The potential for developing local corn from East Nusa Tenggara as raw material for indigenous cuisine and processed products: A mini-review

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Abstract. East Nusa Tenggara is one of the provinces in Indonesia that uses corn as staple food. Bose corn is an indigenous cuisine for people on the island of Timor, East Nusa Tenggara province. The corn used as raw material for this indigenous cuisine is generally local varieties. Local varieties of corn contain high amylose, so it takes a long time to cook. Starch modification is an instantization method which can be used to shorten its cooking time. Nixtamalization and pregelatinization are simple starch modification methods that can be applied by the community using a certain level of calcium hydroxide and appropriate cooking times. Bose corn is one of the indigenous cuisine processing products using local raw materials that can be developed as an instant food.

1. Introduction

In Indonesia, corn is the second staple food source after rice. The demand for corn as food commodity in East Nusa Tenggara is constantly increasing. Corn has an important role as commercial commodity for export trade with limited quantities as well as national corn production has not able to meet national needs [1]. According to East Nusa Tenggara Statistics data 2020 [2], corn production has increased over the last ten years. In 2019, dry shelled corn production in East Nusa Tenggara reached 884,326 tons from the harvested area of 335,901 ha. Besides, in 2009 dry shelled corn production was 638,899 tons from the harvested area of 250,536 ha. Corn is a local food ingredient that has the potential to substitute the function of rice and flour [3].

Corn plants in East Nusa Tenggara are dominated by local corn cultivars (37%) and the rest are superior free pollinated corn Lamuru varieties (16%) and hybrids (6%) [4]. Local farmers prefer to use local varieties rather than hybrids. Local varieties of corn have a high genetic diversity [5], early maturity [6], drought resistance [6], and distinctive characteristics [7]. East Nusa Tenggara is one of the provinces that uses corn as a staple food. Bose corn is an indigenous cuisine for Timor island’s people, East Nusa Tenggara [8]. The corn which used as raw material for this Bose corn is generally local varieties. However, the use of local corn varieties are still limited and only cultivated on a household scale.
Although corn is the plant which considered suitable for semi-arid region in East Nusa Tenggara but poor soil and low rainfall have caused a low corn productivity or even failed harvest [9]. Previous research has been concerned about processing corn into special and processed foods. This paper will discuss the potential of local corn as a raw material for indigenous cuisine and processed foods using simple methods.

2. Corn as raw material for indigenous cuisine

Indonesia is a country that has a variety of cuisines with distinctive flavors. Each region has a special food by the natural potential contained in the area. Various cooking methods may need to undergo raw materials before it is ready to be served or is harmless for consumption. Some regions in Indonesia have special foods that use corn as the main ingredient (Table 1).

Table 1. The indigenous cuisines made from corn from several regions in Indonesia [10].

| No. | The indigenous cuisines | Area of origin | Raw material |
|-----|--------------------------|----------------|--------------|
| 1   | Nasi Kemunak Batanghari  | Jambi          | Keladi, Yellow corn |
| 2   | Lepet jagung             | East Java      | Young corn, grated coconut |
| 3   | Jagung Bose              | East Nusa Tenggara | White corn, salt |
| 4   | Kambeweno Kahitela       | Muna, South-East Sulawesi | White corn, grated coconut, lime |
| 5   | Kambewe                  | Muna, South-East Sulawesi | Dried corn, coconut milk, nuts, lime |
| 6   | Kampalusu                | Muna, South-East Sulawesi | Dried corn, grated coconut, lime |
| 7   | Katumbu                  | Muna, South-East Sulawesi | Young corn, Coconut milk |
| 8   | Kina Gandu               | Tolaki/Moronene, South-East Sulawesi | Corn, coconut milk, pandan leaves, salt |
| 9   | Lapoti Gandu             | Tolaki/Moronene, South-East Sulawesi | Corn, grated coconut, green beans, salt |
| 10  | Barobbo                  | South Sulawesi  | Corn, spinach, vegetables |

Bose corn - as an indigenous cuisine from East Nusa Tenggara is a mixture of corn that has ground until the husk/pericarp is removed and mixed with nuts. The cooking process of the corn and beans takes about 3.5 hours until tender. Then, the coconut milk can be added to make it more savory [11]. The corn which is usually used as raw material for Bose corn is white, but yellow corn is often used by the public (Figure 1). According to the East Nusa Tenggara Food Security Service, Bose corn (100 g) contains carbohydrates (29.27 g), protein (5.79 g), and fat (4.97 g) [12].

Figure 1. Original corn (A: whole corn), corn without pericarp (B: raw Bose corn), and Bose corn after processing (C: the final product).
3. Corn plantation in East Nusa Tenggara
According to Murningsih et al [6], the low productivity of corn in East Nusa Tenggara is due to decision of using local corn which have heterozygous characteristic of local corn. This characteristic means that corn seeds produced as a result of planting from local farmers’ crops over the generations on a limited scale (inbreeding). In addition, corn productivity is also affected by drought stress, which can be overcome by planting dry-resistant and early maturing corn varieties [13]. East Nusa Tenggara is a semi-arid area characterized by lowlands, erratic rainfall, poor soil fertility, diverse agroecosystems and dominant rocky soil [9]. Corn productivity in East Nusa Tenggara can be increased by applying permanent planting holes as a conservation farming method. This method is one of the innovations to eliminate shifting cultivation practices, optimize the use of rocky dominant land and increase water absorption or soil moisture.

4. Chemical composition of corn
Corn is the most abundant source of starch in the world and is the basis of many chemically modified enzymes, and functional products. Starch is the major carbohydrate of the kernel endosperm weight (85%) and the total kernel weight (72%). Generally, corn contained 75-80% of branched amylopectin chain and 20-25% linear amyllose chain [14].

Proximate analysis is a comprehensive analysis of nutrient content which includes moisture, ash content, protein content, fat content, and carbohydrates. This analysis is carried out to determine the nutritional composition of a food ingredient so that we can determine the nutritional levels of foods that can be consumed [7]. Based on the results of the proximate analysis in the United States, whole corn contained 15.5% of moisture, 7.5% of protein, 3.2% of fat, 1.2% of ash, and 61.6% of starch [15]. Table 2 showed the proximate analysis result of local corn which generally have a higher level of protein, fat, ash, and starch. It showed that the nutritional chemical composition of local corn is relatively high and can meet the requirements as raw materials for original and processed foods.

| Chemical composition (%)* | Corn varieties |
|---------------------------|----------------|
|                           | Momola Gornontalo | Pena Tunu’ Ana’ | Piet Kuning | Gumarang | Lamuru |
| Moisture                  | 14.82±0.04       | 10.49±0.01       | 11.31±0.01 | 11.43±0.04 | 12.05±0.01 |
| Ash                       | 1.35±0.01        | 1.45±0.01        | 1.09±0.01 | 1.21±0.11 | 1.11±0.11 |
| Protein                   | 11.51±0.24       | 11.78±0.05       | 7.78±0.10 | 6.88±0.01 | 7.41±0.16 |
| Fat                       | 4.62±0.48        | 5.59±0.22        | 4.95±0.13 | 4.15±0.17 | 4.40±0.02 |
| Carbohydrate              | 67.68±0.67       | 70.69±0.21       | 74.92±0.02 | 76.35±0.33 | 75.05±0.42 |

Note: *Numbers are the mean ±standard deviation of 2 replications

5. Starch modification
Starch is a homopolysaccharide stored in plants as food reserves. This homopolysaccharide consists of glucose units linked together with the glycosidic bonds. The advantages of starch are low cost, biodegradable, renewable, and widely available. However, starch also has several drawbacks, namely low water solubility, retrogradation, decreased viscosity due to the breakdown of the treated glycoside bonds, and the presence of several important groups with different functions such as carboxylic, ester, ether, and amino chain [16]. Therefore, modifications need to overcome these problems and increase the usability of starch. These modifications can be done chemically [17], [18] and physically [19], [20].

Modification of starch on corn kernels will result in interactions between the components in it. The interactions that occur causes a changes in the physicochemical properties of corn kernels [21]. Changes in the physicochemical properties of the corn kernels are desirable but some are undesirable [22]. The cooking process on Boe corn is done to get a tender corn kernel texture for consumption [11].
Modification of starch which can change the texture of the corn kernels to become softer are pregelatinization and nixtamalization methods.

5.1. Nixtamalization

Nixtamalization is a process carried out in Mexico and Central America to convert corn into a staple food for public consumption. The nixtamalization process includes cooking the whole corn kernels in a saturated calcium hydroxide solution (1-5% w/w) by weight of corn, soaking for 8-24 hours, washing to remove alkali, pericarp, and other materials [24]. In nixtamalization, alkaline liquid Ca(OH)$_2$ is given which aims to break the hydrogen bonds of the hydroxyl groups in the starch structure so that there is a change in its viscoelasticity [24]. During the nixtamalization process, calcium enters the corn kernels, and then modifies the physical, structural, chemical, sensory, appearance, and nutritional content of the nixtamal product [25].

The addition of alkaline Ca(OH)$_2$ with a concentration of 0.0-0.4% w/w and heated at 92 °C for 20 minutes can trigger changes in the microstructure of starch. However, the higher the concentration of alkali used, the slower the change. This can be due to the presence of bonds from calcium ions that maintain the amylopectin structure of starch. The use of a 0.2-0.25% (w/w) lime solution indicates that there is a rapid change. Meanwhile, at higher lime concentrations, changes occur more slowly. This is probably due to the saturation of the starch structure that binds to calcium ions [26]. In traditional nixtamalization with Ca(OH)$_2$, calcium diffuses into the endosperm structure by percolation and in the same way into the pericarp. This process depends on the temperature and steeping time. With increasing temperature and steeping time, the hydrolysis and solubility of pericarp components also increased and micro-holes are formed. Micro-holes apparition for critical stepping time in dependence on the temperature represents that a further pathway is presenting to the calcium uptake [23].

Figure 2. Starch interaction through water molecules (a) and calcium hydroxide bridge (b). Hydrogen bonds are indicated by dots [27].

Calcium-starch interaction within alkaline media (pH>8.0) occurs when the amylose molecules and some amylopectin chains carry negative charges. It means that their hydroxyl groups dissociated and allowing interactions with Ca$^{2+}$ and Ca(OH)$^+$ ions. Therefore, the Ca(OH)$_2$ dissociation produce an OH$^-$ anions which destroy the hydrogen bonds (H bonds) within the water molecules-H bonds through the amylose and amylopectin chains are connected. Thus, the starch chain is open and the reactive site is exposed which leads to the partial protonation of the sugar moiety. This stimulates the interaction
between Ca ions and the amylose or amylpectin chains in the form of alkoxides and between them, leading to the formation of Ca bridges (Figure 2.) [17]. Based on this fact, it is known that by controlling the concentration of the swelling agent, it is possible to vary the rate of swelling. At low swelling agent concentrations, water is slowly and reversibly removed and limited swelling occurs [27].

5.2. Pregelatinization
Pregelatinized starch also well known as an instant starch is starch which has been cooked and dried under conditions that allow without or little retrogradation. Pregelatinized starch hydrates quickly and dissolves in cold water. Pregelatinized starch is used in food applications when heat is not available, there is not enough heat for starch processing, and when heat cannot be applied due to the thermal lability of other materials [28]. Time and temperature greatly affect the gelatinization of starch at different stages. The heating treatment of corn starch and increasing the gelatinization gradient carried out by fast (5 minutes) and long (20 and 30 minutes) methods can withstand isothermal at 64-95 °C. The critical temperature points are at 70 and 76 °C, which are the first and second temperature thresholds, respectively. The initial stage of the gelatinization process occurs at a temperature of < 70 °C. The length of heating time can determine the effect of heating time on the gelatinization stage [29].

The swelling power for the native and modified starches at temperatures ranging from 50 to 90 °C. From the study, the swelling power of the starches rose as the temperature increased. This phenomenon was expected, which is an indication that absorption of water by a starch granule can be elevated by increasing temperature [30]. The X-ray diffraction patterns of the treated starches showed that crystallinity was decreased during the thermal treatments; boiling in water and steam healing [31].

There is an advanced stage for increasing the quality of local corn processed food in line with nixtamalization and pregelatinization through local corn. Fortification is a technique of enrichment that may minimize the potential of nutritional insufficiency inside the starch modification [31]. The discussion was confined to the basic method of developing the potential local maize of East Nusa Tenggara as a raw material for Bose corn, an indigenous cuisine, in accordance with the aim of this study. This review initiates the way of research thinking related to instantiation project for indigenous cuisine not limited to Bose corn but other culinary food such as katemak corn which also be an indigenous cuisine of East Nusa Tenggara.

6. Conclusions
Local corn of East Nusa Tenggara has the potential to be developed into indigenous instant cuisine and processed products especially for Bose corn. The introduction of simple technology to process local corn into instant food needs to be done to increase the additional value of the local product.

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