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The Characteristics of Ledok Which is Added with Seaweed

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Abstract
Ledok is a traditional food like porridge originally from Nusa Penida, Klungkung Regency, Bali Province, Indonesia. *Ledok* main ingredient is white corn and cassava tubers and coupled with vegetables and seasoning obtained locally. *Ledok* is potentially developed into functional food because it contains bioactive components such as dietary fiber, minerals and antioxidants. The purpose of the research was to determine the type of seaweed that produces *ledok* with the best characteristics in terms of sensory aspects, nutrient content, minerals, dietary fiber and antioxidant activity. The experiment used a randomized block design with the treatments of the types of seaweed, i.e.: R0 (without seaweed addition), R1 (added with *E.cottoni* seaweed, R2 (added with *E.spinosum* seaweed) and R3 (added with *Gracilaria* sp.seaweed). The treatments were repeated six times. Addition of seaweed was as much as 10 percent of the total weight of the *ledok* materials except water. The characteristics of *ledok* observed were the sensory properties (color, aroma, texture, flavor and overall acceptability), the content of nutrients (water, ash, fat, protein and carbohydrates), antioxidant capacity, IC-50, dietary fiber and minerals. The results showed that the types of seaweed effect on aroma, protein content, antioxidant capacity, Ca and Mn minerals. The addition of *Gracilaria* seaweed produces *ledok* with the best characteristics of acceptability of moderately favored sensory, 0.11% of fat content, 2.54% of protein, 15.28% of carbohydrate, antioxidant capacity of 66.24 ppm GAEAC, IC-50 of 155.32 mg/ml, total dietary fiber of 18,40% db (dry basis), Ca of 2,620.72 ppm and Mn of 17.18 ppm.
Keywords: *ledok*, seaweed, sensory properties, antioxidant capacity, dietary fiber.

1. Introduction

Ledok, a kind of porridge, is one of the traditional foods in the Sub-District of Nusa Penida, Klungkung Regency, Province of Bali, Indonesia. The main ingredients of *ledok* are white corn and cassava tuber. The uniqueness of this *ledok* that it does not use rice as the main ingredient, thus it contributes to reduce the need for rice as the staple food of the Indonesian population. *Ledok* can increase the role of non-rice foods such as corn and tubers. Other ingredients used in the making of *ledok* are: peanut, cowpea, long bean, spinach, chili, garlic, galangal, bay leaf, basil and lime available locally. In simplifying the preparation, increasing the shelf life and widening the distribution range, *ledok* has been developed into instant ones (Suter *et al*. 2007, Suter *et al*. 2009a, Suter *et al*. 2009b and Suter *et al*. 2011). The materials used in the making of *ledok* are local foodstuffs. This is important in order to support the government programs in the field of food security. The ingredients of *ledok* are not dependent on the area or other countries because it is sufficiently available locally in most parts of Indonesia. The materials of *ledok* comes from a variety of foodstuffs so that the nutritional content and quality are expected to be better than the type of food that uses ingredients derived from one type of material only.

Increased public awareness about the importance of healthy food results in the shift of consumer demand for foods. Foodstuffs that are in demand by the consumers, namely those that have a good nutritional composition, good flavors, and contain specific physiological function for the body called functional foods. Functional foods are growing rapidly with the increasing demand for functional foods and the public awareness about health (Suarni 2009).

Ledok has the potential to be developed into functional food because it contains bioactive components such as dietary fiber, minerals and antioxidants that play an important role in the physiological processes of the body. Consumers' demand for functional foods is increasing because functional foods have the properties to improve health or to prevent degenerative diseases such as *diabetes mellitus,* coronary heart disease and high blood pressure (Subroto 2008).

Corn and beans are sources of dietary fiber as one of the active compounds (phytochemicals) responsible for the ongoing metabolic reactions that benefit health. Corn is the second staple food after rice. Besides being a source of carbohydrates, it is also an important source of protein in the menu of Indonesian people. Corn contains the components needed by the body such as: dietary fiber, essential fatty acids, isoflavones, mineral Fe, β carotene (pro vitamin A) and essential amino acids (Krisnamurthi 2010). Cowpea contains fiber, folic acid, calcium, phosphorus, vitamin B1, sodium, iron, and the price is relatively cheap and widely available in traditional markets (Departemen Kesehatan RI 1992).

There are two types of dietary fiber, namely: insoluble fiber that plays a role in the digestive system and reduce the risk of cancer. Dissolved fiber plays a role in reducing the risk of coronary heart disease (CHD) and some types of cancer (Subroto 2008). Soluble fiber has a hypocholesterolemic properties that can reduce cholesterol (Stark & Madar 1994). Seaweed is one type of food that contains high fiber i.e. between 25 - 75%, useful for patients with hyperlipidemia (Lahaye 1991 and Murata *et al*. 1999) and patients with hypertriacylglycerolemia (Murata *et al*. 2002) . According to MacArtain *et al*. (2007), the species of *E. cottoni, Gelidium* sp. and *Sargasum* sp. have a fiber content of 64,43%, 53,05% and 56% respectively. Seaweed species that have been widely cultivated by the local farmers are *Eucheuma cottonii, Eucheuma spinosum* and *Gracilaria* sp. (Herpandi *et al*. 2006). Seaweeds are the richest source of minerals and dietary fibers. Dietary fiber contents of Indonesian seaweed 7,1 – 11,6 g/100 g (Santosa *et al*. 2006). *E. spionosum* in Nusa Penida waters contain dietary fiber by 12.18 % (Diharmi *et al*. 2011), whereas *Gracilaria sp*. contains 11.20 % db of dietary fiber (Princestasari *et al*. 2015). The macromineral contents of Indonesian seaweed are Mg (2,9 - 21,5 mg/g db), Ca (2,8 - 28,3 mg/g db), K (0,3 - 87 mg/g db) and Na (0,7 - 11,9 mg/g db) and the micromineral contents are Cu (0,002 – 0,251 mg/g db), Zn (0,003 – 0,227 mg/g db) and Fe (0,041- 0,813 mg/g db)(Santosa *et al*. 2006). The iodium contents of seaweed range from 0.1 – 0.15 % db (Winarno *et al*. 1990). Minerals are very important for biochemical reactions in the body as cofactors of enzymes. *Eucheuma* sp. is a source of carrageenan (Wibowo *et al*. 2014),whereas *Gracilaria* sp.as a source of gelatin. Because of its dietary fiber, antioxidant and mineral contents, seaweed is very potential to be used as a constituent material of *ledok* to be developed into a functional food.

The experiment in the study was to make *ledok* by adding it with three types of seaweed i.e. *E.cottonii, E. spinosum* and *Gracilaria* sp, because these three seaweeds are mostly cultivated by local seaweed farmers in Bali, contain dietary fiber, bioactive components potential for antioxidants and mineral contents. It is expected that *ledok* produced contain a better chemical content and sensoric characteristic. The aim of this study is to determine the type of seaweed that produces *ledok* with the most excellent characteristics in terms of the sensory aspects, the content of nutrients, minerals, dietary fiber and the antioxidant activity.

2. Materials and Methods

The ingredients used were: white corn, cornmeal, cassava, chilli, shallot, garlic, kaffir lime, spinach leaves, peanuts, basil leaves, bay leaf, salt, and seaweed (*E. cottonii , E. spinosum* and *Gracilaria* sp). The chemicals used were : Kjeldahl tablet, H_2SO_4, NaOH, HCl, hexane, enzyme of alpha-amylase (Termamyl 120 L), pepsin, pancreatin, ethanol, 2,2-diphenyl-1-picrylhydrazyl (DPPH) and ethanol. Equipments used include Kjeldahl equipment, Soxhlet equipment and AAS (Atomic Adsorption Spectrophotometer).

Experiments using Randomized Block Design (RAK), with four treatments: 1) without seaweed addition (R0), 2) with the addition of *E.cottonii* seaweed (R1), 3) with the addition of *E.spinosum* seaweed (R2) and 4) with the addition of *Gracilaria* sp. seaweed (R3). The treatment was repeated six times. The addition of seaweed was as much as 10 percent of the total weight of all ingredients of *ledok* except water.

Dry seaweed was cleaned and sorted, then weighed as much as 100 g, washed with water four times, kept soaked in 1% citric acid solution for 24 hours. The amount of citric acid solution used was 1 liter or the weight ratio of seaweed and a solution of citric acid was 1: 10. After soaking, the seaweed was washed 4 times with water, and was kept drained. Furthermore, the seaweed was cut into small pieces. Vegetables (spinach leaves, basil leaves and bay leaf) were washed with water. All ingredients of *ledok* were weighed according to the formula (Table 1). The seasonings were chili, garlic, shallot, peel of kaffir lime and salt mixed with kaffir lime then blended.

Ledok making process is as follows: The water was heated to boiling, then put the corn and it was boiled until half-cooked (15 minutes), then put the other ingredients except spinach and basil leaves that were last added. The boiling continued until the *ledok* was ready as cooked porridge (20 minutes). Furthermore, the analysis / testing of the characteristics of the *ledok* was conducted.

Table 1. Formula of *ledok*

Num.	Ingredients	Amount (g)
1	White corn	100
2	Cornflour	52.5
3	Cassava	90
4	Chili	3
5	Shallots	5
6	Garlic	1.5
7	Peel of kaffir lime	0.25
8	Spinach leaf	15
9	Beans	107.5
10	Basil leave	10
11	Bay leaf	2
12	Salt	3
13	Seaweeds (as per treatment)	39
14	Water	1.715 ml
The total amount of weight		2,143.75*

*The total weight of ingredients without seaweeds and water = 389.75 g

The parameters (characteristics) observed were the sensory properties covering color, aroma, taste, texture and overall acceptability by hedonic test (Larmond 1977), water content by oven method (AOAC 1990), ash content by dry dyeing method (AOAC 1990), protein content by modified Micro-Kjeldahl method (AOAC 1990), fat content by Soxhlet extraction method (AOAC 1990), carbohydrate content was calculated based on Carbohydrate by differencet (AOAC 1990), mineral content by using Spectrophotometer (Apriyantono *et al.* 1989), dietary fiber content by using multienzyme method (Asp *et al.* 1983) and antioxidant capacity by determination of capture ability of free radical compounds with 2,2-diphenyl-1-picrylhydrazyl (DPPH) (Sompong *et al*. 2011). The data obtained were then analyzed by analysis of variance (ANOVA). If there was a significant effect of each treatment then it was proceed with DMRT (Duncan Multiple Range Test) (Gomez & Gomez 1995).

3. Results and Discussion

3.1. Sensory Properties

The effect of seaweed types on the sensory characteristics of *ledok* (color, aroma, texture, taste and overall acceptability) is presented in Table 2. From Table 2, it can be seen that the types of seaweed have a significant effect (P <0.05) on the aroma of *ledok*, whereas the color, texture, flavor and overall acceptability were not significant. Aroma of *ledok* which was added with seaweeds (*E.cottonii*, *E.spinosum* and *Gracilaria* sp.) was preferably compared with *ledok* aroma that was not added with seaweed. This is because seaweed can produce a distinctive aroma on the *ledok* i.e. the aroma of seaweed. Among the three types of seaweed *E.cottoni, E. spinosum* and *Gracilaria* sp. did not produce a distinctly different aroma of *ledok*. The acceptability rate of the color of *ledok* ranges from 5.25 to 5.60 (fairly preferable), textures between 4.75 (regular) - 5.20 (fairly preferable), taste ranging from 4.50 - 4.80 (normal) and Overall acceptability ranged from 5.00 - 5.30 (fairly preferable).

Table 2. The average score [1]) of the degree of preference to the color, aroma, texture, taste and overall acceptability of *ledok*.

Ledok	Color	Aroma	Texture	Taste	Overall Acceptability
Without Seaweed	5,25±1,02a*	4,90 ±1,21b	5,00 ±1,34a	4,65±1,23a	5,00 ±1,12a
E.cottoni	5,45±0,89a	5,50±1,10ab	5,10±0,97a	4,80 ±1,11a	5,10 ±0,97a
E.spinosum	5,60±0,75a	5,35±1,14ab	4,75± 1,07a	4,65±1,09 a	5,05 ±0,94 a
Gracilaria	5,50±0,76a	5,85±0,81a	5,20 ±1,06a	4,50±1,32 a	5,30 ±1,13a

1) Score 7 = mostly preferable, score 6 = preferable, score 5 = fairly preferable, score 4 = normal, score 3 = somewhat dislike, score 2 = dislike and score 1 = terribly dislike.

*The same letter behind the average value in the same column showed no significant difference (P<0,05) based on DMRT.

3.2. Nutritional Value

The nutritional values i.e. the contents of water, ash, fat, protein and carbohydrate of *ledok* are presented in Table 3. Table 3 shows that the protein content of *ledok* was influenced very significantly (P <0.01) by the types of seaweed added, but the contents of water, ash, fat and carbohydrate were not significantly affected. The protein level of *ledok* added with seaweeds of *E. spinosum* and *Gracilaria* sp. was significantly lower than that of the *ledok* without added with seaweed and that of the addition of *E.cottni* seaweed. The decrease in protein levels may be due to the heated seaweed that formed a gel that was able to bind proteins so that it lowered the protein content of *ledok*.

Table 3. The average values of water, ash, fat, protein and carbohydrate contents of *ledok*

Ledok	Water (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)
Without Seaweed	82,59±3,14a*	0,45 ±0,04a	0,09±0,06 a	3,06 ±0,26a	13,81±3,19a
E.cottoni	82,78±1,84a	0,48±0,03a	0,10±0,05 a	2,99±0,42 a	13,65±2,04a
E.spinosum	81,73 ±6,29a	0,50±0,05a	0,17±0,17 a	2,58 ±0,19b	15,02±6,53a
Gracilaria	81,59 ±2,75a	0,48±0,04a	0,11± 0,07a	2,54±0,44b	15,28±2,88a

*The same letter behind the average value in the same column showed no significant difference (P<0,05) based on DMRT.

The water content of *ledok* ranged from 81.59% - 82.78%, ash content ranged from 0.45% - 0.50%, fat content ranged from 0.09% - 0.17% and carbohydrate levels ranged between 13.65 % - 15.28%.

3.3. Antioxidant Capacity and Dietary Fiber

The average value of antioxidant capacity, IC-50, the levels of soluble dietary fiber, insoluble dietary fiber content and total dietary fiber content of *ledok* can be seen in Table 4. It can be seen that the types of seaweed significantly affected the antioxidant capacity of *ledok*, but had no significant effect on IC-50, soluble dietary fiber, insoluble dietary fiber and total dietary fiber of *ledok*. Antioxidant capacity of *ledok* added with *E. spinosum* seaweed and *ledok* that was added with *Gracilaria* sp. seaweed was higher than the antioxidant capacity of *ledok* without the addition of seaweed. Increased antioxidant capacity is probably because the seaweed contains compounds that act as antioxidants. Phenol, fucoxanthin pigmen, polysaccharide sulphate, phycobilin and vitamin are bioactive components that contribute in the antioxidant activity of seaweed (Nawaly *et al*. -). IC-50 of *E. cottonii* is 106,021 ppm (Maharany *et al*. 2017).

Table 4. The average values of antioxidant, IC-50, soluble dietary fiber, insoluble dietary fiber and total of dietary fiber content of *ledok*.

Ledok	Antioxidant Capacity (ppm GAEAC)	IC- 50(mg/ml)	Soluble dietary fiber (% db)	Insoluble dietary fiber (% db)	Total dietary fiber(% db)
Without Seaweed	54,42±24,81 b*	178,00±22,54a	2,62± 0,53a	15,52 ±1,50a	18,14 ±1,83a
E.cottoni	61,07±23,08ab	170,92±26,51a	2,67± 0,76a	15,63 ±1,02a	18,31 ±0,85a
E.spinosum	64,26±21,05 a	167,25±27,76a	3,08± 0,60a	16,00 ±0,89a	19,08 ±1,28a
Gracilaria	66,24 ±17,97a	155,32±26,12a	2,80± 0,37a	15,68 ±1,15a	18,40 ±1,26a

*The same letter behind the average value in the same column showed no significant difference (P<0.05) based on DMRT.

IC-50 of *ledok* ranged between 155.32 mg/ml - 178.00 mg/ml, soluble dietary fiber ranged between 2.62% bk - 3.08 % db, insoluble dietary fiber ranged between 15.52 % db - 16, 0% db and total dietary fiber ranged between 18.14 % db - 19.08 % db.

3.4. Mineral

The average value of the mineral content of *ledok* is presented in Table 5. From the data of Table 5, it can be seen that the type of seaweed significantly effected on the mineral content of Ca and Mn, but not significantly effected on the mineral content of Cu, Fe and Zn. Levels of Ca mineral of *ledok* added with seaweed of *E.spinosum* and *ledok* added with *Gracilaria* sp. seaweed were higher than the level of Ca of *ledok* added with *E.cottoni* seaweed and *ledok* without the addition of seaweed. The increased levels of Ca of *ledok* may be due to the Ca contents in the *E.spinosum* and *Gracilaria* seaweeds were higher than *E.cottoni*.

The Mn mineral content of *ledok* added with *E.cottoni* seaweed and *ledok* added with *E.spinosum* seaweed were lower than those of *ledok* without the addition of seaweed and *ledok* added with *Gracilaria* sp.seaweed. The lower mineral content of Mn in the *ledok* added with seaweeds of *E.cottoni* and *E.spinosum* may be due to the Mn contents in both types of seaweed were smaller than the Mn content in *Gracilaria* seaweed. The difference of mineral depends on the seaweed habitat. The amount of mineral, organic matter in the water, the depth of water, distance to the shore and environment affect the amount of mineral in seaweed (Venugophal 2010 in Ma'ruf *et al*. 2013). The Cu mineral content of *ledok* ranged between 27.91 ppm - 34.32 ppm, the mineral content of Fe ranged between 214.45 ppm - 370.28 ppm and the Zn mineral content ranged from 39.94

ppm - 52.47 ppm.

Table 5. The average values of the mineral contents of Ca, Cu, Fe, Mn and Zn of *ledok* (ppm)

Ledok	Ca	Cu	Fe	Mn	Zn
Without Seaweed	136,73 ±154,69b*	28,34 ±7,39a	370,28±146,83a	20,47± 3,67a	50,09±10,53 a
E.cottoni	111,85±109,87b	31,76 ±12,24a	214,45 ±78,73a	12,08 ±1,73b	39,94± 12,29a
E.spinosum	2.941,03±425,49a	27,91 ±17,53a	316,17±109,38a	11,19 ±1,35b	52,47 ±8,89a
Gracilaria	2.620,72 ±360,08a	34,32 ±12,20a	288,89 ±70,83a	17,18±4,43a	45,80± 7,52a

*The same letter behind the average value in the same column showed no significant difference ($P<0.05$) based on DMRT.

4. Conclusion

Types of seaweed affected on the aroma, protein content, antioxidant capacity, Ca and Mn minerals, but did not affect on the levels of preference for color, texture, taste and overall acceptability. It also had no effect on water, ash, fat, and carbohydrate contents, as well as the IC-50, soluble dietary fiber, insoluble dietary fiber, total dietary fiber, Cu, Fe and Zn. *Gracilaria* sp. seaweed produced the best quality of *ledok*, of which the acceptability of color, aroma, texture, taste and overall acceptability was fairly preferable, the fat nutrient content was 0.11 %, 2.54 % of protein, 15.28 % of carbohydrate, antioxidant of 66,24 ppm GAEAC, IC-50 of 155,32 ml/ml, soluble dietary fiber 2,80 % db, insoluble dietary of 15,68 % db, total dietary fiber of 18,40 % db, Ca mineral of 2.620,72 ppm and Mn of 17,18 ppm

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