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Quality Attributes and Shelf-Life Estimation of Cassava Flour Incorporated Bakery Product (Biscuit)

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Abstract

Cassava (*Manihotesculentacrantz*) is not true cereals are largely grown all over the world. They are very important due to their excellent nutritional contents especially protein, crude fiber, and carbohydrates. Biscuits were prepared by mixing cassava and wheat flour. Six treatments were prepared by adding 10%, 20%, 30%, 40%, and 50% cassava flour with wheat flour (Sample B, C, D, E, and F respectively) along with controlled treatment of 100% wheat flour (A). The proximate composition of flours was analyzed and prepared biscuits were subjected to sensory evaluation and shelf-life estimation. The obtained data was analyzed statistically by Genstat Discovery Edition 3 (DE3), for Analysis of Variance (ANOVA) at a 5% level of significance. Statistical analysis showed that sensory parameters and overall acceptability of 80 parts wheat and 20 parts cassava flour incorporated biscuit was significantly superior to all biscuits formulations. The proximate results of the best product showed that moisture content, crude fat, crude protein, crude fiber, total ash content, and total carbohydrate were found 3.44±0.25%, 13.80±0.33%, 8.13±0.13%, 1.29±0.19%, 2.41±0.06%, and 70.99±0.50 (g/100g) respectively. The shelf life of the best product was estimated by analyzing acid value and moisture content of the product by using three different packaging materials biaxially polypropylene (BOPP), high-density polypropylene (HDPE), and polypropylene (PP) respectively. The shelf life of the best product (80-20) wheat and cassava flours was found to be satisfactory for 8 weeks. The projected shelf life was found high in polypropylene (PP) and high-density polypropylene (HDPE) for 13.5 and 17.81 weeks for acid value and moisture content respectively.

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1. Introduction

Food deficit is increasing day by day. So it is a burning question to meet the food requirement of millions of people living in poverty in the third world. Attempts to resolve the problems of food production have placed great emphasis on increasing the production and productivity of grain crops, but little attention has been given to crops such as cassava (Sobhan, Ahmmed, Mazumder, & Alim, 2014).

The word biscuit came from the Italian word '*Bis*'- means twice and '*cuit*' means baked. It is a kind of crispy dry bread, more or less hard, various flavored and prepared usually in small flat thin cakes. Biscuits were originally developed to meet the requirement of the longer life of the bakery products and moisture-free to improve their keeping quality. (Arora, 1980).

Cassava (*Manihotesculenta*crantz) is a perennial shrub cultivated in the tropics for its starchy tuberous roots and is used as subsidiary food for over 200 million people. The important characteristics that influence the role of cassava within the tropical farming system are high carbohydrate yields per unit land and labor, adaption to poor soil and or stress compatibility with a variety of crops in association, an indeterminate harvestability, and tolerance to dominant pests and disease (Allen, 2002). Cassava is the seventh among the important crops of the world and is of prime importance in many countries either as a chief staple or as an important supplementary food. Cassava is a starchy root crop that is grown entirely within the tropics. In 2011, the world production of cassava was about 256 million tons (FAO., 1990). Nigeria is the largest producer of cassava. Among the starchy staples, cassava gives a carbohydrate production that is about 40% higher than rice and 25% more than maize, with the result that cassava is the cheapest source of calories for both human nutrition and animal feeding(Mahmood et al., 2019)

Cassava is grown in Nepal for the past 3 decades. Of the five Developmental Regions (DR), the area under this crop is the highest in the Eastern DR and the lowest in the Far-Western DR. In most places, the production techniques are local and traditional and the yield appears to be low. The crop has not been accorded with any official attention and, hence, no organized research has been conducted to develop the crop. Although some local methods of cassava utilization exist, processing units on a commercial scale are absent. Important research areas to promote cassava production and its utilization in Nepal. (Shrestha, 1992). Cassava roots and cassava leaves are used for human consumption and animal feed, Cassava roots are rich in digestible carbohydrates, mainly in starch. Cassava root starch consists of both amylose (20%) and amylopectin (70%). There is a large variation in sucrose content between cassava genotypes. In sweet varieties, sucrose constitutes about 17% of total carbohydrates (Hendershott, 1972). Generally, cassava roots have less than 1% free sugars. Cassava roots are low in protein and fat.

Cassava root has less than the recommended minimum limit in almost all essential amino acids, except tryptophan. Cassava roots should be eaten along with other crops rich in essential amino acids to supplement the deficit, such as vegetables, cereals, fish, and meat. Cassava leaves are much richer in protein than the roots, although the leaf contains a lower proportion of methionine than the root protein. The levels of all other essential amino acids in leaf protein exceed the FAO's recommended reference (FAO., 1990). Cassava has a high content of dietary fiber, magnesium, sodium, riboflavin, thiamine, nicotinic acid, and citrate (Bradbury & Holloway, 1988). A major limitation of cassava production is the rapid post-harvest deterioration of its roots which usually prevents their storage in the fresh state for more than a few days (Okezia, 2004). Fresh cassava roots show deterioration within as little as 24 hours. Apart from rapid post-harvest spoilage, another problem associated with cassava is that the cassava roots contain a toxic component known as cyanogens (Ogunsua & 2016).

Thus, the roots should be subjected to some form of processing usually involving treatment by heat or fermentation before consumption to remove the toxic principles. Processing of cassava into various values added products through the development of appropriate technologies has the potential to increase income and improve the livelihood of cassava growers. Many technologies are available for the processing of cassava elsewhere in the world (Ogunsua & 2016).

2. Materials and Method

2.1 Ingredients selection

The study was conducted in the laboratories of the Department of Food Technology Hattisar Dharan. The raw materials were collected from Mahalaxmi maida mill Sonapur Sunsari and biscuits were prepared in CG Foods (Nepal) Pvt. Ltd. Duhabi. The fresh tender cassava roots collected from Danabari Dharan Sunsari (Nepal) were used in the study.

2.2 Preparation of cassava flour

Cassava roots were washed in clean water to remove adhering soil, dirt and stone, and other unwanted materials. The cleaned roots were then peeled with a knife and they were dipped in salt solution (2%) at room temperature for 30 minutes. Then slicing (3 to 5 mm thick) was done with the help of a knife. The cassava slices were dipped into a solution of KMS (0.5%) and citric acid (0.5%) for half an hour. After draining the solution, the cassava slices were spread over the trays of the cabinet dryer, and the temperature of the dryer was set to 60°C and dried to brittle texture. The grinding was done using the local mill at Dharan-14, Vijayapur. The material ground was passed through the sieve of 600 µm and 150 µm size. The flour was kept in polythene high-density polyethylene, biaxially oriented polypropylene, and polypropylene (BOPP, HDPE, and PP) and sealed (Tonukari, 2004)

Sugar, milk powder, baking powder, ammonium bicarbonate, salt, and other ingredients were procured from the local market. High-density polyethylene, biaxially oriented polypropylene, and polypropylene were used for the package and storage of samples. The basic formulation used for the preparation of cassava biscuits is outlined in Table 1. The basic formulation of biscuits has been adapted from the recipes reported by (Woolfe, 1992).

2.3 Formulation of Biscuits

The biscuits were prepared from the different compositions of cassava flour after incorporation into the wheat flour. Table 1 shows the various formulation of cassava flour incorporated biscuits.

Table 1: The basic formulation of cassava flour incorporated biscuits

Treatments	Wheat flour %	Cassava flour %
A	100	0
B	90	10
C	80	20
D	70	30
E	60	40
F	50	50

2.4 Product development

The biscuits were prepared with the incorporation of cassava flour in 10, 20, 30, 40, and 50% levels with wheat flour keeping sugar and fat amount constant to 35% and 15% respectively on a 100 % flour basis. First of all, creaming was done for 10 minutes by adding shortening and sugar. Then eggs were added and mixing was done for a few minutes. The composite flours and leavening agent sodium bicarbonate (0.50%) were added after mixing. Then molding was done. The biscuits were baked at 200 °C for 12 min in a baking oven. The baked biscuits were cooled for 10-15 minutes and stored in an airtight polyethylene for further analysis. (Mahmood et al., 2019)

2.5 Compositional Analysis

Protein (Kjeldahl, N× 6.25), fat (solvent extraction), moisture (hot air oven), ash (dry ashing), and crude fiber of cassava flour, wheat flour, and best biscuit were determined by AOAC (2000) methods. The carbohydrate content was also calculated by subtraction method (AOAC., 2000).

2.6 Sensory evaluation

The sensory evaluation of biscuits was performed in the cereal lab of the central campus of technology (CCT), TU by 9 Panelist. The panelist were research students, staff, and teachers of CCT, who had some knowledge about the characteristics of biscuits, thus considered to be semi-trained panelists. Sensory evaluation of the product was performed by hedonic rating test. The parameter for sensory evaluation was taken to be color, flavor, texture, and overall acceptability. Sensory evaluation was carried out in the individual booth with adequate light and free from obnoxious odors. Each panelist was provided with samples coded with random numbers and an evaluation card. They were provided with portable water for rinsing between the samples.

2.7 Statistical analysis

All the data obtained from the research work were analyzed by the statistical program known as Genstat discovery edition 3 (2008). From this mean ANOVA (no blocking at 5% level of significance), LSD and mean were obtained to determine whether the samples were significantly different from each other and also to determine which one is superior among them. (Steel, Torrie, & Dickey, 2004)

2.8 Storage studies of prepared biscuits

The cassava incorporated biscuits along with the control sample were stored at ambient temperatures (27°C ± 5°C) for 8 weeks. The stored biscuits were analyzed initially at an interval of 7 days up to 8 weeks. During storage studies, the change in moisture content and acid value, texture, and flavor were observed according to the methods described in (AOAC., 2000).

3. Results and Discussion

Cassava flour and wheat flour were analyzed for moisture, protein, crude fat, total ash, crude fiber, and total carbohydrate content. The results are shown in Table 2. The protein content of raw cassava (5.9%) was lower than that of wheat flour (11%). On the other hand, the carbohydrate content of cassava flour was higher (80%) than wheat flour (73.32%). So, we can expect more energy from cassava flour. Similarly mineral content of cassava flour was higher than that of wheat flour. Because cassava flour contained a higher amount of solid matter compared to wheat flour. (Kabirullah et al. (1996) found ash content in biscuits in the range of 1.09-2.78% which is in agreement with the results observed in this study.

Table 2: Compositional analysis of flours.

Parameter in parts	wheat flour (wb)	cassava flour (wb)
Moisture	12 (0.34)	9.20(1.24
Protein	11(0.26)	5.9(0.6)
Crude fat	1.2(0.63)	0.6(0.2)
Crude fiber	0.4(0.53)	2.3(0.4)
Total ash	1(0.35)	1.8(0.4)
Carbohydrate	73.32(0.95)	80.(0.5)

3.1 Sensory evaluation of prepared biscuit (hedonic rating)

The prepared biscuits were evaluated by 10 tasters. The mean scores for color, flavor, texture, and overall acceptability preference of the biscuits are represented in Table 3. One-way analysis of variance indicated that all these sensory attributes of different biscuits were significantly ($P<0.05$) different and thus the sensory attributes of the biscuit samples showed a varying degree of acceptability (Meilgaard & Civileand, 2007).

The data in Table 3 showed that the biscuits samples C were the most preferred one and significantly better for color, flavor, texture, and overall acceptability. The mean color score of biscuits was increased from 5.55 to 7.66 with an increased concentration of cassava flour. Sample C was got the highest sensory score of 7.66 for color. The color of sample A is not dark brown like other samples because of the low degree of caramelization. This might be since cassava flour contained a higher amount of solid matter compared to wheat flour (Foda & Allam, 1984). Sample C was got the highest sensory score of 8.22 for flavor and was significantly different from other samples. The flavor of biscuits samples B, C, and D was equally acceptable but the biscuits sample A, B and F had the least flavor acceptability.

The texture of sample C was most preferred and significantly different than those with other cassava biscuits. Panelist scores for wheat flour biscuit (control) and 20% cassava flour incorporated biscuit was not significantly different but scores were decreased for other 30%, 40%, and 50% cassava flour biscuits respectively. The samples D, E, F showed cracks on the upper crust which might be due to the low gluten development.(Kabirullah, Rukonuddin, Khan, Tasmin, & Majibur, 2008), In the other words, as the substitution level of cassava flour increased or decreased, the mean sensory score of overall acceptability decreased. The sensory graph shows that there was a significant difference in overall acceptability among the biscuits. This indicates that the overall acceptability of control biscuits (sample A) and biscuits supplemented with cassava flour samples were not equally acceptable. However, the overall acceptability score of biscuits was initially increasing and the decreasing order as control biscuits (A). Sample (C) showed a higher mean score than other cassava incorporated biscuits, so sample C was more acceptable than other biscuits. The mean sensory score for the flavor of sample (C) was the highest and was significantly different from other samples. The flavor of biscuits samples B, C, and D was equally acceptable but the biscuits sample A, B and F had the least flavor acceptability.

3.2 Shelf-life evaluation of the cassava flour incorporated biscuit (CFB)

The shelf life evaluation of CFB was studied for 8 weeks. The product was packed in metalized biaxially

Table 3: Mean score for flavor, color, texture, and overall acceptability of cassava flour incorporated biscuits

	Sensory attributes			
samples	color	flavor	Texture	Overall acceptability
A	5.55^{a}	5.58^{a}	5.33^{a}	5.88^{a}
B	7.11^{b}	7.44^{b}	7.33^{bd}	7.00^{b}
C	7.66^{b}	8.22^{cd}	7.88^{b}	7.87^{c}
D	7.44^{b}	7.88^{bd}	6.88^{cd}	6.88^{b}
E	6.00^{a}	5.88^{a}	6.22^{c}	6.00^{a}
F	5.77^{a}	6.00^{a}	5.22^{a}	5.88^{a}

Table 4: Comparison between cassava flour incorporated biscuit (sample C) to wheat flour biscuit

Parameter(%)	Wheat biscuit (wb)	Cassava biscuit(wb)
Moisture	2.17±0.11	3.44±0.25
Crude protein	9.46±0.09	8.13±0.13
Crude ash	1.37±0.16	2.41±0.06
Crude fat	20.97±0.19	13.80±0.33
Crude fiber	0.55±0.03	1.29±0.19
Total carbohydrate	65.48±0.42	70.99±0.50

polypropylene (BOPP), high-density polypropylene (HDPE), and polypropylene (PP) bags and stored in a cool and dry place at 22-25°C and RH (60-70%). The acid value of extracted fat and the moisture content of the product was evaluated from the date of manufacture up to 8 weeks.

3.2.1 Shelf life estimation based on acid value (AV)

The biscuits are packed in biaxial polypropylene (BOPP), high-density polyethylene (HDPE), and polypropylene (PP) respectively. The shelf-life of the processed biscuits was studied for 8 weeks at ambient conditions (27°C ± 5°C). No remarkable changes were observed up to 2 weeks of storage in case of moisture content and acid value, During storage of samples it was noticed that moisture content, the acid value was increasing slowly. So all the samples became less crisp and the taste changed to rancid. After passing time these defaults become higher. So the study provides a conclusion in case of storage of biscuits fortified with cassava flour were shelf-stable up to 8 weeks of storage at ambient conditions (Table 1). From the experiment, it was shown that when using the higher amount of cassava flour, the physical characteristics of the biscuits remain good. Observing the moisture, protein, fat, and ash contents, results of the shelf-life of the processed biscuits, it may be concluded that good quality cassava flour fortified biscuits may be processed substituting the wheat flour with cassava flour up to 20% levels. The formulation may be improved by the addition of food colors, flavors, and vitamins.

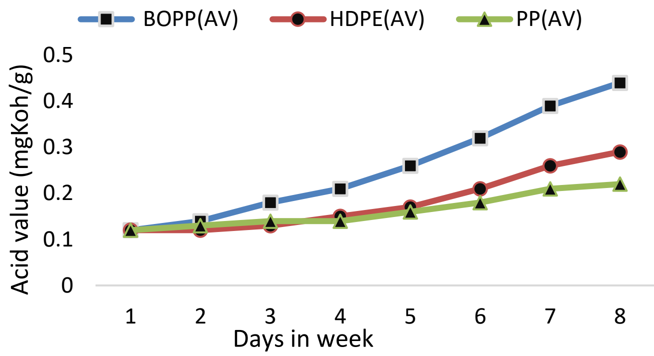

Figure 1: Acid value of biscuit

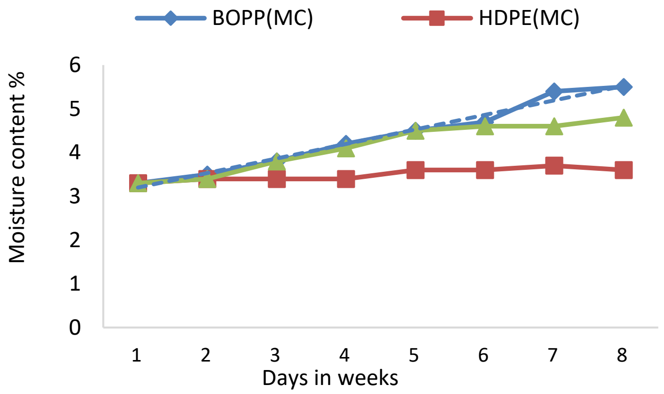

Figure 2: Moisture content of the biscuit

The acid value of the best product was increased in three test packaging materials during storage time. The acid value of 20% cassava flour incorporated biscuit was 0.12 mg KOH/gm before packaging. Acid value increased in three different packaging materials (BOPP, HDPE, and PP) were 0.44, 0.29, and 0.22 mg KOH/gm respectively in 8 weeks (Figure 1) showed that the acid value of product packed in BOPP was cross the standard acid value (0.3 mg KOH/gm) (Mukhopadhyay, 1990) after 8 weeks (Smith, 1972).

3.2.2 Projected shelf life in different packaging

In HDPE, based on observed data the following relation was obtained (R^2=0.965), $Y = 0.013x + 0.115$, When acid value approaches 0.3mg KOH/gm oil the product is no more consumable. According to obtained equation acid value, 0.3mg KOH/gm oil reaches after 12 weeks. Therefore, the expected shelf life of the product in HDPE packaging was estimated to be 12 weeks.

In PP, based on observed data the following relation was obtained (R^2=0.962), $Y = 0.019x + 0.115$, When acid value approaches 0.3mg KOH/gm oil the product is no more consumable. According to obtained equation acid value, 0.3mg KOH/gm oil reaches after 13.5 weeks. Therefore, the expected shelf life of the product in HDPE packaging was estimated to be 13.5 weeks.

In BOPP, based on observed data the following relation was obtained (R^2=0.984), $Y = 0.016x + 0.105$, When acid value approaches 0.3mg KOH/gm oil the product is no more consumable. According to obtained equation acid value, 0.3mg KOH/gm oil reaches after 8.3 weeks. Therefore, the expected shelf life of the product in HDPE packaging was estimated to be 8.3 weeks.

3.2.3 Shelf-life estimation based on moisture content (MC)

The moisture content (MC) of the 20% cassava flour incorporated biscuit was observed to 3.3% at initial which reached 5.5, 3.7%, and 4.8% in 8 weeks when it was packed with biaxial polypropylene (BOPP), high-density polyethylene (HDPE) and polypropylene (PP) respectively. The rate of change of moisture was higher in biaxial polypropylene after 6 weeks compared to HDPE and PP. The initial moisture of the test biscuit (3.3%) was increased to 5.5% by 2.2% in BOPP. The moisture content was below the unacceptability level of a maximum of 6%. Hence, the biscuit could be considered safe for consumption for 8 weeks (Mukhopadhyay, 1990).

Hence, the shelf- life of the product was evaluated and all the parameters determining the self-stability of biscuits were found to be within the standard limit. The rate of increase in AV and moisture content signified that the product would be safe for consumption before the time of 8 weeks. Packaging in laminate packets would have further increased the stability of the biscuit (Mukhopadhyay, 1990).

3.2.4 Projected shelf life in different packaging

In HDPE, based on observed data the following relation was obtained (R^2=0.984), $Y = 0.16x + 3.15$, When moisture content approaches 6% the product is no more consumable. According to obtained equation mc (moisture content) reaches 6% after 17.81 weeks. Therefore, the expected shelf life of the product in HDPE packaging was estimated to be 17.81 weeks.

In PP, based on observed data the following relation was obtained (R^2=0.965), $Y = 0.13x + 3.2$, When moisture content approaches 6% the product was no more consumable. According to obtained equation M.C (moisture content) reaches 6% after 15.53 weeks. Therefore, the expected shelf life of the product in PP packaging was estimated to be 15.53 weeks.

In BOPP, based on observed data the following relation was obtained (R^2=0.9), $Y = 0.12x + 3.1$, When moisture content approaches 6% the product was no more consumable. According to obtained equation mc (moisture content) reaches 6% after 12.16 weeks. Therefore, the expected shelf life of the product in BOPP, packaging was estimated to be 12.16 weeks.

4. Conclusion

Biscuit prepared by incorporation of 20% cassava flour in 80% wheat flour (sample C) showed significantly better sensory property for color, flavor, texture, and overall acceptability. The protein and fat content of optimized cassava flour incorporated biscuits (8.13 %) were lower than control wheat flour biscuits (9.46 %) but crude fiber, carbohydrate, and total ash content were increased significantly.

The acid value (AV) of the 20% cassava flour incorporated biscuit were reached 0.44 mg KOH/g oil, 0.29 mg KOH/g oil, and 0.22 mg KOH/g oil in 8 weeks when it was packed with biaxial polypropylene (BOPP), high-density polyethylene (HDPE), and in polypropylene (PP) respectively. The shelf life of the cassava flour incorporated biscuit was to be satisfactory for 8 weeks. The projected shelf life of cassava biscuits in different packaging materials was 8.3,12 and 13.5 weeks in BOPP, HDPE, and PP for acid value content respectively.

The moisture content of the best product (3.3%) was increased to 5.5%, 3.7%, and 4.8% in BOPP, HDPE, and PP respectively after 8 weeks of storage. These values were not higher than the standard moisture quality parameter of biscuits so, the biscuits were safe in the above-mentioned packaging materials. The projected shelf life of cassava biscuits in different packaging materials was found to be 12.16, 17.81, and 15.53 weeks in BOPP, HDPE, and PP for moisture content respectively

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Conflicts of interest

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