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Effect of Smoking Application on the Quality of Local Timor Corn

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ABSTRACT

Corn is one of the most widely cultivated plants in Indonesia and is used as a staple food by several people, especially in the province of East Nusa Tenggara. The way to store corn is done by farmers, namely smoking. Fumigation is done by burning wood in the smoking room (kitchen). Fumigation is carried out with the intention of preserving corn by utilizing a heat source that comes from the smoke from burning wood or other materials. The purpose of this study was to determine changes in water content changes during the smoking process using plant materials and to determine the quality of local Timor corn. Based on the results of the study, the average ambient temperature was 30.43ºC, the average RH was 81.76%, with an average initial moisture content of 18.76% wb was able to reduce the water content of local Timor corn to 11% wb (using Schleicera oleosa), 10.5% wb (Hyptis suaveolens), and 10.2 (Chromolaena odorata), average reducing sugars 0.52% wb, average protein content 7.82% wb, average carbohydrates 7.59% wb, and average fat 5.35% wb.

1. INTRODUCTION

The main problem in handling post-harvest corn at the farmer level is the loss of yields from harvest to post-harvest. This is due to the limited knowledge and skills of farmers in handling harvest and post-harvest as well as agricultural machinery which is quite expensive. Proper post-harvest handling is needed to obtain high-quality corn. Deficiencies in post-harvest handling can result in enormous losses and even the product loses economic value (Molenaar, 2020). Proper post-harvest handling is required to obtain high-quality maize and prevent fungal contamination. According to Kimatu *et al.* (2012) postharvest handling has an important role in the management of agricultural businesses, especially in preventing aflatoxin poisoning. Improper handling will cause damage to the seeds so as to reduce the quality and price of corn. Post-harvest handling that is poorly performed will cause yield loss, both weight and quality of the resulting product, especially for harvesting in the rainy season (Firmansyah *et al.*, 2007).

In the Timor areas, East Nusa Tenggara (NTT) Province, storage of agricultural products is a method for farmers to overcome excess production during the peak harvest season so that they can be sold when production drops or during a famine. One of the conventional ways to store corn that is generally done by farmers in Timor is smoking in the kitchen area. This method is used to secure corn yields in the rainy season. Storage of corn by smoking is done to reduce water and oxygen content in foodstuffs (Puspita *et al*., 2017). Storage by smoking is done by tying the corn in a corn hanger which in the local language is called *hau feob*. Corn that is hung in the form of a bundle (*aisaf*) or in the form of *kabutu* tightly arranged. The storage period ranges from 1-2 years. The corn storage model with smoking in the kitchen can be seen in Figure 1.

Figure 1. Storage of corn by smoking in the kitchen in Timorese society
(Photo: Nino, 2014)

The smoking carried out by the community in NTT Province has not been well designed so that it can lead to a decrease in quality and damage occurs. According to de Rosari *et al*. (2001) the low quality of maize in NTT is thought to be due to the greatest yield loss at the storage stage. In the smoking process, the time and duration of providing smoke and heat greatly affect the quality of the material. According to Nino (2020), the decrease in quality is caused by improper post-harvest handling techniques, namely the time and duration of applying smoke and excessive heat to corn which can cause loss of reducing sugar. In the smoking process, the heat transferred to the material during the smoking process can cause physical and chemical changes in corn such as protein which can be denatured. The decrease in protein content can be caused by several factors, one of which is the changing amino acid structure due to heating (Syarif *et al*., 2017). Damage to nutrients will increase if heating occurs for a long period (Gardjito, 2013). The same thing was said by Pavlov *et al*., (2008) heating causes the protein structure to denature, accumulate and become simpler forms.

The Timor area has a diversity of flora whose chemicals have been identified as containing secondary metabolites that have the potential as fumigants to reduce the rate of deterioration of corn quality and as raw materials for botanical pesticides. The use of local resources to control pests and diseases in maintaining the quality of agricultural products are very helpful for farmers. da Lopez & Boboy (2008) stated that there are several local plants in NTT which are thought to be used as botanical insecticides. In general, plant-based ingredient controls pests biologically so that it does not affect the quality of food. Plant materials that can be used for this purposes include *Annona sp.* leaves, *Hyptis suaveolens*, *Lantana camara*, *Ageratum conyzoides*, *Chromolaena odorata*, *Schleicera oleosa*, *Khaya senegelensis* root, *Acorus calamus*, *Pyrethrum sp*. flowers, *Capsicum sp*., and *Annona sp*. seed flour. These plant materials are found in many areas of Timor and are endemic plants. Based on this problem, the use of plant materials for post-harvest handling of corn is very important in improving the quality of agricultural materials. This study aims to determine changes in the moisture content and quality of Timor corn during the smoking process using locally available plant materials.

2. MATERIALS AND METHODS

2.1. Location and Time of Research

This research was conducted in Taekas Village, East Miomaffo District, North Central Timor Regency. This research took place for 6 months from May-October 2021. The research material used was local Timor yellow corn and plant material in the form of kirinyuh leaves (*Chromolaena odorata*), kusambi leaves (*Schleicera oleosa*), and gringsingan leaves (*Hyptis suaveolens*). The local Timor corn used during the smoking process is 6 fogu (dawan language term) or the equivalent of 60 kg. The smoking process is carried out in a closed kitchen. Bundles of husked-corn were tied to a hanger called *hau feob* with a height of about 2.5 m from the stove.

Figure 2. Plant materials used to produce smoke: (a) Kusambi (*Schleicera oleosa*), (b) Kirinyuh (*Chromolaena odorata*); and (c) Gringsingan (*Hyptis suaveolens*).

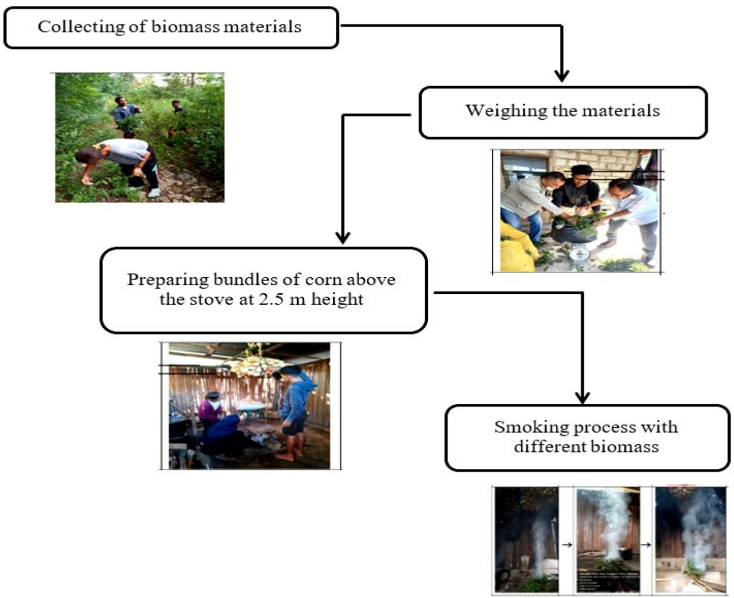

Figure 3. Flowchart of corn smoking experiment

2.2. Research Stages

This research was conducted in 2 stages, namely data collection in the field (smoking) and analysis of material quality. Smoking was carried out every day for 6 months, namely in the morning and evening with a weight of plant material for smoking 2 times each treatment for each type of biomass material. The flow chart for the implementation of smoking corn can be seen in Figure 2. The analysis was carried out at the Laboratory of the Faculty of Agriculture (University of Timor) and continued at the Laboratory of Agricultural Product Processing Technology (Universitas Gadjah Mada). The stages of research implementation can be seen in Figure 3.

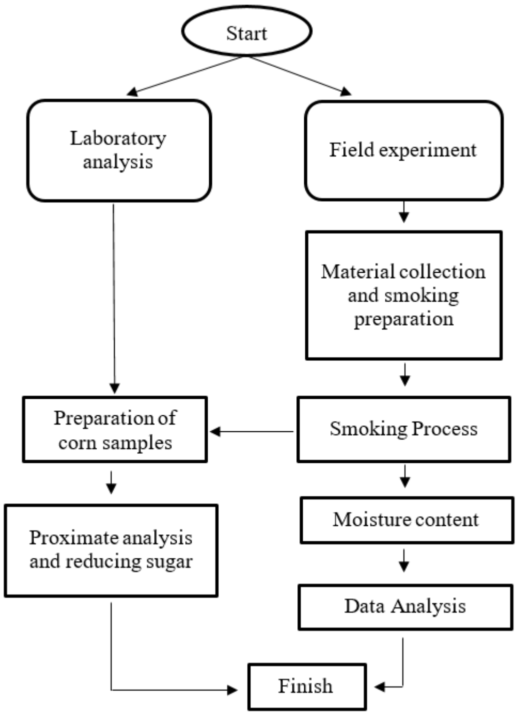

Figure 3. Flowchart of corn smoking using plant material

2.3. Parameters and Data Analysis

2.3.1. Air Temperature

Air temperature measurement is done by measuring the ambient temperature in the smoking area (kitchen). Temperature measurements were carried out in the environment around the smoking room (in the kitchen) using a calibrated stem thermometer. Temperature measurements are carried out at intervals of 1 time per week.

2.3.2. Relative Humidity (RH)

Measurement of relative humidity of drying air is carried out by measuring the relative humidity of the environment. Relative humidity is measured using a wet bulb and dry bulb thermometer. A wet bulb thermometer is made by covering the tip of the thermometer using gauze and keeping it moist. Measurements were carried out every day during the smoking process. Relative humidity measurements were carried out at intervals of 1 time per week.

2.3.3. Moisture Content

Measurement of water content is carried out to analyze the water content of the material using the gravimetric method. Measurement of water content was carried out at intervals of 1 time per week. The water content of the material is calculated using Equation (1).

$$Ka = \frac{Wm}{Wm+Wd} x\ 100\ \% \quad (1)$$

where *Ka* is the moisture content on a wet basis (% w.b), *Wd* is the weight of dry matter (g), *Wm* is the weight of water in the material (g).

2.3.4. Reducing Sugar

Analysis of changes in reducing sugar content using the Luff Schoorl method. The analysis was carried out at the TPHP laboratory at Gajah Mada University. For the analysis of reducing sugars a sample weighing 50 grams is needed.

2.3.5. Macro Nutrition

Analysis of protein content was carried out by the Kjeldahl method, while the analysis of fat content was carried out by the Soxlet method. Analysis of protein content and fat content was carried out with a sample weight of 50 grams. Equation 2 is used to calculate carbohydrate content (AOAC 1995).

$$\boldsymbol{Kk\ (\%\ bk\ ) = 100\%\ (P + Ka + L)} \quad (2)$$

where *Kk* is the carbohydrate content, *P* is the protein content, *Ka* is the water content and *L* is the fat content.

3. RESULTS AND DISCUSSION

3.1. Temperature and Relative Humidity

Based on Figure 3, it can be seen that the highest smoking temperature is found in the treatment using plant material of kusambi (*Chromolaena odorata*) leaves with an average temperature of 39 °C, while the lowest smoking temperature is found in the treatment using Gringsingan (*Schleicera oleosa*) with the lowest average temperature of 28 °C. Based on the temperature obtained from smoking using plant materials, it is still in the safe temperature range to prevent bacterial growth during the indoor storage process. According to Bintoro (2008) the condition of the storage room temperature that meets the requirements for storing corn with a moisture content of 13% wb. is at a maximum temperature of 28 °C.

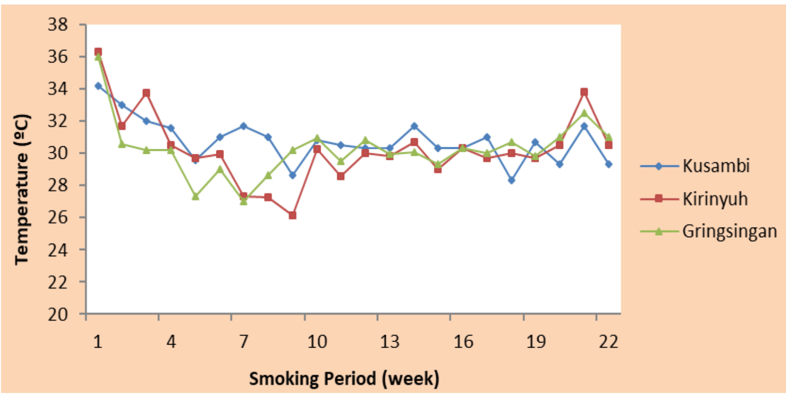

Figure 3. Temperature and air humidity during corn smoking experiment

Smoking using *Chromolaena odorata* has a higher temperature than smoking using *Schlecera oleosa* and *Hyptis suaveolens*. This is because the leaves and stems of *Cromolaena odorata* contain 56 essential oils including α-Pinene 42.2%, β-Pinene 10.6% and Germacrene D 9.7% (Priano, 2016). This affects the temperature to increase because the heat generated is still there and spreads in the smoking chamber.

In Figure 4, it can be seen that in the treatment with *Hyptis suaveolens* the relative humidity was higher than in the treatment with *Schleicera oleosa* and the treatment with *Cromolaena odorata* with low relative humidity. Sequentially the average relative humidity values of the three treatments were 80.61%, 81.27%, and 83.40%. Based on the SNI standard, a good corn storage technique is the maximum corn moisture content of 14% with a maximum humidity of 80% (SNI, 1988). The relative humidity in the Hiptys Suaveolens treatment was higher because the lower the smoking temperature, the higher the relative humidity. The higher the smoking temperature, the lower the relative humidity (Mulyono *et al*., 2013). However, at 06.00-07.00 the relative humidity is high this is because the temperature in the morning tends to be low and at 12.00-12.10 the relative humidity decreases because during the day the air temperature increases. The higher the temperature of the smoking air, the lower the relative humidity (RH) produced (Nino, 2017). The highest relative humidity during the smoking process was recorded at 83.40%. This is related to changes in water content, it can be seen that during the smoking process the average final water content produced from the three plant material is 10.56%. Based on the relationship between final moisture content and relative humidity, the resulting heat is quite high but the heat effect generated from the smoking process using plant materials has the potential as a drying medium.

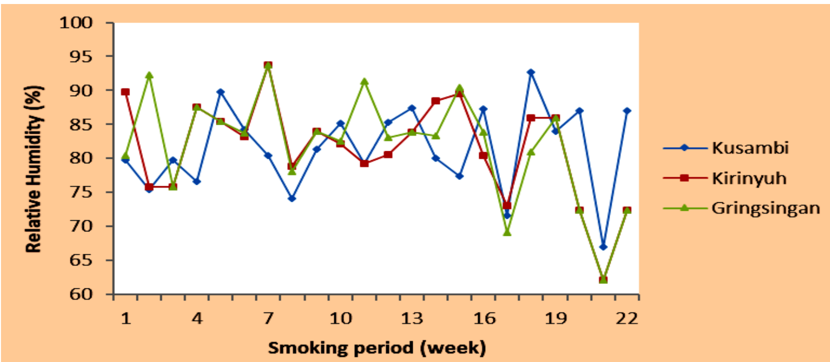

Figure 4. The relationship between RH and time during the smoking process

3.2. Changes in Water Content

Based on Figure 5, it can be seen that the final moisture content of the three smoking sites was 11% wk (*Schleicera oleosa*), 10.2% wk (*Chromolaena odorata*), and 10.5% wk (*Hyptis suaveolens*). Of the three treatments of plant material, *Cromolaena odorata* gave a lower water content value. This is because the smoking area in the treatment with plant material *Cromolaena odorata* has a higher temperature than the treatment with plant material of *Hyptis suaveolens* and *Schleicera oleosa*. The higher the temperature of the drying air, the heat transfer and mass between the air and the material will be greater and in the end the drying process will be faster (Widjanarko *et al*., 2012). Fitriani (2008) also stated that the ability of the material to release water from its surface will be greater with increasing drying air temperature. Although the water content of the treatment with the plant material of *Cromolaena odorata* had the lowest value of 10.2%, in the treatment with the plant material *Hyptis suaveolens* and the treatment with the plant material of *Schleicera oleosa* the water content finally met the standard for storage because the water content produced was already below 12%. The moisture content of grain materials such as corn to be safe during storage must be dried to a moisture content of 14-12% (Magan & Aldred, 2007). Low water content can increase product shelf life (Katiandagho *et al*., 2017).

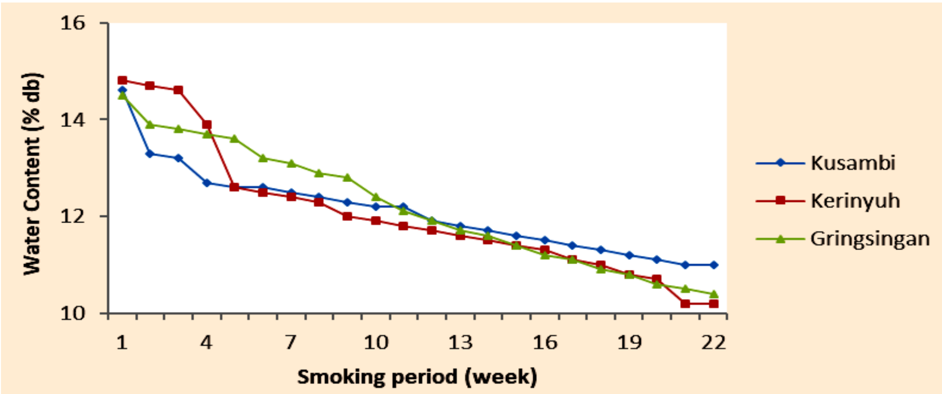

Figure 5. Changes in Final Moisture Content

3.3. Reducing Sugar

Reducing sugars are a group of sugars or carbohydrates that are capable of reducing electron-accepting compounds. Figure 6 shows the change in reducing sugar content where SP1 is before smoking and SP2 is after smoking. The value of reducing sugar before smoking was 0.59% and decreased by 7.6-15.3% after smoking depending on the type of plant material used. The percentage decrease in reducing sugar content from the largest to the smallest was 15.3% for smoking with *Hyptis suaveolens* (Gringsingan), 11.9% for smoking with *Cromolaena odorata* (Kirinyuh), and 7.6% for smoking with *Schleicera oleosa* (Kusambi).

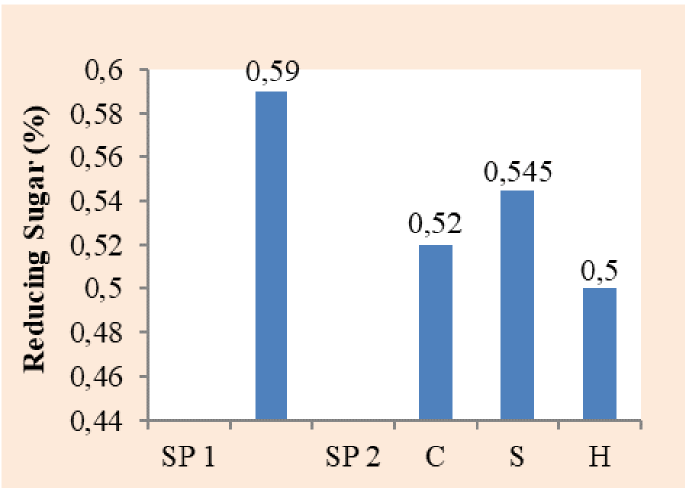

Figure 6. Value of Reducing Sugar Before and After Smoking (C = *Cromolaena odorata*; S = *Schleicera oleosa*; H = *Hyptis suaveolens*)

Based on the results of the analysis showed that the highest reducing sugar content after smoking using plant material was found in the treatment with *Cromolaena odorata* plant material with a value of 0.54% wk. In the treatment with plant material of *Cromolaena odorata* has the highest reducing sugar content because the compounds contained in *Cromolaena odorata* are tannins. According to Ratman *et al.* (2016), tannins have antioxidant benefits. Antioxidants can inhibit oxidation reactions by binding to free radicals thereby slowing the process of rancidity and decay. Treatment using *Hyptis suaveolens* plant material has low reducing sugar content because plant material *Hyptis suaveolens* contain essential oils. This essential oil ingredient can also affect the smoking process. Smoking with *Hyptis suaveolens* plant material can cause oxidation reactions, resinification, polymerization, thereby affecting the reduction of reducing sugars. Giving heat for a long time can result in a decrease in the quality of foodstuffs such as glucose content (Nuryani, 2013). In addition, the cause of the decrease in reducing sugar levels was caused by oxidation and polymerization reactions due to smoking which was carried out for quite a long time, namely for 6 months, so that when compared with the quality requirements set by the Indonesian National Standard, it was still very low. The decrease in reducing sugar levels was due to the hydrolysis of cellulose/hemiselulose into reducing sugars, but some of the resulting reducing sugars were further converted to furfural which in turn could form formic acid (Yulianingsih, 2010).

3.4. Macro-Nutrition

Based on the results of the analysis in Table 1. the value of protein content before smoking is 7.11% and after smoking using plant material the protein content increases, namely in smoking with plant material *Cromolaena odorata* and *Schleicera oleosa* with protein content values of 7.82% and 8.76 %. The longer the drying time, the water content contained in it will also decrease, causing an increase in protein content (Paggara, 2008). The same thing was said by Ibrahim *et al.* (2012) where evaporation of water during heating causes the water content to decrease and the solids concentration will increase. In addition, compounds in plant materials of *Cromolaena odora* and *Schlecera oleosa* have tannins that can protect corn protein from degradation due to excessive heat or microorganism degradation. According to Tanuwiria *et al.* (2019), tannins are able to bind proteins by forming strong complex bonds with protein molecules. In addition, the tannins contained in the vegetable ingredients *Cromolaena odora* and *Schlecera oleosa* give a distinctive aroma, namely a pungent smell. This aroma can prevent warehouse pests from attacking corn kernels. The distinctive aroma produced from vegetable ingredients *Cromolaena odora* and *Schlecera oleosa* does not affect the quality of the seeds so that they are safe for consumption or used as seeds. This is because the corn used in this experiment is corn that still has husks.

The value of fat content before smoking is 6.55%. After smoking, the fat content decreased and was influenced by the type of plant materials used, namely (5.07% wb) on smoking with *Schleicera oleosa* plant, (5.35% wb) with *Cromolaena odorata*, and (5.7% wb) with *Hyptis suaveolens*. The value of fat content after smoking is still said to be good because it meets the value of the Indonesian National Standard (SNI) for fat content in corn is 3.0%. The results of this study when compared with the work of Nino (2017) on corn drying by utilizing natural air gave a proximate value that was not much different, namely protein content of 9.05%, fat content of 3.74% and carbohydrate content of 74.99%.

Table 1. Proximate analysis of corn before and after smoking using different plant materials

Before smoking treatment (%wb)			
	Fat	**Carbohydrate**	**Protein**
	6.55	71.39	7.11
After smoking treatment (%wb)			
Plant material	**Fat**	**Carbohydrate**	**Protein**
Schleicera oleosa	5.07	73.66	8.76
Cromolaena odorata	5.35	73.59	7.82
Hyptis suaveolens	5.7	73.49	7.2

The value of carbohydrate content before smoking was 71.9% then after smoking using plant material the value of carbohydrate content increased, namely *Schleicera oleosa* (73.66% wb), *Cromolaena odorata* (73.59% wb) and *Hyptis suaveolens* (73.49% wb). This is because the antioxidants contained in plant materials have the ability to donate electrons and bind other electrons. The increase in the value of carbohydrate content is due to the uptake of electrons from lipid compounds. This is supported by the statement of Halliwell (2012) which states that antioxidants are compounds that have the ability to donate electrons, bind and end chain reactions of free radicals. In addition, the increase in carbohydrate content was caused by reduced water content in corn.

4. CONCLUSION AND RECOMENDATION

This research was conducted for 6 months from May-October 2021 with an average temperature of 30.43°C, relative humidity of 81.76%. During the fumigation process, the water content of the three treatments had met the standard moisture content of 11% wk, (*Schleicera oleosa*) 10.2% wk (*Cromolaena odorata*) and 10.55 bk (*Hyptis suaveolens*). The value of the highest reducing sugar content was found in the treatment with plant material *Cromolaena odorata*, which was 0.54% wb. The highest value of protein content and carbohydrate content was found in the treatment of plant material Schleicera oleosa with a value of 8.76% wb and 73.66% wb, while the highest fat content value was found in the treatment of plant material *Cromolaena odorata* with a value of 5.35% wb. In terms of quality, it can be concluded that the three plant material *Schleicera oleosa*, *Cromolaena odorata*, *Hyptis suaveolens* have phytochemical compounds capable of maintaining proximate levels in corn during the smoking process.

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