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## Effect of harvesting date and cultivar on yield, chemical, quality and production of biscuits from mixture of cassava and soft wheat flour

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**Abstract**

The current study was conducted in the two successive growing seasons of 2022/2023 and 2023/2024 on recently reclaimed sandy soil at the National Research Centre Station in Nubaria Region, Behira Governorate. This study examined the impact of harvesting dates on the quality and productivity of cassava cultivars as well as the impact of producing biscuits from cassava cultivars on the final product's suitability for consumption and quality. Split plot design was used in the study, with cultivars Indonesian, Brazilian, and American in the main plot and harvesting dates of 8, 9, and 10 months in the subplot. Results indicated that American cv. recorded the lowest plants length, leaves number, main stem number, hydrocyanic acid content and fibers %. Also, the American cv. gave the highest physical root quality, yield, dry matter and tuber root starch percentage. Regarding, the findings of the harvesting date indicated that the features of vegetative growth reduced with age. As aging increased, tuber root quality, dry matter, starch percentage, and fiber percentage all increased and produced the lowest hydrocyanic acid concentration values. Biscuit was prepared using ratios of 0:100, 5:95, 10:90, 15:85 and 20:80 cassava flour /wheat flour (WF) respectively and assessed for their color attributes, baking quality and sensory properties. Results showed that American cassava cv. flour had higher levels of moisture, protein, and carbohydrates, whereas Brazilian cassava flour had higher levels of ash, and Indonesian cassava flour had higher levels of fiber and total sugars. Furthermore, it can be proposed that up to 20% cassava flour be used in wheat flour biscuit recipes to create biscuits with good sensory qualities that are acceptable.

Keywords: Cassava, cultivars, harvesting dates, wheat flour, cassava flour, baking quality, sensory evaluation and biscuits

## 1. Introduction

In Egypt, cassava is an unusual crop (a tuber root) that is still not taken off despite its economic significance and effectiveness of production. Cassava (*Manihot esculenta* Crantz) is belongs to the botanical family Euphorbiaceae. One of the most significant sources of starch is cassava. Because of its high starch content and ability to grow in hard climates, cassava is an essential meal in both tropical and subtropical locations where it is produced [1 & 2]. Cassava has been used as a raw resource for industry, alternative fuel production, animal feed, and human food production. Cassava roots are rich in carbs and have a good nutritional value. Their carbohydrate production is 20% and 40% higher than that of corn and rice, respectively [3]. Three cassava cultivars in Egypt are the subject of limited study. These cultivars belong within the category of sweet ones, meaning they contain just a little of hydrocyanic acid. Their names are based on the country from which the cultivar was imported. The Indonesian variety, for example is imported from Indonesia, and so are the rest of the varieties. It was necessary to investigate it in order to determine how they differed by studying the harvest dates. As reported by El-Sayed *et al.* [4], harvesting cassava (an Indonesian cultivar) at 10 months of maturity produced the maximum yield, dry matter percentage, root quality, and starch in tuber roots; harvesting at 8 months showed the opposite tendency. In the case of Hanapi *et al.* [5], compared to harvesting at 7 and 8 months, cassava crop produced the maximum weight of tuber root, yield, and dry weight yield starch content for 5 clones when harvested at 9 months. Furthermore, due to its unique quality qualities, cassava flour is frequently used in place of wheat flour in bakery applications [6]. The sensory and textural characteristics of bread made with cassava flour instead of high gluten flour were investigated by Jensen *et al.* [7]. In the study, Ekunseitan *et al.* [8] exchanged premium cassava flour for wheat flour and modified the ratios of cassava, mushroom, and wheat flour to evaluate the compound flour's nutritional and functional properties. Cassava flour and wheat flour are comparable in terms of their starch content, decreased degradation tendency, melting onset, and absorption of water. However, cassava flour lacks sulfur-containing amino acids and gluten, and its low diastolic action results in poor bakery productivity [1 & 2]. The reason why biscuits are the most popular baked good is that they are naturally nutritious, reasonably priced, and come in a cultivar of forms. Due to their versatility, most bakery items can include a cultivar of nutrient-dense components. Due to their widely accepted flavor, adaptability, preservation, ease, texture, and look, biscuits are a

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popular and practical food product. Designing innovative food products with natural components is a highly appealing approach with a sizable market since they have functional qualities and offer unique health advantages beyond conventional nutrition. The purpose of this study is to identify how harvest dates affect cassava cultivar quality and production. Along with the potential to create and assess biscuits based on their chemical, baking quality, and sensory attributes utilizing wheat flour mixed with varying percentages of cassava flour.

## 2. Materials and Methods

The current investigation was conducted at the National Research Center's Nubaria Region Station in the EL-Behira Governorate in northern Egypt on recently reclaimed sandy land over the two growing seasons of 2022/2023 and 2023/2024. This experiment designed to determine how cassava harvest dates and cultivars affected the quality and productivity. Also, biscuits made from cassava varieties, as well as how this affected the product's appropriateness for consuming. Cassava cultivars were planted on 9$^{th}$ May and 17$^{th}$ April during the two growing seasons, respectively. Similar-thickness cassava stalks, around 2.5 to 3.0 cm in diameter, were cut into 25 to 30 cm in height stalk cuttings, which were then planted vertically by immersing two thirds of the cutting in the soil and leaving the other third above ground under a drip irrigation system. Three various cultivars (Indonesian, Brazil and American) and three harvesting dates (eight, nine and ten months) from planting were combined to create nine treatments for the field experiment. The trial was established as a split plot design, with different cultivars as the main plot and harvesting dates as the subplot. Both main and subplot were arranged in a randomized complete blocks with 4 replicates, in both planting seasons. Each subplot was 10 m$^2$ and had one row with a width of one meter and stalk cuttings were spaced one meter apart from each other. All agricultural practices needed for growing the cassava plants were performed.

**1-Field experiment**

**Data recorded**

**1. Vegetative growth, tuber root yield and its components**

Harvesting was done 8, 9 or 10 months after planting to record the following data in each harvesting date according to [9]:

- Length of plant.
- The number of leaves / plant.
- The number of main stems/ plant.
- The number of lateral branches / plant.
- Total yield of tuber root / ton/fed.
- The diameter of tuber root.
- The length of tuber root.
- The weight of tuber root.

**b. Chemical characters of tuber roots**

1. Dry matter % of tuber roots.
2. Starch % as described by AOAC [10].
3. Total fibers % of tuber root was determined as described by AOAC [11].
4. Hydrocyanic acid concentration was determined according to AOAC [11] and Foda [12].

**2- Biscuit production experiment**

The experiment on biscuit production involved making biscuits using different cassava types and observing how this affected the product's quality and acceptability for consumption.

**Materials**

Wheat flour (72% extraction), sucrose, sunflower oil, egg, salt, baking bowder and Vanilla were purchased from the local market, Dokki, Egypt. All chemical reagents were of analytical grade purchased from Sigma-Aldrich (Germany).

**Methods**

**Preparation of mixture:**

Wheat Flour was well blended with cassava flour to produce individual mixtures containing 0, 5, 10, 15 and 20 % American Cassava, Brazilian Cassava and Indonesian Cassava, respectively. All samples were stored in airtight containers.

**Preparation and evaluation of baking quality and sensory quality attributes of biscuits:**

The basic formula of biscuit and that containing different levels of American Cassava, Brazilian Cassava and Indonesian Cassava and other ingredients are shown in Table (1). Biscuits were prepared by mixing wheat flour (72%) with other ingredients; 14.7 ml of sucrose solution (5.93%) and the suitable amount of water were added according to [13]. The formulas were baked in an oven at 200 °C for about 15 minutes. Weight, volume, specific volume, diameter, thickness (height) and spread ratio of biscuits were recorded, every parameter was measured in triplicate and the mean was calculated. Organoleptic (sensory) characteristics of biscuits were evaluated according to [14] where each formula was subjected to sensory analysis by 20 panellists.

Each panellist was asked to assign scores 0-10 for color, flavor, taste, texture, appearance and overall acceptability.

**Color quality of Processed Products:**

Objective evaluation of colour for biscuits was measured. Hunter a*, b* and L* parameters were measured with a colour difference meter using a

Hunter colour meter (Tristimulus Colour Machine) with the CIE lab colour scale (Hunter, Lab Scan XE - Reston VA, USA) in the reflection mode. The instrument was standardized each time with white tile of Hunter Lab Colour Standard (LX No.16379): X= 72.26, Y= 81.94 and Z= 88.14 (L*= 92.46; a*= -0.86; b*= -0.16). Colour difference (ΔE) was calculated from a, b and L parameters, using Hunter-Scotfield's equation [15] as follows: $\Delta E= (\Delta a^2+ \Delta b^2+ \Delta L^2)^{1/2}$, Where a=a-a0, b=b-b0 and L=L-L0, The Hue angle (tg-1 b/a) and saturation index (√a2+b2) were calculated.

**Analytical Methods**

**Chemical composition**

Moisture, ash, crude protein, fat and crude fiber contents were determined in raw materials and products (biscuits) according to the methods outlined in [16]. Carbohydrates were calculated by difference as mentioned as follows: Carbohydrates = 100 – (% protein + % fat + % ash + % crude fiber).

**Statistical analysis**

Using MSTAT-Computer V4, data on vegetative growth, yield, and its components were statistically evaluated as split plot design, as stated by [17]. For assessing the differences in composition between treatment means, the Fishers adjusted least significant difference (LSD) at $P \leq 0.05$ was utilized.

The obtained results were evaluated statistically using analysis of variance as reported by [18].

**Table 1: Composition of mixtures used in manufacture of biscuits (g).**

| Ingredients | Biscuit formulas with | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Control | American Cassava at levels | | | | Brazilian Cassava | | | | Indonesian Cassava | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) |
| Wheat flour72% | 100 | 95 | 90 | 85 | 80 | 95 | 90 | 85 | 80 | 95 | 90 | 85 | 80 |
| Sucrose (gm) | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| Sunflower oil | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 | 28 |
| Cassava flour | - | 5 | 10 | 15 | 20 | 5 | 10 | 15 | 20 | 5 | 10 | 15 | 20 |
| Baking powder | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Eggs | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Vanilla | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

## 3. Results and Discussion

**-Vegetative growth parameters**

Outcomes in Tables (2 and 3) manifested the influence of cultivars on the plants growth. In this respect, Brazilian cultivar recorded the highest plant length, leaves number, main stems number and lowest branches number. As for the Indonesian cultivar registered moderate values of reading for the previously mentioned studied traits, except number of main stems were no significant differences between it and the American cultivar. The American cultivar done the lowest plant length, leaves number and the highest branches number during the two seasons. This result may be due to the nature of the growth of the cultivars, noted that the Brazilian cultivar gives main branches from the beginning of growth and did not give secondary branches. As for the Indonesian cultivar, the main branches start from 50 cm of growth followed the secondary branches. As for the American cultivar, the main branches started after about 20 cm of growth and give the secondary branch then secondary branches of the same. The difference obtained between the cultivars used in the experiment in terms of the final form of growth is due to the genotype of each cultivar. This requires us to choose the appropriate cultivar to obtain the highest productivity of the tuber roots crop [19]. As for the effect of harvesting dates on the plants growth in both seasons, a decrease in growth characteristics was observed with age. Thus, the increasing plant lenght and number of leaves of the plants was found when harvesting cassava after 8 months from planting, then the values decreased after 9 months from planting, and lowest values of plant lenght and number of leaves when harvesting after 10 months from planting. These results are normal because one of the signs of plant maturity is the fall of the leaves. Regarding, the main stems number and branches number, there were no statistically significant differences between them for three harvesting dates. This result is due to the fact that the number of main stems and branches is a constant characteristic.

The interaction between cassava cultivars and harvesting dates showed that significantly affected plants growth during the two seasons. The Brazilian cultivar at harvesting after 8 months from planting gave the highest values plant length and leaves number, while, American cultivar recorded the lowest values at cassava harvesting after 10 months from planting. During the three harvesting dates, the largest main stems number was observed with the Brazilian cultivar and the largest number of branches with the American cultivar.

**Table 2: Effect of cassava cultivars and harvesting dates on plant lenght, leaves number and main stems number at harvest time during 2022/2023 and 2023/2024.**

| Treatments | | Plant length | | Leaves number | | Main stems number | |
|---|---|---|---|---|---|---|---|
| | | First season | Second season | First season | Second season | First season | Second season |
| **Effect of Cultivars** | | | | | | | |
| **Indonesian** | | 234.4 | 177.4 | 81.5 | 101.7 | 2.5 | 2.4 |
| **Brazilian** | | 257.0 | 192.3 | 89.3 | 116.7 | 3.4 | 3.4 |
| **American** | | 201.8 | 165.6 | 68.8 | 114.2 | 2.7 | 2.5 |
| **LSD at 0.05** | | 4.7 | 6.3 | 5.4 | NS | 0.5 | 0.9 |
| **Effect of Harvesting dates** | | | | | | | |
| **8** | | 282.3 | 196.0 | 136.0 | 128.0 | 2.8 | 2.7 |
| **9** | | 234.2 | 180.4 | 85.2 | 118.5 | 2.8 | 2.6 |
| **10** | | 176.7 | 158.8 | 18.5 | 86.2 | 3.0 | 3.0 |
| **LSD at 0.05** | | 12.8 | 6.2 | 7.7 | 16.3 | NS | NS |
| **Effect of interaction** | | | | | | | |
| **Indonesian** | 8 | 285.7 | 190.3 | 141.7 | 120.0 | 2.6 | 2.3 |
| | 9 | 232.7 | 181.1 | 85.6 | 122.7 | 2.3 | 2.3 |
| | 10 | 185.0 | 160.8 | 17.3 | 99.3 | 2.6 | 2.6 |
| **Brazilian** | 8 | 298.7 | 211.5 | 143.0 | 143.3 | 3.3 | 3.3 |
| | 9 | 260.3 | 193.3 | 100.0 | 110.3 | 3.6 | 3.3 |
| | 10 | 212.0 | 172.1 | 25.0 | 96.6 | 3.3 | 3.6 |
| **American** | 8 | 262.7 | 186.3 | 123.3 | 120.7 | 2.6 | 2.6 |
| | 9 | 209.7 | 167.0 | 70.0 | 122.7 | 2.6 | 2.3 |
| | 10 | 133.3 | 143.6 | 13.3 | 62.6 | 3.0 | 2.6 |
| **LSD at 0.05** | | 22.2 | 10.7 | 13.4 | 28.3 | 0.8 | 0.9 |

**Table 3: Effect of cassava cultivars and harvesting dates on branches number, yield and tuber roots length at harvest time during 2022/2023 and 2023/2024.**

| Treatments | | Branches numbe | | Yield ton/ fed. | | Tuber roots length | |
|---|---|---|---|---|---|---|---|
| | | First season | Second season | First season | Second season | First season | Second season |
| **Effect of Cultivars** | | | | | | | |
| **Indonesian** | | 4.1 | 4.8 | 10.922 | 10.257 | 37.5 | 46.3 |
| **Brazilian** | | 1.8 | 1.1 | 11.900 | 12.465 | 33.2 | 38.9 |
| **American** | | 16.1 | 10.4 | 13.233 | 14.108 | 33.4 | 44.0 |
| **LSD at 0.05** | | 4.3 | 2.7 | 0.902 | 1.623 | NS | 2.1 |
| **Effect of Harvesting dates** | | | | | | | |
| **8** | | 7.7 | 6.4 | 8.756 | 9.004 | 29.3 | 35.0 |
| **9** | | 7.3 | 5.8 | 13.200 | 13.781 | 34.1 | 42.0 |
| **10** | | 7.0 | 4.1 | 14.100 | 14.044 | 40.7 | 52.2 |
| **LSD at 0.05** | | NS | 0.9 | 0.902 | 0.682 | 3.6 | 3.2 |
| **Effect of interaction** | | | | | | | |
| **Indonesian** | 8 | 3.3 | 4.6 | 7.833 | 7.608 | 35.3 | 36.0 |
| | 9 | **4.6** | 6.3 | 11.167 | 10.715 | 34.3 | 44.1 |
| | 10 | 4.3 | 3.6 | 13.767 | 12.447 | 43.0 | 59.0 |
| **Brazilian** | 8 | 4.0 | 1.3 | 8.567 | 8.999 | 24.3 | 32.1 |
| | 9 | 0.6 | 1.0 | 12.067 | 12.994 | 35.0 | 37.7 |
| | 10 | 1.0 | 1.0 | 15.067 | 15.400 | 40.3 | 46.8 |
| **American** | 8 | 16.0 | 13.3 | 9.867 | 10.403 | 28.3 | 36.8 |
| | 9 | 16.6 | 10.3 | 16.367 | 17.633 | 33.0 | 44.3 |
| | 10 | 15.6 | 7.6 | 13.467 | 14.286 | 39.0 | 50.8 |
| **LSD at 0.05** | | 3.9 | 1.5 | 1.563 | 1.182 | 6.3 | 5.6 |

**2- Total yield and tuber root parameter**

The obtained data demonstrated that, the American cultivar gave the highest yield, diameter, weight and dry matter of tuber roots followed by the Brazilian cultivar and then the Indonesian cultivar during the two seasons, within Tables (3 and 4). Concerning, Tuber roots length the highest values recorded with Indonesian cultivar followed by the American cultivar and then the Brazilian cultivar in the second seasons, Table 3. This result according by [19 & 9] on cassava, they said that the American cultivar recorded the highest yield, diameter, weight and dry matter of tuber roots compared to other cultivars ( Brazilian or Indonesian).

Data in Tables (3 and 4) pointing that cassava harvesting after 9 or 10 months from planting significantly increased yield ton/ fed. without significant differences between them, in both seasons, while harvesting after 8 months from planting reduced this criterion. As for the length, diameter, weight and dry matter of tuber roots was showed highest values when cassava harvesting dates after 10 months from planting, followed by harvested after 9 months and then harvested after 8 months during the two growth seasons. The decreasing in yield at the age of 8 months of planting is due to the recording of the lowest values of the previously mentioned studied traits with this age. This result agreement by [20] mentioned that generally, there was an increase in cassava yield with harvest time.

Regarding the interaction between cultivars and harvesting dates, the results in Tables 3 and 4, clearly revealed that American cultivar gave the highest tuber roots yield at harvest after 9 months from planting. As for the Indonesian and Brazilian cultivars increased yield at harvest after 10 months from planting. The observed genotype differences in relation to rates of photosynthesis could be the major factor explaining the variation in growth and total production in this study as was observed in previous study [21]. Differences in tuber yield may also be brought about by differences in growing periods to reach maturity specified for each genotype. The results are in agreement with those obtained by [22 & 23].

**Table 4: Effect of cassava cultivars and harvesting dates on diameter, weight and dry matter of tuber roots at harvest time during 2022/2023 and 2023/2024**.

| Treatments | | Tuber roots diameter | | Tuber roots weight | | Tuber roots dry matter | |
|---|---|---|---|---|---|---|---|
| | | First season | Second season | First season | Second season | First season | Second season |
| **Effect of Cultivars** | | | | | | | |
| **Indonesian** | | 3.2 | 3.5 | 300.7 | 352.0 | 36.3 | 31.6 |
| **Brazilian** | | 3.8 | 4.4 | 376.3 | 418.2 | 39.5 | 37.2 |
| **American** | | 4.1 | 5.4 | 402.6 | 564.0 | 43.9 | 51.5 |
| **LSD at 0.05** | | 0.5 | 0.8 | 62.6 | 61.5 | 4.9 | 5.5 |
| **Effect of Harvesting dates** | | | | | | | |
| **8** | | 2.6 | 3.3 | 295.7 | 339.0 | 32.1 | 31.6 |
| **9** | | 3.7 | 4.6 | 387.5 | 499.7 | 39.2 | 40.3 |
| **10** | | 4.8 | 5.3 | 396.5 | 495.5 | 48.3 | 48.4 |
| **LSD at 0.05** | | 0.3 | 0.7 | 39.2 | 45.8 | 1.8 | 4.3 |
| **Effect of interaction** | | | | | | | |
| **Indonesian** | 8 | 2.0 | 2.5 | 216.7 | 237.3 | 32.7 | 26.7 |
| | 9 | 3.3 | 3.5 | 319.9 | 377.0 | 36.4 | 28.0 |
| | 10 | 4.2 | 4.5 | 365.8 | 441.9 | 39.8 | 40.2 |
| **Brazilian** | 8 | 2.8 | 3.4 | 287.4 | 309.2 | 29.4 | 27.8 |
| | 9 | 3.7 | 4.6 | 384.4 | 452.0 | 39.4 | 37.6 |
| | 10 | 5.1 | 5.1 | 457.2 | 493.6 | 49.8 | 46.2 |
| **American** | 8 | 3.1 | 4.2 | 383.1 | 470.7 | 34.4 | 40.2 |
| | 9 | 4.1 | 5.8 | 458.3 | 670.2 | 41.9 | 55.4 |
| | 10 | 5.1 | 6.3 | 366.6 | 551.1 | 55.5 | 58.8 |
| **LSD at 0.05** | | 0.5 | 1.2 | 68.0 | 79.4 | 3.1 | 7.5 |

**3. Chemical characters of tuber roots**

As presented in Figure (1), Indonesian cultivar produced the highest hydrocyanic acid content and fibers percentage. On the contrary, American cultivar recorded the lowest value of hydrocyanic acid content and fibers percentage in both seasons. The highest mean values of starch percentage were obtained by American cultivar with slight differences among others cultivars, i.e., Indonesian and Brazilian in both seasons. This result agreement by [9], on cassava, they mentioned that the American cultivar gave the highest starch percentage and lowest fibers percentage of tuber roots compared to other cultivars (Brazilian and Indonesian).

Concerning, the effect of harvesting dates on chemical characters of tuber roots Figure (2). Delaying harvesting dates till 10 months from planting gave the highest values of starch percentage and fibers percentage as well as gave the lowest value of hydrocyanic acid content in two growing seasons. The results obtained agree by fibers [24], on cassava, Note that harvesting cassava after 10 months increases the starch and fiber content and reduces the hydrocyanic acid content in the tuber roots.

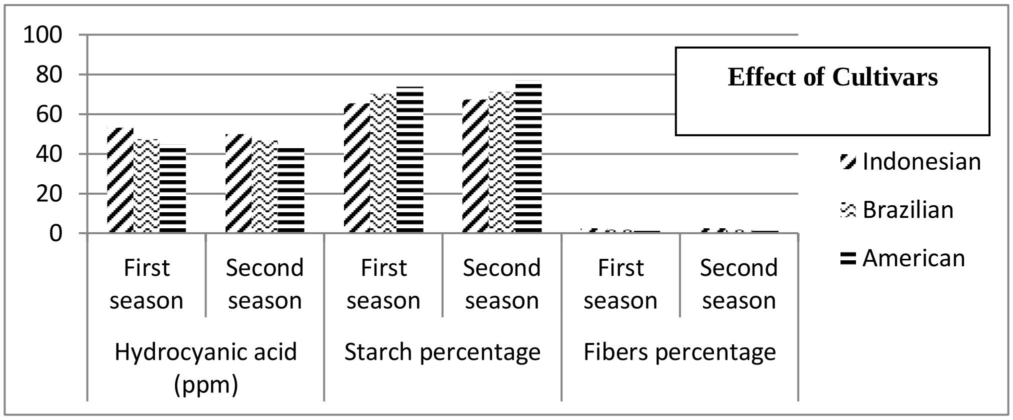


**Fig. 1. Effect of cassava cultivars on hydrocyanic acid (ppm), starch percentage and fibers percentage of tuber roots during 2017/2018 and 2018/2019.**

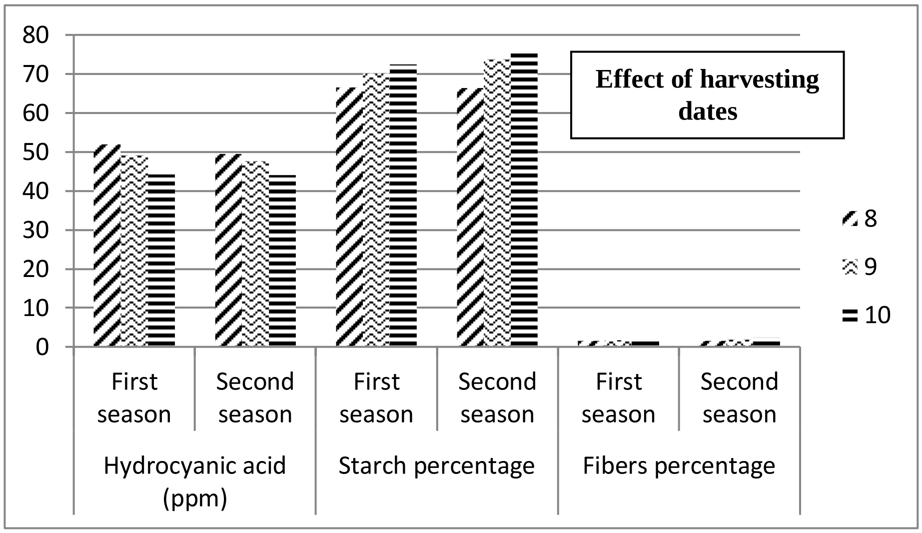


**Fig. 2. Effect of harvesting dates on hydrocyanic acid (ppm), starch percentage and fibers percentage of tuber roots during 2017/2018 and 2018/2019.**

Significant interaction between cassava cultivars and harvesting dates for chemical characters of tuber roots were noticed in both seasons (Table 5). American cultivar recorded the highest starch percentage and lowest fibres percentage when harvested after 9 months from planting during the two seasons. The same cultivar gave the lowest hydrocyanic acid content when harvested after 10 months from planting.

**Table 5: Effect of interaction between cassava cultivars and harvesting dates on hydrocyanic acid (ppm), starch percentage and fibers percentage of tuber roots during 2017/2018 and 2018/2019.**

| Treatments | | Hydrocyanic acid (ppm) | | Starch percentage | | Fibers percentage | |
|---|---|---|---|---|---|---|---|
| | | First season | Second season | First season | Second season | First season | Second season |
| **Effect of interaction** | | | | | | | |
| **Indonesian** | 8 | 58.3 | 52.2 | 61.1 | 63.6 | 2.10 | 2.20 |
| | 9 | 55.1 | 50.3 | 67.8 | 67.2 | 2.20 | 2.43 |
| | 10 | 45.7 | 47.0 | 67.1 | 71.3 | 3.06 | 3.23 |
| **Brazilian** | 8 | 50.3 | 48.2 | 66.8 | 66.7 | 1.20 | 1.10 |
| | 9 | 47.6 | 47.7 | 71.5 | 71.5 | 1.90 | 1.76 |
| | 10 | 44.5 | 44.5 | 72.3 | 75.4 | 2.16 | 2.20 |
| **American** | 8 | 47.5 | 47.8 | 71.5 | 68.6 | 1.20 | 1.10 |
| | 9 | 44.8 | 45.2 | 78.3 | 82.6 | 1.23 | 1.26 |
| | 10 | 42.4 | 40.7 | 71.4 | 80.4 | 1.56 | 1.56 |
| **LSD at 0.05** | | 4.5 | 4.0 | 8.1 | 6.8 | 0.34 | 0.44 |

**Gross chemical composition of raw materials**

Table 6 showed the chemical composition of raw materials such as wheat flour and different cultivars of cassava (American, Brazilian, and Indonesian). The moisture content of raw materials indicated the highest content 12.22% in wheat flour, while the lowest content 6.59 % in flour of cassava Brazilian. The protein content of raw materials ranged between 4.71 and 9.55%, where protein content maximized in wheat flour (9.55%) and minimized in flour of cassava Indonesian (4.71%). while American cultivar had high content of carbohydrates, protein and moisture (87.57, 5.27 and 7.94%), respectively. While Brazilian cultivar had high content of ash (6.78%), meanwhile Indonesian cultivar had high content of fiber (3.39). Similar results have been reported by [25 - 27].

**Table 6: Chemical composition of flour from cassava cultivars**

| Samples | Moisture (%) | Protein (%) | Fat (%) | Fiber (%) | Ash (%) | T.C. (%) |
|---|---|---|---|---|---|---|
| Wheat flour | 12.22±0.44 | 9.55±0.22 | 1.01±0.011 | 0.62±0.025 | 0.53±0.018 | 76.07±0.65 |
| American Cassava | 7.94±0.11 | 5.27±0.08 | 0.20±0.001 | 2.82±0.13 | 4.14±0.09 | 87.57±0.59 |
| Brazilian Cassava | 6.59±0.09 | 5.02±0.010 | 0.22±0.003 | 3.33±0.17 | 6.78±0.07 | 84.65±0.46 |
| Indonesian Cassava | 7.78±0.17 | 4.71±0.06 | 0.29±0.002 | 3.39±0.11 | 4.87±0.03 | 86.74±0.62 |

**Where: T.C =Total carbohydrates**

**Colour attributes of biscuits**

Color is one of the most important sensory attribute that affect directly the consumer preference of any product. Special attention should be given to bakery products to attract the consumer attention. The color parameters of biscuit samples were evaluated using a Hunter laboratory colorimeter (Table 7). The L scale ranges from 0 black to 100 white; the a scale extends from a negative value (green hue) to a positive value (red hue) and the b scale ranges from negative blue to positive yellow. Biscuit from wheat flour and cassava flour it was darker than wheat flour, where lightness (L*) and redness values (b*) decreased as a percentage of cassava flour used in biscuit processing increased, while yellowness (a*) of biscuit samples, where their values were getting higher in biscuits containing cassava flour compared with control. The same trend was observed in case of total color difference (ΔE) of biscuit samples, where their values were getting higher as cassava flour level was increased. The obtained result could be attributed to the darkness of cassava flour sample (lower L*). Such a finding is in agreement with results described by [28 - 30]

**Table 7: Effect of adding cassava flour to wheat flour on color parameters of biscuit**

| Samples | L* | a* | b* | Saturation | a/b | ΔE* |
|---|---|---|---|---|---|---|
| **1** | 74.8±0.26 | 6.97±0.11 | 32±0.26 | 32.75±0.25 | 0.22±0.1 | 81.66±0.56 |
| **2** | 67.46±0.22 | 11.4±0.13 | 33.54±0.15 | 35.42±0.21 | 0.34±0.2 | 76.19±0.52 |
| **3** | 67.75±0.29 | 10.02±0.10 | 47.86±0.13 | 48.90±0.19 | 0.21±0.03 | 83.55±0.49 |
| **4** | 64.82±0.19 | 10.45±0.07 | 26.85±0.19 | 28.81±0.22 | 0.39±0.06 | 70.93±0.45 |
| **5** | 71.21±0.31 | 9.69±0.09 | 27.42±0.22 | 29.08±0.27 | 0.35±0.26 | 76.92±0.65 |
| **6** | 69.48±0.19 | 9.59±0.15 | 29.58±0.20 | 31.10±0.21 | 0.32±0.01 | 76.12±0.70 |
| **7** | 74.26±0.35 | 6.97±0.08 | 29.73±0.17 | 30.54±0.23 | 0.23±0.02 | 80.29±0.59 |
| **8** | 71.82±0.25 | 7.61±0.06 | 24.83±0.21 | 25.97±0.24 | 0.31±0.05 | 76.37±0.55 |
| **9** | 74.16±0.27 | 5.36±0.05 | 24.64±0.23 | 25.22±0.21 | 0.22±0.04 | 78.33±0.50 |
| **10** | 79.93±0.40 | 4.09±0.06 | 21.79±0.18 | 22.17±0.17 | 0.19±0.03 | 82.95±0.69 |
| **11** | 73.93±0.36 | 5.59±0.09 | 22.89±0.19 | 23.56±0.15 | 0.25±0.02 | 77.59±0.62 |
| **12** | 73.28±0.42 | 6.64±0.11 | 25.08±0.27 | 25.94±0.13 | 0.26±0.03 | 77.74±0.56 |
| **13** | 73.03±0.35 | 6.71±0.09 | 25.13±0.18 | 26.01±0.11 | 0.27±0.03 | 77.52±0.65 |

Where: samples ( 1-13) see Table 1

**Baking quality of biscuits**

Results presented in Table 8 showed the diameter (cm), thickness (cm), spread ratio (%), weight (g), volume ($cm^3$) and specific volume (v/w), of biscuits. Biscuit diameter, thickness, volume,
specific volume is decreased with increasing mixing level of cassava flour, while the weight and spread ratio showed a significant rise upon addition of cassava flour. This effect may be due to the higher fiber content in cassava flour. Biscuits having higher spread ratios are considered most desirable [31& 32].

**Table 8. Effect of adding cassava flour to wheat flour on baking quality of biscuit**

| Samples | Diameter (cm) | Thickness (cm) | Spread ratio (diam. /ht.) | Weight (g) | Volume (cc) | Specific volume (cc/g) |
|---|---|---|---|---|---|---|
| 1 | 4.65 | 1.12 | 4.15 | 11.49 | 22.15 | 1.93 |
| 2 | 4.50 | 1.06 | 4.25 | 12.00 | 20.5 | 1.71 |
| 3 | 4.40 | 1.02 | 4.31 | 12.15 | 19.7 | 1.62 |
| 4 | 4.35 | 1.0 | 4.35 | 12.19 | 19.00 | 1.56 |
| 5 | 4.30 | 0.95 | 4.53 | 12.25 | 18.60 | 1.52 |
| 6 | 4.60 | 1.09 | 4.22 | 12.55 | 21.5 | 1.71 |
| 7 | 4.50 | 1.06 | 4.25 | 12.70 | 20.05 | 1.61 |
| 8 | 4.40 | 1.0 | 4.40 | 13.00 | 19.5 | 1.5 |
| 9 | 4.35 | 0.96 | 4.53 | 13.15 | 19.0 | 1.41 |
| 10 | 4.55 | 1.15 | 3.96 | 12.24 | 21.33 | 1.74 |
| 11 | 4.54 | 1.10 | 4.13 | 12.55 | 20.67 | 1.65 |
| 12 | 4.50 | 1.06 | 4.25 | 12.91 | 19.33 | 1.50 |
| 13 | 4.45 | 1.0 | 4.45 | 13.19 | 19.00 | 1.44 |

Where: samples ( 1-13) see Table 1

**Sensory evaluation of biscuits as affected by supplemented with cassava flour**

Sensory evaluation is considered one of the limiting factors of consumer acceptability for organoleptic properties including color, odor, taste, texture, appearance and overall acceptability. The effects of cassava flour on sensory characteristics of biscuits are presented in Table (9) and Fig. (3). with the increase in the level of cassava flour in the formulation, the sensory scores for color, taste, odor, texture, appearance and overall acceptability of biscuits decreased. Data indicated that a significant ($P<0.05$) changes were found in all properties for all experimental products. Data in Table (9) showed that biscuit made from mixture containing 20% cassava flour had lower scores for most properties compared to the other tested products. Besides it showed the lowest score for overall acceptability (5.5) for biscuit. The highest overall acceptability scores of biscuit were registered for control (100% wheat flour). Finally, the results showed that in all the sensory qualities that increase the proportion of cassava flour about 20% less than in the sensory qualities, especially color and appearance. Also, these results were confirmed by the results of the physical properties of biscuits. From the sensory acceptability rating, it was concluded that biscuits were made from cassava flour could be incorporated all levels used in this study to wheat flour in the formation of biscuits without significantly affecting on sensory quality.

**Table 9. Sensory characteristics of biscuit**

| Samples | Color (10) | Texture (10) | Oder (10) | Taste (10) | Appearance (10) | Overall acceptability (10) |
|---|---|---|---|---|---|---|
| 1 | 8.9 $^{a}$ | 8.5 $^{a}$ | 9.3 $^{a}$ | 8.9 $^{a}$ | 8.8 $^{a}$ | 8.7 $^{a}$ |
| 2 | 8.1 $^{b}$ | 7.8 $^{b}$ | 8.1 $^{c}$ | 8.7 $^{a}$ | 8.1 $^{b}$ | 8.1 $^{b}$ |
| 3 | 7.6 $^{d}$ | 7.3 $^{c}$ | 8.6 $^{b}$ | 7.2 $^{d}$ | 7.5 $^{c}$ | 7.2 $^{c}$ |
| 4 | 7.4 $^{e}$ | 7.0 $^{c}$ | 8.2 $^{c}$ | 7.0 $^{d}$ | 6.7 $^{d}$ | 6.8 $^{d}$ |
| 5 | 7.1 $^{e}$ | 6.7 $^{d}$ | 9 $^{a}$ | 6.6 $^{e}$ | 5.5 $^{e}$ | 5.6 $^{e}$ |
| 6 | 8.5 $^{b}$ | 8.0 $^{b}$ | 9.1 $^{a}$ | 8.3 $^{b}$ | 8.2 $^{b}$ | 8.2 $^{b}$ |
| 7 | 8.2 $^{b}$ | 7.4 $^{c}$ | 8.7 $^{b}$ | 8.0 $^{b}$ | 8.0 $^{b}$ | 7.3 $^{c}$ |
| 8 | 7.9 $^{c}$ | 6.9 $^{c,d}$ | 8.2 $^{c}$ | 7.8 $^{c}$ | 7.7 $^{c}$ | 6.8 $^{d}$ |
| 9 | 7.5 $^{d}$ | 5.8 $^{d}$ | 9.1 $^{a}$ | 6.7 $^{e}$ | 6.6 $^{d}$ | 5.5 $^{e}$ |
| 10 | 9.1 $^{a}$ | 8.1 $^{a}$ | 8.1 $^{c}$ | 8.1 $^{b}$ | 8.0 $^{b}$ | 8.5 $^{a}$ |
| 11 | 8.2 $^{b}$ | 7.9 $^{b}$ | 9.3 $^{a}$ | 7.9 $^{c}$ | 7.8 $^{c}$ | 7.7 $^{b}$ |
| 12 | 7.8 $^{c}$ | 7.2 $^{c}$ | 8.5 $^{b}$ | 6.1 $^{f}$ | 6.9 $^{d}$ | 6.9 $^{c}$ |
| 13 | 7.3 $^{e}$ | 6.9 $^{c,d}$ | 9.2 $^{a}$ | 5.8 $^{g}$ | 5.7 $^{e}$ | 5.7 $^{e}$ |
| LSD at 5% | 0.509 | 0.533 | 0.425 | 0.511 | 0.471 | 0.542 |

Where: samples ( 1-13) see Table 1

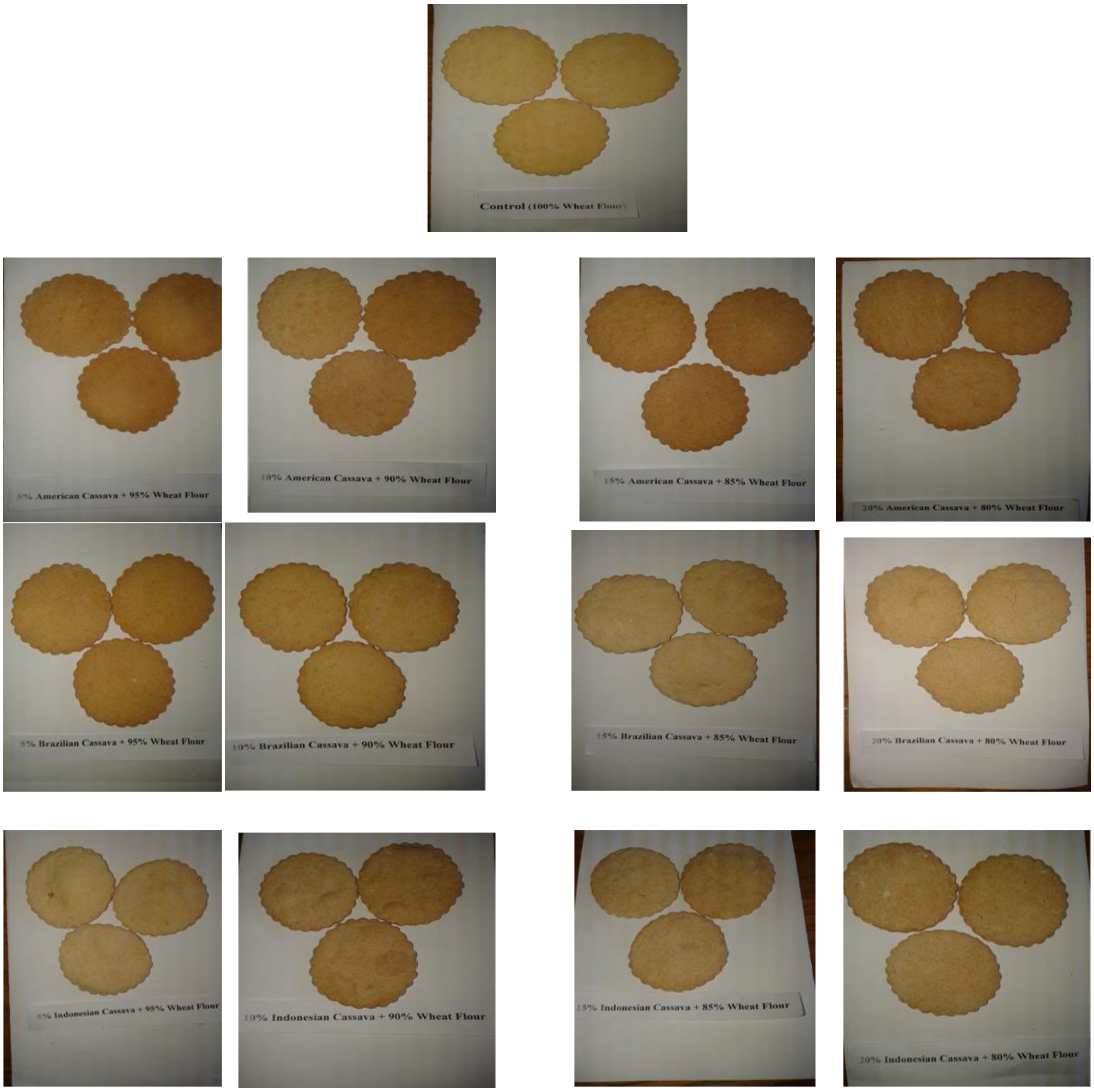


**Figure 3. Biscuits supplemented with cassava flour**

## Conclusion

From the obtained results, it could be concluded that when planting the American cultivar, the best harvest is obtained after 9 months, next Brazilian and Indonesian cultivars are planted and the better harvest is after 10 months. As well as, cassava flour could be used with wheat flour to prepare biscuit characterized with its good sensorial properties, higher baking quality, in addition to their positive effect on the technological characteristics and suitable for celiac patients.

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