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# Application of Pressurized Cooking and Freezing Technique to Improve the Quality of Instant *Ledok*

**Luh Putu Wrasiati[1], I Made Anom Sutrisna Wijaya[2,*] and I Ketut Suter[3]**


## ABSTRACT

*Ledok* is atraditional non-rice, forage-like food from Nusa Penida Island, Klungkung regency, Bali Province, Indonesia. The main ingredients of *Ledok* are corn and cassava tubers, which are frequently mixed with red beans, peanuts and vegetables. To be accepted as a commercial food product, in-depth research into the formulation, process engineering, quality control, shelf life and marketing are required. In this research, optimization of the preliminary cooking process using a pressurized cooking treatment (pressure cooker) with a variation of 6–12 min cooking time followed by freezing at -20 $^{o}$C for 24–72 hr was carried out to improve the quality of instant *Ledok*. The objectives of this research were to study the effect of pressurized cooking and the freezing time on the quality of instant *Ledok* and to determine the appropriate pressurized cooking and freezing time of instant *Ledok*. The analysis performed in this research included analysis of yield, water absorption, cooking time and proximate analysis. The results indicated that the longer the pressurized cooking and freezing time, the smaller the yield, the greater the absorption of water and the shorter the cooking time. The results of proximate analysis indicated that the variation in pressurized cooking and freezing time did not affect the levels of protein, fat, crude fiber, ash and carbohydrate content of instant *Ledok*. The most appropriate cooking and freezing times that resulted in the best quality characteristics of instant *Ledok* were 12 min pressurized cooking time and 72 hr freezing time.


**Keywords:** instant *Ledok*, traditional food, quality characteristics, pressurized cooking, freezing

## INTRODUCTION

Carbohydrates are a staple food needed to fulfill the nutritional needs of the community (Winarno, F.G., 2008). Where the staple food is based on only one type of carbohydrate source such as rice, food security is weakened because of potential difficulties in the constant supply and distribution of large amounts. Therefore, other sources of carbohydrates are required based on a local food source that is not rice which can be grown in the local area and can be utilized to meet the basic needs of local communities without relying on imports from other countries.

Some local food sources that have been and are being developed as a substitute for rice


1 Department of Agricultural Engineering, Faculty of Agricultural Technology, Udayana University, Bukit Jimbaran Campus, Badung, Bali 80361, Indonesia.

2 Department of Agro-industrial Technology, Faculty of Agricultural Technology, Udayana University, Bukit Jimbaran Campus, Badung, Bali 80361, Indonesia.

3 Department of Food Science and Technology, Faculty of Agricultural Technology, Udayana University, Bukit Jimbaran Campus, Badung, Bali 80361, Indonesia.

* Corresponding author, e-mail: anom_wijaya@unud.ac.id


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carbohydrate sources are corn, sorghum, sago, pumpkin and various types of tubers (Sumaryanto, 2009; Ariani, 2010; Rahmatullah and Suryani, 2012). The combination of several local food sources to obtain proper formulation and processing technology (both simple and sophisticated) is required to provide food continuously. In addition, government promotions through food fairs, advertising, and culinary competitions have been used to introduce and promote local non-rice food sources (Food Security Agency, 2009).

One local non-rice food which is still consumed by the people in the region of Nusa Penida, Klungkung regency, Bali province, Indonesia is *Ledok* which is a traditional food consisting primarily of corn and cassava tubers that are mixed with red beans or peanuts (Suter *et al*., 2007). Beside these materials, people also often add green vegetables, seasonings and fresh fish such as tuna Suter *et al*. (2011) and mackerel into *Ledok* (Sugitha *et al.,* 2007). The development of *Ledok* for human consumption is necessary so that the dependence on rice can be reduced gradually. Further development to make *Ledok* into commercial food products requires in-depth research in the fields of formulation, process engineering, quality control and marketing.

*Ledok* commercialization can be achieved by converting the traditional *Ledok* into instant *Ledok*. In general, the production process of instant food includes several stages of processing: preliminary cooking, refrigeration or freezing, drying and packaging (Limonu *et al*., 2008). Foodstuffs which are generally processed into instant food products are sweet potatoes, cassava, maize, rice and noodles (Isnaeni, 2007 ). Research related to the instant products from the raw materials of *Ledok* has been carried out by Sugiyono *et al.* (2004), Isnaeni (2007), Sugitha *et al.* (2007), Suter *et al.* (2007) and Agustina (2008).

Research has been reported on *Ledok* that aims to formulate raw materials and improve the quality and nutritional content. For example, Sugitha *et al.* (2007), reported that instant *Ledok* porridge with the addition of mackerel at 1.96% of the total raw material increased the levels of protein and fat; the cooking time to turn the instant *Ledok* flour into porridge that was ready to eat was 5 min. Suter *et al*. (2011) modified the *Ledok* formulation by adding seaweed and tuna to increase the fiber and protein content. Their results found that the addition of tuna into *Ledok* can also increase the protein content of *Ledok*. However, the cooking process of the instant *Ledok* into a ready-to-eat meal required 17.5 min. A long cooking process results in wasted energy and time and the loss of nutritional substances which is why in-depth research needs to carried out to shorten the cooking time and retain the quality of instant *Ledok*.

One approach to shorten the cooking time and maintain the quality of instant product is the use of a pressurized cooking process. Much research on the use of pressure cooking to improve and maintain the quality of food products has been carried out. Tovar and Melito (1996) studied the role of high pressure cooking in reducing the resistant starch in legumes. Fernandez *et al.* (1998) perfomed research on the effect of pressure cooking on the quality of chicken meat. Negi *et al.* (2001) investigated the effect of pressurized cooking on the digestability of moth bean. Park and Kim (2006) observed the effect of pressurized cooking on aflatoxin in rice. Khandelwal *et al.* (2010) used pressurized cooking to reduce the polyphenol and tannin contents of pulse-based foods.

The current study investigated the effects of pressure cooking and freezing instant *Ledok* on quality characteristics such as physical characteristics (yield, power rehydration, porosity, density and cooking time) and the chemical composition (moisture, fat, protein, ash, carbohydrate and energy). The production process of instant *Ledok* occurs in several stages, involving soaking, pre-cooking, cooking, refrigeration or freezing, thawing and drying. In a study conducted by Suter *et al.* (2011), pre-cooking was conducted by steaming or boiling for 30–35 min depending on the type of raw material.

The objectives of the current study were to assess the effect of treatments using pressurized cooking and freezing time on the quality characteristics of instant *Ledok*, and to determine the proper pressurized cooking and freezing times to obtain the best quality characteristics of instant *Ledok*.

## MATERIALS AND METHODS

### Materials and equipment

The materials used were cassava, yellow corn, peanuts, red beans, dried vegetables, spices, and materials for analysis of quality characteristics and were obtained from local markets in Denpasar, Bali, Indonesia. The equipment used was a gas stove, cookware, pressure cooker, freezer, oven dryers, desiccators, glass jars, sealer, food analysis tools and glassware.

### Research procedure

This study used a factorial randomized complete design with two factors—pressurized cooking time and freezing time. The pressurized cooking time treatments consisted of four levels (6, 8, 10 and 12 min) and the freezing time treatments consisted of three levels (24, 48 and 72 hr). The freezing temperature was -20 $^{o}$C. The entire experiments were repeated twice to obtain 4 × 3 × 2 = 24 combinations of treatments. Data analysis was performed using two way analysis of variance with the SPSS software (version 15.0; SPSS Inc. Chicago, IL, USA). Duncan's test was applied to test significance at the level $P < 0.05$.

First, the raw materials (casava, corn, peanuts and red bean) were prepared and soaked in cold water for 3 hr. The casava was cut into cubes (5 × 5 × 5 mm) before soaking in cold water. Next, samples of each raw material were cooked using the pressure cooker for 6, 8, 10, and 12 min, and then left to cool at room temperature for 30 min before being frozen at -20 $^{o}$C for 24, 48 and 72 hr. After thawing at room temperature for 1 hr, the materials were dried in oven dryer at 60 $^{o}$C to a moisture content of 3%. The dried materials were then mixed together to constitute instant *Ledok*.

The quality characteristics of instant *Ledok* were determined based on the physical characteristics and chemical composition (proximate analysis).

### Physical Characteristics

#### Yield

Yield (Association of Official Analytical Chemists, 1984) was calculated using Equation 1:

$$Yield\ (\%) = \frac{a}{b} \cdot 100\% \quad (1)$$

where: *a* is the weight of instant *Ledok*, *b is the* weight of fresh cassava, corn and red beans and all measurements are in grams.

#### Water absorption

Water absorption (Hubeis, 1985) was calculated by cooking instant *Ledok* in boiling water for 3 min and then comparing the weight of the cooked *Ledok* with the weight of the initial instant *Ledok*. The calculation was formulated using Equation 2:

$$Water\ absorption\ (\%) = \frac{(w_f - w_i)}{w_i} \cdot 100\,\% \quad (2)$$

where: $w_f$ is the final weight of cooked *Ledok and* $w_i$ is the initial weight of instant *Ledok* with all measurements in grams.

#### Cooking time

Cooking time was determined from a modification of Suter *et al*. (2011). A total of 100 g of instant *Ledok* was cooked in 500 mL of boiling water and stirred until the mixture thickened. The total time required from when the instant *Ledok* was placed in the boiling water until it was ready to eat was calculated as the cooking time in minutes.

**Chemical characteristics (proximate analysis):**

**Water content**

The water content was determined using Association of Official Analytical Chemists (2005). A sample of instant *Ledok* (5 g) was put into an aluminum cup of known weight which had previously been dried in an oven at 105 °C for 1 hr. Samples were dried until reaching a constant weight and then cooled in a desiccator and weighed. The difference in weight before and after drying was calculated as the water content using Equation 3:

$$Water\ content\ (\%_{wb}) = \frac{(w_i - w_d)}{w_i} \cdot 100\% \quad (3)$$

where $w_i$ is the initial weight *and* $w_d$ is the dried weight both measured in grams.

**Ash content**

The ash content was measured using the furnace method (Association of Official Analytical Chemists, 2005). A sample (5 g) was placed in a porcelain cup of known weight and was burnt in a furnace at 600 °C for 3 hr after which the sample was cooled in a desiccator and weighed. The ash content was calculated using Equation 4:

$$Ash\ content\ (\%) = \frac{Weight\ of\ ash}{Sample\ weight} \cdot 100\% \quad (4)$$

**Fat content**

The fat content was determined using the Soxhlet method (Association of Official Analytical Chemists, 2005). A dried sample (5 g) was wrapped in filter paper and put into the Soxhlet flask. Petroleum ether was incorporated into a fat flask that had been weighed and then subsequently extracted for 5 hours. The distillated fat solvent in the flask was dried in an oven at 105 °C. The fat content was determined using Equation 5:

$$Fat\ content\ (\%) = \frac{(Final\ flask\ weight - Initial\ flask\ weight)}{Sample\ weight} \cdot 100\% \quad (5)$$

**Protein content**

The protein content was determined using the micro-Kjeldahl method (Association of Official Analytical Chemists, 2005). A sample (0.2 g) was weighed and then put into a 100 mL Kjeldahl flask and added with 2 g of $K_2SO_4$, 40 mg of HgO and 2.5 mL of concentrated $H_2SO_4$. The mixture was allowed to react for 30 min until the liquid was a clear green color and it was then left to cool. Next, 35 mL of distilled water and 10 mL of concentrated NaOH was added and distillation was performed. The distillate was collected in a 125 mL Erlenmeyer flask containing $H_3BO_3$ and titrated with 0.02 N HCl. The reference solution was analyzed as the sample. The protein content was calculated using Equation 6:

$$Pr otein\ content\ (\%) = 6,25 \cdot \left[ \frac{(v_{HCl} - v_{blanko}) \cdot N_{HCl} \cdot 14,007}{w_s} \cdot 100\% \right] \quad (6)$$

where $v_{HCl}$ is the HCl (titration) volume in milliliters, $v_{blanko}$ is the reagent blank volume in millimeters, $N$ is normality and $w_s$ is the sample weigth in milligrams.

**Carbohydrate content**

The carbohydrate content was calculated using an analysis by difference (Equation 7):

$$Carbohydrate\ content\ (\%) = 100 - (\%\ of\ protein + \%\ of\ fat + \%\ of\ water + \%\ of\ ash) \quad (7)$$

## RESULTS AND DISCUSSION

Examples of instant *Ledok* at the various processing stages used are presented in Figure 1 and the color of the raw materials of instant *Ledok* still appeared fresh, even though the water content was 3%. This result agreed with Patras *et al.* (2009) who found that high pressure cooking preserved the color of tomato puree compared with a conventional thermal treatment.

**Physical characteristics of instant *Ledok***

**Yield**

The yields of raw materials in instant *Ledok* (cassava, corn, peanuts and red beans) are presented in Figure 2. Treatments of different pressurized cooking and freezing times and their interactions had a significant effect on the yield of cassava, beans, corn and peanuts. The yield of cassava was highest at 6 min cooking time (40.27%), and lowest at 12 min cooking time and freezing for 72 hr (29.87%). The corn yield was highest at 6 min cooking time (36.53%) and

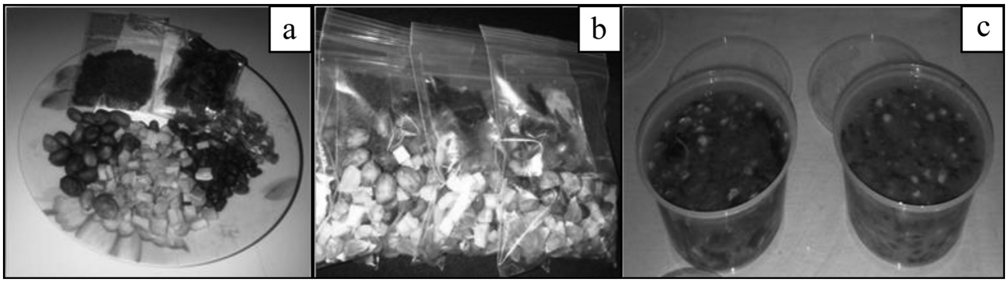


**Figure 1** Instant *Ledok:* (a) Unpackaged; (b) Packaged; (c) Ready to eat.

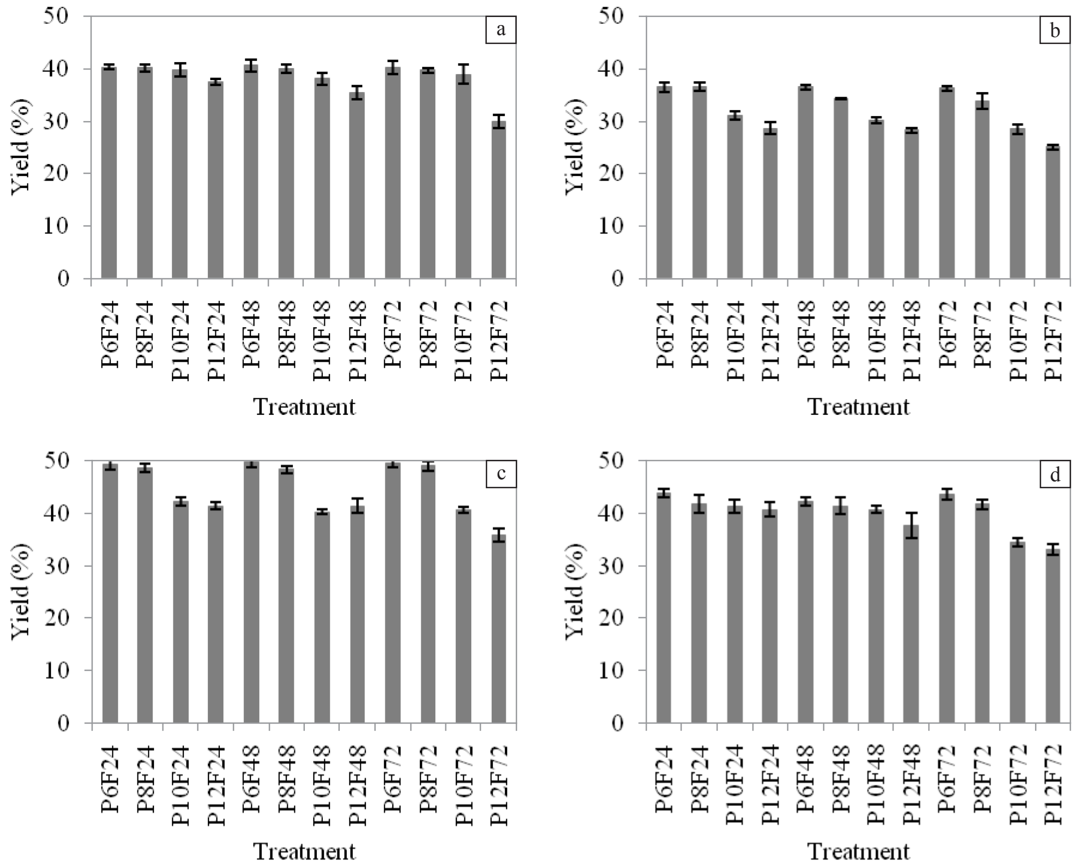


**Figure 2** Raw material yields from instant *Ledok*: (a) Casava; (b) Corn; (c) Peanuts; (d) Red bean (Vertical error bars = ± SD; Treatment codes: P = Pressure cooking, followed by time in minutes; F = Freezing, followed by the time in minutes).

lowest at 12 min cooking time and freezing for 72 hr (25.07%). The highest bean yield was after cooking for 6 min (44.00%) and after 12 min cooking time and freezing for 72 hr (33.10%). For peanuts, the highest yield was after 8 min cooking time (49.73%) and the lowest was after 12 min cooking time and freezing for 72 hr (35.87%). A longer cooking time and longer freezing time resulted in a lower yield of cassava, maize, beans and peanuts. Rahayoe *et al*. (2009) stated that pressurized cooking affected mechanical properties such as the yield, density and volume of cassava. The pressurized cooking process resulted in the cells of materials expanding and being damaged, thereby increasing the rate of decrease in the water content during drying. Martunis (2012) stated that the longer the drying time on tubers like potatoes, the greater the amount of water removed from the material and this affected the yield of potato starch.

**Water absorption of instant *Ledok* after immersion for 3 minutes**

The water absorption results of the raw materials of instant *Ledok* cooked in boiling water for 3 min are presented in Figure 3. The treatments of different pressurized cooking and freezing times and their interactions significantly affected the water absorption of cassava, beans, corn and peanuts.

The water absorption in cassava was greatest after 12 min cooking time and freezing for 72 hr (113.57%) and lowest after 6 min cooking

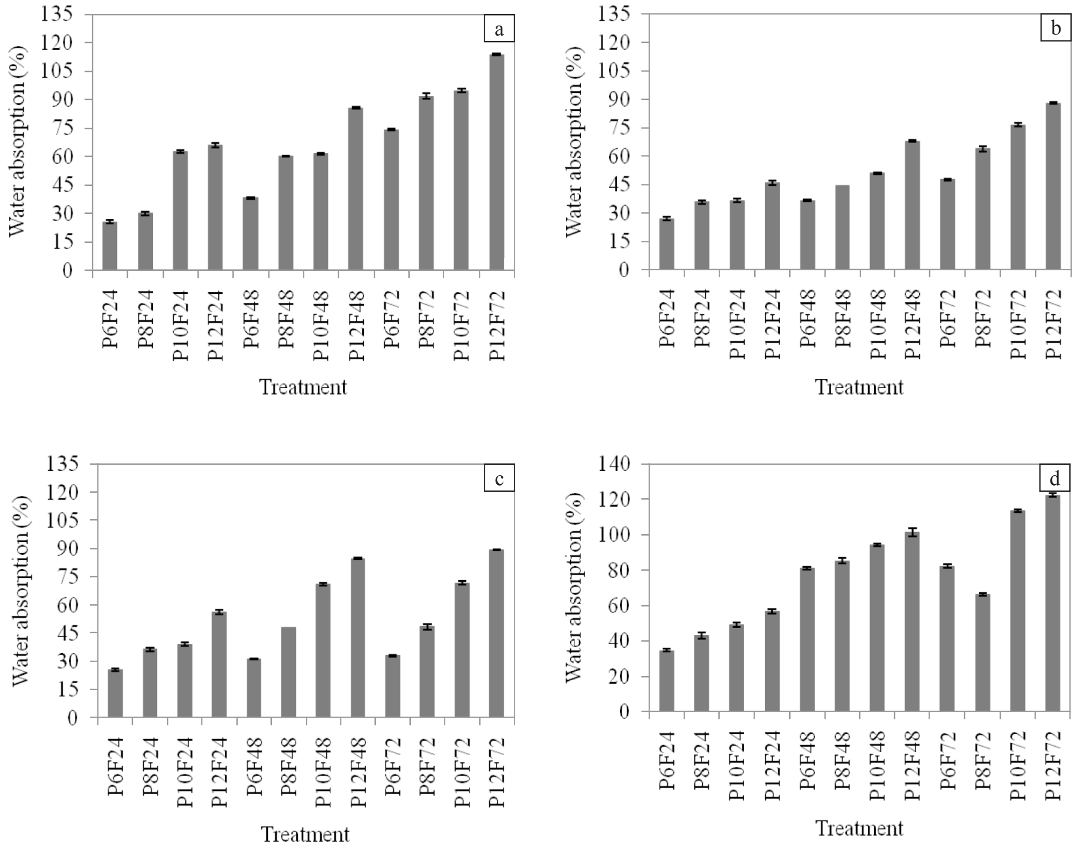


**Figure 3** Water absorption of raw materials from instant *Ledok*: (a) Casava; (b) Corn; (c) Peanuts; (d) Red bean (Vertical error bars = ± SD; Treatment codes: P = Pressure cooking, followed by time in minutes; F = Freezing, followed by the time in minutes).

time and freezing for 24 hr (25.42%), which was not significantly different from the 8 min cooking time and freezing for 24 hr (29.99%). For corn, the highest water absorption occurred after 12 min cooking time and freezing for 72 hr (88.01%) and the lowest after 6 min cooking time and freezing for 24 hr (26.91%), while for red beans, the water absorption was highest after cooking for 12 min and freezing for 72 hr (122.47%) and the lowest after cooking for 6, 8, and 10 min and freezing for 24 hr (35.40, 43.13, and 49.28%, respectively). In peanuts, the water absorption was highest after 12 min cooking time and freezing for 48 hr (84.62%), which was not significantly different from a cooking time of 12 min and freezing for 72 hr (89.36%), and the lowest was after 6 min cooking time and freezing for 24 hr (25.56%).

Red beans had the highest water absorption of the raw materials of *Ledok*. The fresh red beans that were used had the highest water content among the materials (74.31 ± 0.6%). In the pressurized cooking process, the cells of red beans were damaged so that the water contained in the cell was easily removed when the red beans were frozen. The drying process performed after freezing resulted in even more water being expelled so that the cavity inside the cell became larger. In the dry state (water content 3 ± 0.2%), red beans would very easily absorb water and swell until they exceeded their original volume. Pressurized cooking can inflate and damage the surface of the cells so that the cells become wider, have a faster drying rate and the material becomes porous. Material with a high water content has a higher limit of reversible deformation compared to the materials with low water levels (Rahayoe *et al*., 2009). Research conducted by Husein *et al*. (2006) regarding instant corn “Gritz”, suggested that slow freezing and drying using an oven drier resulted in material becoming more porous and producing a faster rehydration time compared to using a quick freezing and drying cabinet drier, a vacuum drier or a fluidized bed drier.

**Cooking time of instant *Ledok***

The cooking times of instant *Ledok* samples produced from various pressurized cooking and freezing times are presented in Figure 4 which shows that the cooking time for instant *Ledok* (from 2.9 to 5.6 min) was reduced with increased pressurized cooking time and freezing.

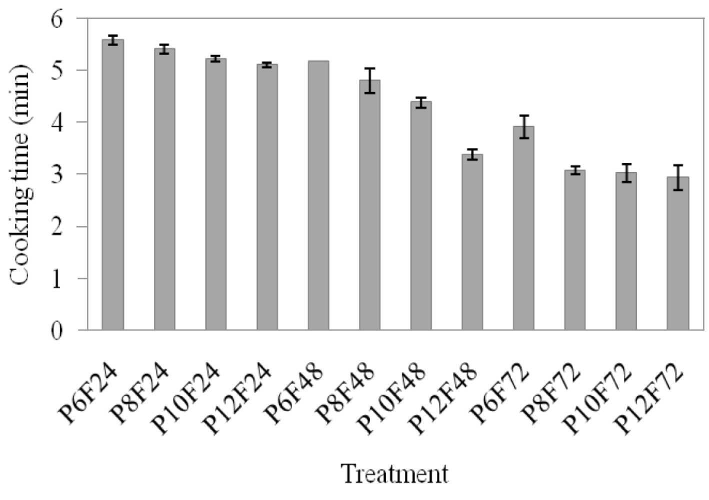


**Figure 4** Cooking time of instant *Ledok* for different treatments. (Vertical error bars = ± SD.; Treatment codes: P = Pressure cooking, followed by time in minutes; F = Freezing, followed by the time in minutes).

The shortest cooking time was after pressurized cooking for 12 min and freezing for 72 hr. The results of Sugiyono *et al*. (2004) showed that an instant corn grits product had a shorter cooking time than for corn grits. Cooking time is closely associated with the gelatinization process and according to French (1984), gelatinization occurs due to heating at a high moisture content resulting in melting followed by hydration and the irreversible development of cells. Material that has experienced the process of gelatinization during cooking and is then frozen and dried, when reheated will absorb more water faster, so the cooking time becomes shorter.

**Chemical characteristics of instant *Ledok***

The chemical characteristics of instant *Ledok* (protein, fat, ash, crude fiber and carbohydrates) are presented in Table 1 which shows that the chemical characteristics of instant *Ledok* treated with various pressurized cooking and freezing time treatments were not significantly different. Hayashi (1990) stated that high pressure leads to the effective reduction of the activity of food quality-related enzymes and that only non covalent bonds (hydrogen, ionic, and hydrophobic bonds) are affected, causing unfolding of protein chains which causes negligible impairment of nutritional values, taste, color, flavor or vitamins content.

It would appear from a nutritional prospective, that high pressure processing is an excellent food processing technology which has the potential to retain compounds with health properties in foods. Macronutrients such as carbohydrates, proteins and lipids and most micronutrients such as anthocyanins, carotenoids, and total phenolics do not appear to be affected by high pressure processing (Gamlath and Wakeling, 2011). Careful selection of a cooking pressure around 400–600 MPa and an exposure time of 5–15 min are essential to retain the levels of bioactive compounds and antioxidant properties (Patterson *et al*., 2006; Gamlath and Wakeling, 2011).

## CONCLUSION

Treatments involving different pressurized cooking times and freezing had a significant influence on the yield and water absorption of instant *Ledok*, but had no effect on the levels of

**Tabel 1** Chemical characteristics of instant *Ledok*.

| Treatment | Protein (%) | SD | Fat (%) | SD | Ash (%) | SD | Fiber (%) | SD | Carbohydrate (%) | SD |
|---|---|---|---|---|---|---|---|---|---|---|
| P6F24 | 13.32 | 0.8111 | 10.83 | 0.5374 | 0.02 | 0.0007 | 17.80 | 0.2942 | 58.03 | 1.6419 |
| P8F24 | 12.99 | 0.7898 | 10.81 | 0.5381 | 0.02 | 0.0007 | 15.52 | 0.5445 | 60.65 | 0.7828 |
| P10F24 | 11.99 | 0.7432 | 9.28 | 0.5226 | 0.02 | 0.0014 | 16.60 | 0.1980 | 62.02 | 1.4651 |
| P12F24 | 13.15 | 0.6201 | 10.15 | 0.6597 | 0.02 | 0.0007 | 14.50 | 0.7283 | 62.19 | 0.7672 |
| P6F48 | 12.77 | 0.4610 | 10.74 | 0.1527 | 0.02 | 0.0014 | 16.78 | 0.3677 | 59.69 | 0.6774 |
| P8F48 | 12.42 | 0.5056 | 10.45 | 0.1605 | 0.02 | 0.0014 | 15.25 | 0.1831 | 61.86 | 0.4815 |
| P10F48 | 11.89 | 0.7311 | 10.16 | 0.1556 | 0.02 | 0.0014 | 15.47 | 0.2482 | 62.46 | 0.6371 |
| P12F48 | 13.21 | 0.7241 | 9.90 | 0.3755 | 0.02 | 0.0007 | 15.51 | 0.2206 | 61.36 | 0.5685 |
| P6F72 | 13.32 | 0.4610 | 11.72 | 0.5848 | 0.02 | 0.0021 | 16.92 | 0.4738 | 58.02 | 0.5699 |
| P8F72 | 12.97 | 0.5763 | 11.98 | 0.7220 | 0.02 | 0.0021 | 15.22 | 0.3048 | 59.81 | 1.6009 |
| P10F72 | 13.12 | 0.5091 | 10.35 | 0.1676 | 0.02 | 0.0014 | 16.75 | 0.2263 | 59.77 | 0.5692 |
| P12F72 | 11.81 | 0.8471 | 11.09 | 0.3302 | 0.02 | 0.0014 | 14.31 | 0.2319 | 62.76 | 1.4078 |

Treatment codes: P = Pressure cooking, followed by time in minutes; F = Freezing, followed by the time in minutes.

protein, fat, ash, crude fiber and carbohydrate. The longer the cooking time and the longer the freezing time, the lower the yield and the higher the water absorption. Instant *Ledok* with the best characteristics resulted from the treatment of 12 min pressure cooking and 72 hr freezing, since it had the shortest cooking time, the highest water absorption and the proximate analysis was not different from the other treatments.

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