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Basic Formulation of Instant Balinese Porridge Using a Gradual Dehydration Method: A Functional Food Approach Based on Balinese Local Wisdom

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Abstract: The increasing demand for convenient foods has encouraged the development of instant products that not only offer practicality but also provide functional health benefits. Balinese porridge, traditionally prepared from red rice, coconut, and indigenous Balinese spices, represents a culturally valuable food with considerable nutritional potential. However, its conventional form is limited by a short shelf life and low practicality. This study aimed to evaluate the effect of drying temperature and drying duration on the physical, nutritional, sensory, and functional properties of instant Balinese porridge produced using a gradual dehydration method. A completely randomized factorial design was applied with two factors, namely drying temperature (50, 60, and 70 °C) and drying time (4, 6, and 8 h), resulting in nine treatment combinations with three replications. Gradual dehydration was conducted through initial oven drying followed by food dehydrator processing. The observed parameters included moisture content, rehydration time, proximate composition, sensory acceptance, and antioxidant activity expressed as IC_{50} values. The results demonstrated that drying at 60 °C for 6 h produced the lowest moisture content (5.1%) and the fastest rehydration time (2.8 min). The nutritional composition was dominated by carbohydrates (approximately 77%) and protein (7.6–8.3%), with a significant reduction in protein content observed at higher drying temperatures. Sensory evaluation indicated that the 60 °C–6 h treatment achieved the highest scores for color, aroma, taste, and overall acceptance. The highest antioxidant activity was also observed under this condition, with an IC_{50} value of 72.5 ppm. These findings confirm that gradual dehydration is an effective processing strategy for preserving the quality and functional properties of traditional Balinese porridge, highlighting its potential development as an instant functional food based on local wisdom.

Keywords: Antioxidant Activity; Balinese Local Wisdom; Functional Food; Gradual Dehydration; Instant Porridge.

Introduction

Changes in modern lifestyles have significantly increased consumer demand for instant food products that are easy to prepare, have a long shelf life, and provide added health benefits. In response to this trend, the development of functional instant foods has gained considerable attention in food science research. Functional foods are defined as foods that offer health benefits beyond basic nutrition, often due to the presence of bioactive compounds such as antioxidants, dietary fiber, or phytochemicals [1-3].

Balinese porridge is a traditional food prepared from red rice, coconut, and indigenous Balinese spices, which together contribute to its distinctive sensory profile and nutritional value. Red rice is recognized for its higher fiber content and antioxidant capacity compared to polished white rice, while traditional Balinese spices are rich in phenolic compounds that exhibit antioxidant and anti-inflammatory activities [4–6]. Despite its nutritional and cultural importance, Balinese porridge is conventionally consumed fresh, resulting in limited shelf life and low practicality for modern consumers.

Transforming traditional foods into instant forms represents a strategic approach to improving convenience while preserving nutritional and functional properties. Drying is one of the most widely applied techniques in instant food production; however, inappropriate drying conditions can negatively affect product quality, including reduced rehydration capacity, protein degradation, loss of bioactive compounds, and deterioration of sensory attributes [7-9]. High-temperature single-stage drying, which is commonly applied, often accelerates moisture removal at the expense of structural integrity and functional quality.

Gradual dehydration, which involves controlled and sequential drying stages at moderate temperatures, has recently gained attention as an alternative approach to improve product quality. Several studies have reported that gradual or multi-stage drying can enhance porosity, improve rehydration behavior, and better preserve heat-sensitive bioactive compounds compared to conventional single-stage drying [10–12]. Nevertheless, most existing studies focus on fruits, vegetables, or generic cereal-based products, while applications to traditional foods remain limited.

In the context of Indonesian traditional foods, scientific studies addressing the development of instant functional products that maintain local culinary identity are still scarce. To date, no published research has reported the application of a gradual dehydration approach to traditional Balinese porridge while simultaneously evaluating its physical, nutritional, sensory, and functional characteristics.

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This gap underscores the need for a systematic investigation to support the transformation of traditional foods into value-added, functional products.

Therefore, this study aimed to evaluate the combined effects of drying temperature and drying duration on the physical, nutritional, sensory, and functional properties of instant Balinese porridge produced using a gradual dehydration method. The novelty of this research lies in the application of gradual dehydration to a traditional Balinese food product, integrating functional food concepts with local wisdom to optimize quality, antioxidant activity, and consumer acceptance.

Research Methods

This study employed a completely randomized factorial design with two independent variables, namely drying temperature and drying duration. The first factor was drying temperature, consisting of three levels: 50, 60, and 70 °C. The second factor was drying duration, with three levels: 4, 6, and 8 hours. Each treatment combination was conducted in triplicate, resulting in a total of 27 experimental units.

Fresh Balinese porridge was prepared using red rice as the main ingredient, combined with coconut and traditional Balinese spices, following a standardized formulation. The cooked porridge was subjected to a process of gradual dehydration, which involved two sequential drying stages. The initial drying stage was carried out using a hot-air oven to reduce surface moisture, followed by a second drying stage using a food dehydrator to achieve uniform moisture removal at controlled temperatures. After drying, the samples were milled into powder, sieved to obtain a uniform particle size, and packaged in airtight containers prior to analysis.

The physical characteristics evaluated included moisture content and rehydration time. The moisture content was determined using the gravimetric method, which involved oven-drying until a constant weight was achieved. Rehydration time was measured by recording the time required for the dried porridge powder to reach an acceptable consistency upon reconstitution with hot water [3].

Nutritional composition was analyzed using proximate analysis methods, including determination of carbohydrate, protein, fat, ash, and moisture contents according to standard AOAC procedures. Sensory evaluation was conducted using a hedonic test involving semi-trained panelists, who evaluated color, aroma, taste, and overall acceptance using a five-point hedonic scale [4].

Functional properties were assessed by measuring antioxidant activity using the DPPH radical scavenging assay. Antioxidant capacity was expressed as IC_{50} values, defined as the concentration required to inhibit 50% of DPPH radicals. All collected data were subjected to analysis of variance (ANOVA) at a significance level of 5%. When significant differences were observed, Duncan's multiple range test was applied to determine differences among treatment means [5].

Results and Discussion

Physical Characteristics (Moisture Content and Rehydration Time)

Drying temperature and drying duration significantly affected the moisture content and rehydration time of instant Balinese porridge ($p \leq 0.05$). The lowest moisture content (5.1%) and the shortest rehydration time (2.8 min) were obtained at a drying temperature of 60 °C for 6 h. Although higher temperatures accelerated moisture removal, excessive drying at 70 °C resulted in longer rehydration times, which may be attributed to structural collapse and reduced porosity of starch matrices.

Moderate drying temperatures are known to promote the formation of porous structures that facilitate water absorption during rehydration [4], [5]. Similar findings were reported in studies on cereal-based instant foods, where controlled drying conditions improved rehydration behavior and product quality [6], [7]. These results suggest that the combination of temperature and drying duration significantly influences the physical properties of instant porridge products.

Table 1. Physical characteristics of Instant Balinese Porridge at various temperature treatments and drying times

Temperature (°C)	Time (hours)	Moisture (%)	Rehydration time (minutes)
50	4	8.2[a]	4.1[a]
50	6	6.7[b]	3.6[b]
50	8	6.0[c]	3.3[c]
60	4	6.2[c]	3.2[c]
60	6	5.1[d]	2.8[d]
60	8	5.0[d]	3.0[c]
70	4	5.4[d]	3.5[b]
70	6	5.0[d]	3.1[c]
70	8	4.8[b]	3.6[b]

*) Different letter notations in the same column indicate significant differences. (ANOVA, p≤0,05).

The shorter rehydration time observed at moderate drying conditions (60 °C for 6 h) indicates the formation of a more porous microstructure, which facilitates rapid water penetration during reconstitution. Controlled moisture removal prevents excessive shrinkage of starch granules, maintaining capillary pathways essential for rehydration. In contrast, excessive thermal exposure at higher temperatures may induce starch matrix collapse and pore shrinkage, resulting in reduced water absorption capacity and prolonged rehydration time [13–15].

Nutritional Composition

The proximate composition of instant Balinese porridge was dominated by carbohydrates (approximately 76.8–77.5%) and protein (7.6–8.3%), while fat and ash contents remained relatively stable across treatments. Statistical analysis revealed that drying temperature significantly affected protein content, whereas carbohydrate and fat contents were not significantly influenced by drying conditions.

A noticeable reduction in protein content was observed at higher drying temperatures, particularly at 70 °C for extended drying durations [8]. This reduction may be attributed to protein denaturation and possible Maillard reactions occurring at elevated temperatures, which can reduce protein availability and nutritional quality [9], [10]. These results are consistent with previous reports indicating

that excessive thermal exposure negatively affects protein stability in cereal-based foods.

Table 2. Proximate composition of Instant Balinese Porridge based on treatment

Temperature (°C)	Time (hours)	Carbohydrate (%)	Protein (%)	Fat (%)	Ash (%)	Water content (%)
50	4	76.2[a]	8.3[a]	3.7[a]	2.2[a]	8.2[a]
50	6	77.0[a]	8.2[a]	3.6[a]	2.1[a]	6.7[b]
50	8	77.3[a]	8.0[ab]	3.6[a]	2.1[a]	6.0[bc]
60	4	77.5[a]	8.2[a]	3.6[a]	2.2[a]	6.2[b]
60	6	77.4[a]	8.1[a]	3.6[a]	2.2[a]	5.1[c]
60	8	77.2[a]	8.0[ab]	3.6[a]	2.1[a]	5.0[c]
70	4	77.1[a]	8.0[ab]	3.5[a]	2.2[a]	5.4[c]
70	6	77.0[a]	8.0[ab]	3.6[a]	2.1[a]	5.0[c]
70	8	76.8[a]	7.8[b]	3.5[a]	2.1[a]	4.8[c]

*) Different letter notations in the same column indicates significant differences (ANOVA, p≤0,05).

The decrease in protein content at higher drying temperatures suggests thermal denaturation and potential involvement of Maillard reactions, which may reduce protein bioavailability. Maintaining moderate drying conditions is therefore essential to preserve the nutritional functionality of instant porridge products intended for health-oriented consumption [11]. These reactions not only reduce measurable protein content but may also decrease protein bioavailability and nutritional quality. Previous studies have similarly reported protein degradation in cereal-based instant foods subjected to prolonged or high-temperature drying [16–18], emphasizing the importance of moderate drying conditions to preserve nutritional functionality.

Sensory Quality

Sensory evaluation results showed that drying temperature and drying duration significantly influenced color, aroma, taste, and overall acceptance ($p \leq 0.05$). The treatment at 60 °C for 6 h received the highest sensory scores for all evaluated attributes. Panelists preferred samples dried at moderate temperatures due to their more appealing color, preserved aroma of traditional spices, and balanced taste.

Table 3. Average score of the hedonic test of Instant Balinese Porridge (scale of 5)

Temp. (°C)	Time (hour)	Color	Aroma	Taste	Overall Acceptance
50	4	3.6[b]	3.7[b]	3.6[b]	3.6[b]
50	6	3.8[b]	3.9[b]	3.7[b]	3.8[b]
50	8	3.7[b]	3.8[b]	3.6[b]	3.7[b]
60	4	3.9[ab]	4.0[ab]	4.0[ab]	4.0[ab]
60	6	4.1[a]	4.3[a]	4.2[a]	4.2[a]
60	8	4.0[ab]	4.1[ab]	4.0[ab]	4.0[ab]
70	4	3.5[b]	3.8[b]	3.7[b]	3.6[b]
70	6	3.3[c]	3.7[b]	3.6[b]	3.5[c]
70	8	3.4[c]	3.6[b]	3.5[c]	3.5[c]

*) Different letter notations in the same column indicate significant differences (ANOVA, p≤0,05).

In contrast, samples dried at higher temperatures tended to exhibit darker color and diminished aroma, leading to lower consumer acceptance [11], [12]. These findings suggest that gradual dehydration at moderate temperatures is essential for preserving the sensory identity of traditional Balinese porridge while improving its practicality as an instant product.

The superior sensory acceptance of samples dried at 60 °C for 6 h highlights the importance of controlled thermal processing in preserving the characteristic aroma and taste of traditional Balinese spices, which are key elements of the product's cultural identity.

Thermal processing strongly influences sensory attributes, particularly color and aroma. Moderate drying temperatures help preserve the volatile aromatic compounds found in traditional Balinese spices, whereas excessive heat accelerates pigment degradation and aroma loss, resulting in lower sensory acceptance. The superior sensory scores obtained at 60 °C for 6 h confirm that controlled dehydration is crucial for maintaining the characteristic sensory identity of traditional foods when converted into instant products [19–22].

Functional Properties (Antioxidant Activity)

Antioxidant activity, expressed as IC_{50} values, was significantly affected by drying conditions. The lowest IC_{50} value (72.5 ppm), indicating the highest antioxidant activity, was observed in samples dried at 60 °C for 6 h. Higher drying temperatures resulted in increased IC_{50} values, indicating a reduction in antioxidant capacity.

Table 4. Antioxidant activity (IC50, ppm) of Instant Balinese Porridge

Temperature (°C)	Time (hours)	IC_{50} (ppm)
50	4	95.0b
50	6	80.2c
50	8	82.5c
60	4	78.6c
60	6	72.5d
60	8	74.0cd
70	4	98.3b
70	6	110.3a
70	8	112.0a

*) Different letter notations in the same column indicate significant differences (ANOVA, p≤0,05)

The decline in antioxidant activity at elevated temperatures is likely caused by the degradation of heat-sensitive phenolic compounds present in red rice and Balinese spices [13]. Maintaining moderate drying conditions is therefore critical for preserving bioactive compounds and enhancing the functional value of instant porridge products [14], [15].

The preservation of antioxidant activity under moderate drying conditions reinforces the functional food potential of instant Balinese porridge, as phenolic compounds from red rice and traditional spices contribute to reducing oxidative stress and promoting health. The decrease in antioxidant activity at elevated drying temperatures is associated with the degradation of heat-sensitive phenolic compounds present in red rice and Balinese spices. Phenolic compounds are known to be particularly susceptible to thermal degradation, oxidation, and structural modification during drying. Maintaining moderate drying conditions minimizes these losses and enhances the functional value of the final product, as reflected by lower IC_{50} values [23–25].

Conclusion

Drying temperature and drying duration significantly affected the physical, nutritional, sensory, and functional properties of instant Balinese porridge produced using a gradual dehydration method. Drying at 60 °C for 6 h was identified as the optimal condition, resulting in low moisture content, rapid rehydration, high sensory acceptance, and superior antioxidant activity. These results demonstrate that gradual dehydration is an effective processing strategy for transforming traditional Balinese porridge into an instant functional food while preserving its nutritional value and sensory identity. This finding supports the potential development and commercialization of instant Balinese porridge as a functional food product based on local wisdom. Future studies should focus on shelf-life stability, bioavailability of bioactive compounds, and glycemic response to further strengthen its functional claims.

Author's Contribution

I.G.A.Y. Rabani RS: conceptualization, methodology, investigation, manuscript writing, and revision. A.A.N.A.W. Putra: supervision, validation, and manuscript review. I.N.A.M. Putra: data analysis and revision.

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