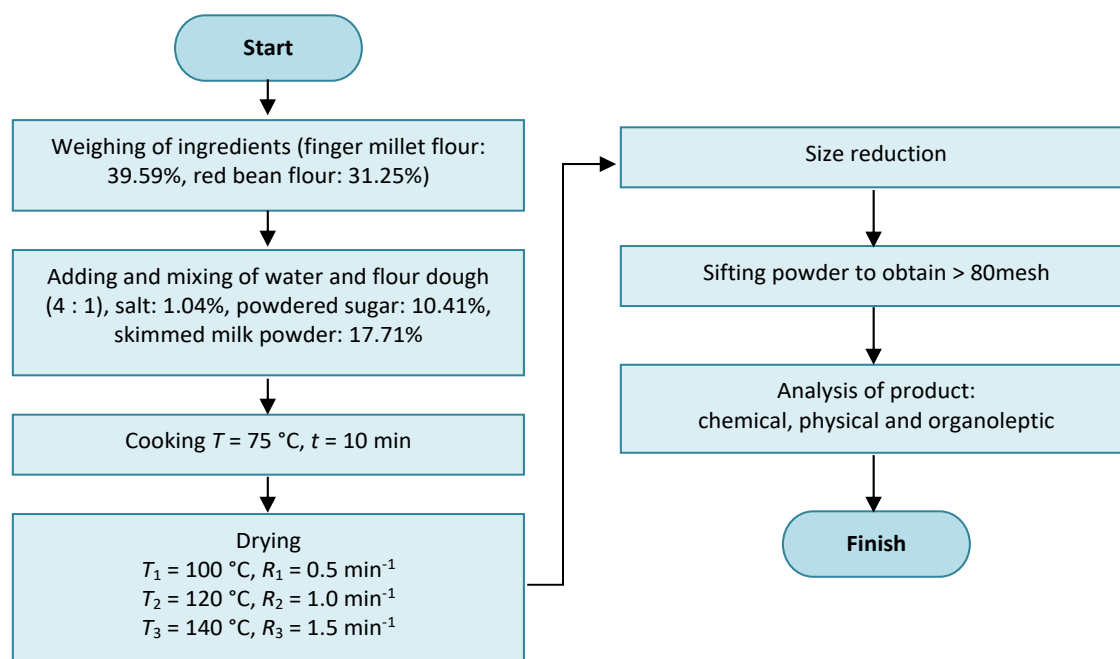


Fig. 2 Flowchart of making weaning food-based finger millet

Physical responses

Solubility and cooking time were two physical characteristics of the weaning meal. Solubility is defined as the maximum quantity of a substance that can be completely dissolved in a given amount of solvent (Gong et al., 2007). It can be calculated by measuring the number of samples that did not dissolve in the time and conditions given. The cooking time was measured based on the time where the powder turned into a slurry.

Organoleptic responses

Colour, taste, and aroma are reactions to weaning meals. Thirty panellists took the hedonic test, an acceptability test with a hedonic scale turned into a number scale from 1 (very dislike) to 6 (very like).

Statistical analysis

The experiment was performed using a randomised block design with two factors: drum temperature (100 °C, 120 °C, and 140 °C) and drum rotation (0.5 min⁻¹, 1.0 min⁻¹, and 1.5 min⁻¹), with a total of 9 treatments. All the treatments were carried out in three replications. Two-way ANOVA followed by Duncan's multiple range test were applied as data analysis techniques. The values were deemed 95% significant ($p < 0.05$). Values are expressed as mean $\pm$ standard deviation. Means with different letters were significantly different at $p < 0.05$. Lowercase letters are read horizontally, while uppercase letters are read vertically.

Results and discussion

Moisture content

Results showed that the treatment of temperature and rotational speed of the drum dryer cylinder and the interaction between temperature and rotational speed significantly affected the moisture content of weaning meal product ($p < 0.05$), as presented in Table 1.

Table 1 Effect of temperature and rotational speed on moisture content (%)

Temperature (°C)	Rotational speed (min ⁻¹)		
	0.5	1.0	1.5
100	4.30 $\pm$ 0.41 ^{ab}	4.32 $\pm$ 0.39 ^{aB}	4.33 $\pm$ 0.39 ^{aC}
120	4.24 $\pm$ 0.44 ^{ab}	3.56 $\pm$ 0.01 ^{bA}	4.00 $\pm$ 0.45 ^{aB}
140	4.35 $\pm$ 0.28 ^{aA}	3.35 $\pm$ 0.27 ^{bA}	3.34 $\pm$ 0.28 ^{bA}

Note: values are expressed as mean $\pm$ standard deviation. Means with different letters were significantly different at $p < 0.05$. Lowercase letters are read horizontally, while uppercase letters are read vertically

As indicated in Table 1, temperature difference has a more significant influence than rotating speed. The greater the temperature in the drying cylinder, the lower the moisture level of the final material. On the other hand, when the drier operates at 100 °C, the faster the drying cylinder rotates, the higher the moisture content of the material produced. This result was the same as other studies had found that a faster rotational speed leads to a wetter end product (Valous et al., 2002; Pua et al., 2010). Limitations

in the pressure control system on the steamer as a source of hot steam are assumed to cause the water content to decline when the dryer operates at 120 °C and 140 °C. In accordance with SNI (Indonesian National Standard) No. 01-7111.1-2005 (National Standardization Agency of Indonesia, 2005), the maximum amount of moisture content is 4%, thus the moisture content of instant powder based on finger millet and red beans in each treatment conformed to the established standards.

Ash content

The analysis of variance showed that the treatment of temperature, the rotational speed of the drum dryer cylinder, and the interaction of both significantly affected the ash content of the weaning meal product ($p < 0.05$). Further results of Duncan's test presented in Table 2 demonstrated that the temperature treatment, the rotational speed of the drum dryer cylinder, and their interaction considerably affected the ash content of instant slurry formed from weaning food ($p < 0.05$). At a temperature of 100 °C, the rotation of 0.5 min⁻¹ was not considerably different from 1.5 min⁻¹; however, the rotation of 1.5 min⁻¹ was significantly different from 0.5 min⁻¹. At a treatment temperature of 120 °C, the rotation of 0.5 is not distinguishable from 1.5 min⁻¹, but it is distinguishable from 1 min⁻¹. At a treatment temperature of 140 °C, the rotational speed of 0.5 min⁻¹ did not differ from 1 and 1.5 min⁻¹, although the rotational speed of 1 min⁻¹ did differ from 1.5 min⁻¹.

Table 2 Effect of temperature and rotational speed of double drum dryer on ash content (%)

Temperature (°C)	Rotational speed (min ⁻¹)		
	0.5	1.0	1.5
100	3.54 $\pm$ 0.12 ^{aB}	3.37 $\pm$ 0.10 ^{aC}	3.32 $\pm$ 0.08 ^{BB}
120	3.65 $\pm$ 0.03 ^{BB}	3.20 $\pm$ 0.09 ^{aB}	3.53 $\pm$ 0.12 ^{BC}
140	2.85 $\pm$ 0.03 ^{BA}	2.73 $\pm$ 0.02 ^{aA}	2.67 $\pm$ 0.11 ^{aA}

Note: values are expressed as mean $\pm$ standard deviation. Means with different letters were significantly different at $p < 0.05$. Lowercase letters are read horizontally, while uppercase letters are read vertically

Cylinder's low temperature and high rotating speed resulted in high ash content. Whereas high temperatures result in low ash content, this is because there are minerals that do not change much when heated, so they do not get hurt when the instant porridge is made (Karmas and Harris, 2012). According to SNI No. 01-7111.1-2005 (National Standardization Agency of Indonesia, 2005), the maximum ash level of instant powder is 3.5%; therefore, the ash content of instant powder based on finger millet and red beans in each treatment meets the established norms.

Carbohydrate content

The analysis of variance results on the carbohydrate content showed that the treatment of temperature, the rotational speed of the drum dryer cylinder, and the interaction of both significantly affected the carbohydrate content of the weaning meal product ($p < 0.05$).

Table 3 provides additional findings from Duncan's test, which revealed that the percentage of carbohydrates

was the same at 100 °C and various speeds as it was at 140 °C. The amount of carbohydrates changed depending on how fast the drying cylinder turned for each treatment at the treatment temperature of 120 °C. This shows that temperature is more important than the speed at which the drying cylinder rotates. When the dryer operates at the temperature of 120 °C, the influence of speed on carbohydrate content can be readily apparent. Based on Indonesian National Standard No. 01-7111.1-2005 (National Standardization Agency of Indonesia, 2005), the weaning meal protein standard for instant powder specifies the carbohydrate content maximum of 77%. Table 3 shows that the carbohydrate content of the weaning meal produced meets the Indonesian National Standard criteria.

Table 3 Effect of temperature and rotational speed on carbohydrate content

Temperature (°C)	Rotational speed (min ⁻¹)		
	0.5	1.0	1.5
100	76.67 ± 0.32 ^{aB}	76.70 ± 0.20 ^{aA}	76.77 ± 0.12 ^{aA}
120	75.98 ± 0.48 ^{aA}	77.33 ± 0.29 ^{cB}	76.40 ± 0.17 ^{bA}
140	77.48 ± 0.11 ^{aC}	77.65 ± 0.05 ^{aB}	77.83 ± 0.19 ^{aB}

Note: values are expressed as mean ± standard deviation. Means with different letters were significantly different at $p < 0.05$. Lowercase letters are read horizontally, while uppercase letters are read vertically

Protein content

Results revealed that drying temperature influenced the protein and fat content ($p < 0.05$). Other than that, neither the treatment of drum rotational speed nor the interaction between temperature variables and drum rotating speed affected the protein and fat concentration ($p > 0.05$).

Table 4 demonstrates that Duncan's test revealed that protein content increased with increasing drying temperature. The analysis showed that the highest protein value was obtained at 140 °C. The increase in protein content continued as drying temperature increased. This result showed agreement with a previous study (Riansyah et al., 2013), when the water content decreased, the protein content in the material increased. Using heat in food processing can reduce the percentage of water content, which causes protein content to increase. Another previous study (Paggara, 2008) also stated that the higher the drying temperature, the more water vapourised. The decrease in water content is also a supporting factor in increasing the protein content. Based on Indonesian National Standard No. 01-7111.1-2005 (National Standardization Agency of Indonesia, 2005), the weaning meal protein standard for instant powder specifies the protein content range of at least 8–22 g per 100 g. Table 4 demonstrates that the lower protein threshold of 8.00 ± 0.11 g was met while the twin drum dryer operated at 140 °C and 1.5 min^{-1} .

For the fat content, it was found that the fat content of the drum dried at 100 °C differed significantly from those dried at 120 °C and 140 °C. The fat content of the drum dryer cylinder at 120 °C was not significantly different from that at 140 °C. The Indonesian National Standard No. 01-7111.1-2005 requires the fat content between 6 and 15% for instant powdered dietary supplements.

Table 4 Effect of drum dryer cylinder temperature on protein and fat content

Temperature (°C)	Protein content (%)	Fat content (%)
100	7.43 ± 0.33^a	8.31 ± 0.074^a
120	7.76 ± 0.34^b	8.27 ± 0.113^b
140	8.00 ± 0.11^c	8.24 ± 0.089^b

Note: values are expressed as mean ± standard deviation. Means with different letters were significantly different at $p < 0.05$

Solubility and cooking time

The results indicated that the drum dryer cylinder's temperature treatment significantly affected the solubility and cooking time of the product ($p < 0.05$), as shown in Table 5. The connection between temperature and rotational speed did not affect the solubility and cooking time of the product ($p > 0.05$).

Table 5 Effect of drum temperature on the solubility and cooking time of finger millet-based weaning food enriched with composite flour

Temperature (°C)	Solubility (%)	Cooking time (min)
100	65.47 ± 2.83^a	30.78 ± 1.02^a
120	67.21 ± 1.09^b	31.78 ± 2.17^a
140	67.95 ± 0.69^b	36.67 ± 0.88^b

Note: values are expressed as mean ± standard deviation. Means with different letters were significantly different at $p < 0.05$

The post-hoc analysis showed that the solubility of instant weaning meals made at the drying temperatures of 100 °C, 120 °C, and 140 °C was significantly different from those made at the drying temperatures of 120 °C and 140 °C. The solubility level of the instant weaning meal, which was dried at 120 °C, was significantly different from that at 140 °C. Water solubility is one of the physical properties of powder products related to the rehydration process. It is not suitable for a product to dissolve close to 100% because it will dissolve more in water and become liquid. Solubility is essential for the mouthfeel of the food consumed (Hidayat et al., 2009).

Regarding the cooking time, the ANOVA test showed that the temperature treatment of the drum dryer cylinder had a significant effect on the cooking time of the instant porridge produced ($p < 0.05$). The rotational speed factor and the interaction between temperature and rotational speed had no significant effect on the cooking time of the instant porridge produced ($p > 0.05$). The post-hoc analysis of Duncan's multi-range test showed that the cooking time at the drum dryer cylinder temperature of 100 °C was not significantly different from the temperature of 120 °C, but significantly different from the temperature of 140 °C. The cooking time at the temperature of the drum dryer cylinder of 100 °C was not significantly different from the temperature of 120 °C, but significantly different from the temperature of 140 °C. The drum dryer cylinder at the temperature of 120 °C was not significantly different from the temperature of 100 °C, but significantly different from the temperature of 140 °C. The temperature of the drum dryer cylinder at 140 °C was significantly different from that of 100 °C and 120 °C.

Table 6 Effect of drum temperature and rotational speed on colour preference

Temperature (°C)	Colour	Rotational speed (min ⁻¹)	Colour
100	4.74 ± 0.01 ^a	0.5	4.52 ± 0.01 ^a
120	4.78 ± 0.01 ^a	1.0	4.87 ± 0.01 ^b
140	4.94 ± 0.01 ^b	1.5	5.06 ± 0.01 ^c

Note: values are expressed as mean ± standard deviation. Means with different letters in the same column were significantly different at $p < 0.05$

Table 7 Two-way interaction of temperature and rotational speed factor on aroma

Temperature (°C)	Rotational speed (min ⁻¹)		
	0.5	1.0	1.5
100	5.30 ± 0.03 ^{aB}	5.23 ± 0.02 ^{aA}	5.15 ± 0.02 ^{bA}
120	5.30 ± 0.01 ^{bB}	5.34 ± 0.02 ^{bA}	5.07 ± 0.01 ^{aA}
140	5.08 ± 0.01 ^{aA}	5.33 ± 0.02 ^{bA}	5.07 ± 0.03 ^{aA}

Note: values are expressed as mean ± standard deviation. Means with different letters were significantly different at $p < 0.05$. Lowercase letters are read horizontally, while uppercase letters are read vertically

Colour preference

Table 6 shows that the temperature treatment and the rotating speed of the drum dryer cylinder influenced the colour of the instant porridge ($p < 0.05$), but their interaction had no effect ($p > 0.05$).

The post-hoc analysis shown in Table 6 indicates that the colour attribute at the working temperature 100 °C of the drum dryer is not statistically different from that at 120 °C, but is distinct from that at 140 °C. At the operating temperature of 120 °C, the colour characteristic of the drum dryer differs dramatically from that at 140 °C. Regarding the rotational speed of the drum dryer cylinder, the colour characteristics differ for the rotational speeds of 0.5, 1.0, and 1.5 min⁻¹.

Even if a product has a high nutritional content, tastes excellent, and has a decent texture, the product becomes less desirable if the colour is less appealing (Creusen and Schoormans, 2005). The findings of the examination of final product's colour indicate that the average value given by the panellists for all the treatments is 5. This indicates that the panellists prefer the final product's colour.

Aroma preference

Table 7 presents the result of aroma analysis. The results indicate that the temperature treatment had no effect on the aroma characteristics of the instant porridge ($p > 0.05$). The rotational speed of the drum drier cylinder and the interaction between temperature and rotational speed have a substantial influence on the aroma of the instant porridge ($p < 0.05$).

The fragrance attribute at the drum dryer cylinder speed of 0.5 min⁻¹ and temperature of 100 °C is not really different from the one at 120 °C, but it is very different from the one at 140 °C.

Aroma is an odour sensation created by the chemical stimulation of volatile substances detected by the nerves of the sense of smell when food enters the mouth. The aroma of quick porridge is strongly reminiscent of millet and has a faint bean taste. The presence of red beans containing lipoxygenase enzymes imparts a bean-like flavour. Even though the fast product from finger millet-based weaning

meal mixed with composite flour has a distinct aroma and flavour of millet and beans, the panellists prefer it, as seen by the average rating of 5.

Taste preference

The temperature treatment of the drum dryer cylinder affected the flavour characteristics of the instant porridge ($p < 0.05$). The treatment of rotational speed and the relationship between rotational speed and temperature did not influence the attribute of flavour ($p > 0.05$).

The post-hoc analysis (as shown in Table 8) indicates that the taste characteristics of the product at 100 °C were substantially different from those at 120 °C and 140 °C. The panellists did not like the taste of instant porridge made from finger millet-based weaning meal enriched with composite flour across all the treatments, as evidenced by the range of values (3–4) obtained.

Table 8 Effect of drum temperature on taste attributes of weaning food product

Temperature (°C)	Taste
100	3.73 ± 0.04 ^a
120	3.94 ± 0.02 ^b
140	4.07 ± 0.01 ^b

Note: values are expressed as mean ± standard deviation. Means with different letters were significantly different at $p < 0.05$

Conclusion

The study demonstrated that drum dryer temperature and rotational speed significantly affected the characteristics of finger millet-based weaning food enriched with composite flour. Adjusting these parameters can help optimise the moisture content, ash content, protein content, carbohydrate content, fat content, solubility, cooking time, and preference of the weaning food. Temperature had a more significant influence on moisture content than rotational speed. Temperature above 120 °C results in lower moisture content at rotational speed higher than 1.0 min⁻¹ and meets the criteria for instant porridge (lower than 4%).

Lower moisture content at higher temperatures is leading to increased protein concentration, but carbohydrates and fats remain relatively constant. The best drying condition for finger millet-based weaning food enriched with composite flour was at the rotational speed of 1.5 min⁻¹ and temperature of 140 °C. So, this value is recommended, apart from fulfilling the standard criteria, processing with a higher rotational speed can increase the output capacity of the process.

References

- ANANDITO, R. B. K. – SISWANTI – NURHARTADI, E. – HAPSARI, R. 2016. Formulation of food bars made from white millet flour (*Panicum miliaceum* L.) and red bean flour (*Phaseolus vulgaris* L.). In *Agritech*, vol. 36, no. 1, pp. 23–29. DOI: <https://doi.org/10.22146/agritech.10680>
- AOAC 1995. Official Methods of Analysis. 16th ed. Washington: of The Association of Official Analytical Chemist, 1925 pp. ISBN 978-0-935584-54-7.
- CÓRDOVA, C. – VIVANCO, J. P. – QUINTERO, J. – MAHN, A. 2020. Effect of drum-drying conditions on the content of bioactive compounds of broccoli pulp. In *Foods*, vol. 9, no. 9, p. 1224. DOI: <https://doi.org/10.3390/foods9091224>
- CREUSEN, M. E. – SCHOORMANS, J. P. 2005. The different roles of product appearance in consumer choice. In *Journal of product innovation management*, vol. 22, no. 1, pp. 63–81. DOI: <https://doi.org/10.1111/j.0737-6782.2005.00103.x>
- GONG, Y. – GRANT, D. J. – BRITTAI, H. G. 2007. Principles of solubility. Solvent systems and their selection in pharmaceuticals and biopharmaceuticals. New York: Springer, pp.1–27. ISBN 978-0-387-69154-1. DOI: https://doi.org/10.1007/978-0-387-69154-1_1
- HABIYAREMYE, C. – MATANGUIHAN, J. B. – D'ALPOIM GUEDES, J. – GANJYAL, G. M. – WHITEMAN, M. R. – KIDWELL, K. K. – MURPHY, K. M. 2017. Proso millet (*Panicum miliaceum* L.) and its potential for cultivation in the Pacific Northwest, US: a review. In *Frontiers in plant science*, vol. 7, p. 1961. DOI: <https://doi.org/10.3389/fpls.2016.01961>
- HIDAYAT, B. – KALSUM, N. – SURFIANA, S. 2012. Characterization of modified cassava flour processed using the partial pregelatinization method. In *Jurnal Teknologi dan Industri Hasil Pertanian*, vol. 14, no. 2, pp. 148–159. (In Indonesian)
- HIDAYAT, D. D. – SAGITA, D. – DARMAJANA, D. A. – INDRIATI, A. – RAHAYUNINGTYAS, A. – SUDARYANTO, A. – KURNIAWAN, Y. R. – NUGROHO, P. 2021. Development and thermal evaluation of double drum dryer for ready-to-eat food products to support stunting prevention. In *INMATEH-Agricultural Engineering*, vol. 64, no. 2. DOI: <https://doi.org/10.35633/inmateh-64-04>
- HOFFMAN, J. R. – FALVO, M. J. 2004. Protein—which is best? In *Journal of sports science & medicine*, vol. 3, no. 3, p. 118.
- KALE, P. G. – VAIRAGAR, P. R. 2018. Application of pearl millet in functional food. In *International Journal of Agriculture*, vol. 11, no. Special, pp. 90–94.
- KARMAS, E. – HARRIS, R. S. 2012. Nutritional evaluation of food processing. Springer Science & Business Media, 786 pp. ISBN 94-011-7030-4. DOI: <https://doi.org/10.1007/978-94-011-7030-7>
- MUJUMDAR, A. S. 2006. Handbook of Industrial Drying. 3rd ed. Boca Raton : CRC Press, 1279 pp. ISBN 978-1-4665-9665-8. DOI: <https://doi.org/10.1201/9781420017618>
- NATIONAL STANDARDIZATION AGENCY OF INDONESIA. 2005. Complementary foods for breast milk (MP-ASI) – Part 1: Instant porridge. Jakarta : National Standardization Agency of Indonesia, No. SNI 01-7111.1-2005.
- OKONYA, J. – MAASS, B. 2014. Protein and iron composition of cowpea leaves: An evaluation of six cowpea varieties grown in Eastern Africa. In *African Journal of Food, Agriculture, Nutrition and Development*, vol. 14, no. 65, pp. 9329–9340.
- OKOS, M. R. – CAMPANELLA, O. – NARSIMHAN, G. – SINGH, R. K. – WEITNAUER, A. C. 2018. Food Dehydration. Handbook of Food Engineering. CRC Press, 152 pp. ISBN 978-0-429-44973-4.
- PAGGARA, H. 2008. Effect of drying time on protein content of sago worms (*R. furegineus*). In *Jurnal Bionature*, vol. 9, no. 1, pp. 55–60. (In Indonesian)
- PONTIERI, P. – TROISI, J. – ROMANO, R. – PIZZOLANTE, G. – BEAN, S. R. – TILLEY, M. – MOTTO, M. – ALETTA, M. – GIUDICE, F. D. – SICARDI, M. – ALIFANO, P. – GIUDICE, L. D. 2020. Nutritional composition of a selected white food-grade waxy sorghum variety grown in Mediterranean environment. In *Australian Journal of Crop Science*, vol. 14, no. 9, pp. 1525–1532. DOI: <https://doi.org/10.21475/ajcs.20.14.09.p2783>
- PRASANNA, M. S. – SOWJANYA, V. S. – JAYA, E. – RAJENDER, G. 2020. Development of millet based instant weaning mix. In *Journal of Pharmacognosy and Phytochemistry*, vol. 9, no. 4.
- PUA, C. K. – HAMID, N. S. ABD. – TAN, C. P. – MIRHOSSEINI, H. – RAHMAN, R. B. ABD. – RUSUL, G. 2010. Optimization of drum drying processing parameters for production of jackfruit (*Artocarpus heterophyllus*) powder using response surface methodology. In *LWT – Food Science and Technology*, vol. 43, no. 2, pp. 343–349. DOI: <https://doi.org/10.1016/j.lwt.2009.08.011>
- QOSIM, W. A. – RANDALL, A. – YUWARIAH, Y. – NURAINI, A. – NURMALA, T. – IRWAN, A. W. 2016. Characterization and relationships of 23 genotypes of millet (*Setaria italica* L. Beauv) planted intercropping with sweet potatoes based on agromorphological characters. In *Jurnal Pangan*, vol. 25, no. 1, pp. 21–32. (In Indonesian)
- RIANSYAH, A. – SUPRIADI, A. – NOPIANTI, R. 2013. The effect of different drying temperatures and times on the characteristics of Siamese gourami salted fish (*Trichogaster pectoralis*) using oven. In *Jurnal Fishtech*, vol. 2, no. 1, pp. 53–68. (In Indonesian)
- SIHAG, M. K. – SHARMA, V. – GOYAL, A. – ARORA, S. – SINGH, A. K. 2015. Effect of domestic processing treatments on iron, β-carotene, phytic acid and polyphenols of pearl millet. In *Cogent Food and Agriculture*, vol. 1, no. 1, p. 1109171. DOI: <https://doi.org/10.1080/23311932.2015.1109171>
- SUDARMADJI, S. – SUHARDI – HARYONO, B. 2010. Analysis of Food and Agricultural Ingredients. Yogyakarta : Liberty Yogyakarta, 172 pp. ISBN 979-499-193-7. (In Indonesian).
- TUMWINE, G. – ATUKWASE, A. – TUMUHIMBISE, G. A. – TUCUNGWIRWE, F. – LINNEMANN, A. 2018. Production of nutrient-enhanced millet-based composite flour using skimmed milk powder and vegetables. In *Food science and nutrition*, vol. 7, no. 1, pp. 22–34. DOI: <https://doi.org/10.1002/fsn3.777>
- VALOUS, N. A. – GAVRIELIDOU, M. A. – KARAPANTSIOS, T. D. – KOSTOGLU, M. 2002. Performance of a double drum dryer for producing pregelatinized maize starches. In *Journal of Food Engineering*, vol. 51, no. 3, pp. 171–183.

