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Improving the Dietary Fiber Content of Tapioca Using Corn Fiber as a Fiber Supplement

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Abstract:- This research aims to enhance the dietary fiber content of locally produced cassava (manihot spp) food, tapioca, by incorporating corn (Zea mays) as a fiber supplement. Tapioca was prepared by grating cassava into coarse particles and washing it with water to remove starch. Starch analysis was conducted using a spectrophotometric method, revealing a starch content of 70.21% before washing and pressing, and 64.95% after washing and pressing. The tapioca samples were blended with corn fiber (obtained from wet milling of corn seeds that were destarched and dried in the sun) in various ratios: Sample A (100% pure tapioca), Sample B (90% tapioca, 10% corn), Sample C (80% tapioca, 20% corn), Sample D (70% tapioca, 30% corn), and Sample E (60% tapioca, 40% corn). Proximate analysis was performed on the blends to assess the increase in fiber content and any other changes introduced by the corn. Organoleptic properties such as binding, crunchiness, and color were also evaluated. The analysis revealed that the fiber content of tapioca increased from 2.7% to 3.95%, with the blend containing 70% tapioca and 30% fiber showing the highest increase in fiber content and good binding properties.

I. INTRODUCTION

The association between fiber intake and health cannot be over emphasized, with research data showing beneficial effect of dietary fibers, these include direct effect on gut function and digestion and also looking at the effect in directly on blood glucose control, cardiovascular function indeed it has been linked to a protection against severe condition such as diabetes, cardiovascular diseases, colon cancer and obesity [28]. Some major sources of fibers include whole grains, peels of fruits, nuts and vegetable. Although readily available, they are not consumed in sufficient quantities and the average intake of the general population in the United State and the European Union as well as African countries remain below recommendation [4]

The world health organization (WHO) reports that eating over 25grams of fiber everyday provides great health benefit, helping protect against cardiovascular disease, diabetes and a swarm of other health issues. But most people aren't even coming close to this number. The United State National Academy of science institute of medicine recommends that adult men ages 14-50 consume 38grams of dietary fibers per day, men 51 and older 30grams, women ages 19-50 to consume 25grams per day women 51 and older 21grams. Similarly, the British Nutrition foundation has recommended a minimum fiber intake of 30gram per day for healthy adults. Only few foods contains substantial amount of fiber to meet up the regular fiber intake. Fibre supplementation therefore is a realistic and efficient dietary intervention. Fibre can serve as prebiotics and stimulate the growth of certain beneficial bacterial [13, 17]

In this research, we are examining the use of dietary fiber supplements to increase the fiber content of a traditional African dish called "TAPIOCA" after removing the starch. The quantity of starch was measured before and after processes such as washing, cooking, and drying of the cassava. Cassava is one of the main sources of carbohydrates in tropical regions, ranking third after rice and maize. There are two types of cassava - sweet (Manihot palmate) and bitter (Manihot utilisima or esculentum), with the bitter variety containing higher levels of hydrocyanide acid, anti-nutritional factors, and toxins. Farmers often prefer the bitter variety due to its ability to repel pests, animals, and thieves. Cassava (Manihot esculenta crantz) is a significant root crop and a key food staple.

The advantage of this plant is its ability to grow in dry and less fertile land, as well as its relative highly resistance to disease. Most people in the tropics use the tubers as sources of carbohydrate [7]

Major constrain to cassava utilization is that the crop deteriorate rapidly. Cassava has a shelf life of between 24-28hours after harvesting and as a result, fresh cassava root must be processed into a more shelf-stable form within 2-3days from harvest to prevent or reduce loss in yield. One of such stable cassava product is tapioca grit [3]. Tapioca grit is a de-starched, dried cassava granule or fluke it is one of the largest produced staple cassava in the world [1, 2] .Cassava grit is also one of the cheapest source of calories for human

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nutrition mainly on the south eastern Nigeria [2] .Corn fibre is a common inexpensive by product of the corn wet milling process which comprises about 10% of the processed dry corn (Zea mays). Corn fibre is a good source of dietary fibre and also contains phytosterels which are effective reducer of LDL- Cholesterol level in humans (Hicks et al., 2001). A high level of LDL-Cholesterol is the main reason for cardiovascular diseases. In Brazil, corn is consume in the form of grain and their derivatives resulting from dry milling which leads to the mechanically separation of the anatomical part of the corn (endosperm, pericarp and germ)[15,24] .The fraction that the grain known as the pericarp is transform into a residue, consisting essentially of hemicellulose, cellulose and lignin.

In Europe and North America, this product has been used as a source of insoluble dietary fibers in bread industry and farinaceous product [27]

In Nigeria, as well as in brazil, however the use of corn fiber has been directed primarily to animal feeding [5,9] with no addition value (calorie) to the product.

Some alternative fiber sources available in the market, or have already been studied, including mango (Mangifera Indica), apple (Malus domestica), lemon (citrus lemon) and orange (citrus sinensis) [12, 20, and 26]

One important of insoluble dietary fibers is the provision of the mass required for the peristaltic action of the intestine [25]. Since they remain intact along the digestive tract [22], they also promote the reduction of energy nutrient absorption and increase the faecal bulk which may increase satiety and reduces food intake.

Soluble and insoluble dietary fiber helps in reducing body weight, contributing to the control of obesity and reduces disease resulting from positive energy balance like saccharine disease[10], obesity 'which is considered a low intensity chronic inflammation, certain type of cancer [11] and non-alcoholic hepatic steatosis (NASH) [21]

Civilization-related diseases can be adjusted by including a greater amount of dietary fiber in the diet. Over the past two hundred years (200 years), diets have become increasingly processed, leading to a great loss of fiber content. In this situation, it is advisable to search for new sources of dietary fiber, which we can get from waste products, individual feeds, or agricultural waste.

Cassava is one of the major crops commonly consumed by a lot of persons in Nigeria today, though it contains about some amount of fiber when processed by starch removal into tapioca. It is, therefore, reasonable to standardize the amount of starch removed when making a batch or semi-continuous product and also increase the fiber content of tapioca using additives which can act as a food with low calorific value and substantial fiber content as regular consumption of dietary fiber has been one of the most consistent recommendations of nutritionist for the prevention of diabetes, hypercholesterolemia, and obesity. These recommendations are based on the finding that dietary fibre has a physiological effect that promotes significant change in human gastrointestinal function such as lowered glycaemic response reduction in cholesterol level etc. [8]

II. METHODOLOGY

All analysis and preparation procedures were carried out following standard analytical method described by, AOAC (2000). Official methods of Analysis (16th Ed)[6]

- *Sample Collections and Preparation for Starch Determination*

The Cassava root was obtained from Sapele town in Delta State, where it was peeled using a knife and subsequently washed with water in order to eliminate any impurities. Following this, the root was grated into coarse particles and underwent multiple washes with water while being pressed repeatedly to extract the starch content. A quantity of 500 grams of the cassava shafts and lumps was then selected and placed into a crucible labelled as Sample A, with this process being repeated until a total of six samples were obtained, labelled as Samples A, B, C, D, E, and F. Subsequently, Samples B, C, D, E, and F were each washed with different volumes of water, specifically 2 liters, 4 liters, 6 liters, 8 liters, and 10 liters, respectively. In order to determine the initial starch content present in the cassava tuber, the starch content of Sample A was assessed using spectroscopic method.

III. DETERMINATION OF STARCH CONTENT

- *Iodine Reagent Preparation*

The Iodine reagent is prepared according to the CLEAPSS Recipe, which involves the addition of 3 g of KI to 2.54 g I2 and dilution with water to reach a total volume of 100mL. The resulting stock solution is then diluted by a factor of 10 and stored in a light-protected environment.

- *Starch Standard Solution Preparation*

A 0.1% starch reference solution was made using soluble starch powder (Sigma, S9765). Specifically, 1 gram of the soluble starch is placed in a 100 mL conical flask and filled to the mark with distilled water. The mixture is heated until it becomes transparent, then filtered using a filter paper. Following filtration, the filtrate is transferred to a standard 1L volumetric flask and filled to the mark with distilled water. Subsequently, 10 mL is aliquoted into a 100 mL volumetric flask and filled to the mark with distilled water, resulting in a concentration of 100 mg/L. Through successive dilutions, solutions of 10 mg/L, 20 mg/L, 30 mg/L, 40 mg/L, and 50 mg/L are prepared from the initial solution. For example, to create a 10 mg/L standard starch solution, 10 mL of the 100 mL starch solution is placed in a 100 mL conical flask and diluted with distilled water. The same process is followed for the 20 mg/L, 30 mg/L, 40 mg/L, and 50 mg/L standard starch solutions. Subsequently, six test tubes labelled A to F are obtained; 10 mL of distilled water is pipetted into test tube A, while 10 mL of the 10 mg/L standard solution is placed in test tube B, and so on until test tube E is filled. Next, 30 µL of the prepared iodine reagent solution is added to test tubes

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B to E. After allowing 3 minutes for colour development, the test tubes are shaken. To establish a baseline, the absorbance of the distilled water in test tube A is measured at 600 nm using a cuvette, and the spectrophotometer is zeroed. Subsequently, the absorbance of samples B, C, D, E, and F are measured at 600 nm. The obtained results are recorded, and a graph is plotted correlating absorbance with concentration.

➢ *Determining the Concentration of Starch in Tapioca Samples*

The starch concentration in tapioca samples was determined through a series of procedures. Initially, the various tapioca samples were individually blended in a blender. Subsequently, 1 gram of sample A, which had not been washed with water, was transferred into a 100ml conical flask and diluted with distilled water to the mark. The resulting solution underwent heating and filtration using filter paper, similar to the preparation process for standard starch solutions. Following filtration, the filtrate was transferred into a volumetric flask and diluted to the 1-liter mark with distilled water. A 1ml aliquot of this solution was then transferred into a conical flask and diluted to the 50ml mark, representing a 50-fold dilution. Subsequently, 10ml of the starch solution was dispensed into test tube A, followed by the addition of 0.3µL of iodine reagent to induce colour development upon shaking. A portion of the solution was then pipetted into a cuvette, and the absorbance was measured and recorded.

➢ *Extraction of Corn Fiber from Corn*

The extraction of corn fiber from corn involved obtaining it as a by-product from the wet milling of corn seeds, subsequent to washing and pressing, and allowing the residue to dry.

➢ *Tapioca and Corn Fiber Blend*

Table 1 Tapioca and Corn Fiber Blend

Sample	Cassava	Corn
A	100	0
B	90	10
C	80	20
D	70	30
E	60	40

IV. PROXIMATE ANALYSIS DETERMINATION OF THE TAPIOCA – CORN FIBER BLEND

➢ *Moisture Determination*

The moisture content of the cassava blend was determined using the AOAC method (2000). Official method of analysis, Association of official analytical chemist 16th edition AOAC international publishers. Clean and dry petri-dish was weighed and the weight was recorded (W_1). About 2g of the sample was weighed into the dish (W_2). The petri-dish containing the sample was transferred into an oven and the oven was maintained at about 105°c and dried for about three hours, allowed to cool and weighed. The process was repeated until a constant weight (W_3) was obtained. The percentage moisture content was then calculated as follows;

$$\% \text{ moisture} = \frac{loss\ in\ weight}{weight\ of\ sample\ before\ drying} \times 100$$

$$= \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where w_1 = initial weight of empty crucible

W_2 = weight of crucible + sample before drying

W_3 = weight of crucible + sample after drying.

➢ *Ash Content Determination*

Determination of the content of the flour blends was carried out according to the methods of AOAC (2000) official methods of analysis association of official analysis chemist. 16th edition, AOAC international publisher Washington DC.

2g of the flour blends were weighed into the crucibles and their weights were recorded. The crucible containing the sample were placed in a muffle furnace and ignited at a temperature of 550^{0}c which was maintained for three hours. The muffle furnace was then allowed to cool after which the crucible which was represented in percentage was calculated thus:

$$\% \text{ ash} = \frac{W_2 - W_1}{weight\ of\ sample} \times 100$$

Where w_2 = weight of crucibile + ash
W_1=weigh of empty crucible

➢ *Crude Fibre Determination*

The crude fibre of the composite flour samples was determined according to the official methods of AOAC (2000) official methods of analysis association of official analysis chemist. 16th edition, AOAC international publisher Washington DC.

2g of each sample were boiled under reflux in a 200ml solution containing 1.25g of sulphuric acid per 100ml of solution. The solution was filter and washed with water and filtrate was tested for acidity. The residue was washed continuously until the filtrate was no longer acidic. The residue was then transferred into a beaker and boiled with a 200ml solution of 1.25% NaOH. The solution was filtered and again washed. The final residue was filtered and washed thoroughly with hot water and twice with ethanol. The residue was dried in an electric oven and weighed after which it was incinerated, cooled and weighed. The percentage crude fibre was calculated as follow:

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% crude fibre = $\frac{W_2 - W_3}{W_1} \times 100$

Where w_1=weight of sampled used

W_2=weight of crucible + residue

W_3=weight of crucible + ash

➢ *Crude Protein Determination*

The crude protein content of the flour blend was determined by the kjedhal method 1g of each of the samples was introduced into a digestion flask and kjedhal catalyst (selenium tablets) was added to the samples, 20ml concentrated sulphuric acid was added and allowed to digest over a flame for eight hours until a clear solution was obtained after which it was cooled. The cooled digest was transferred into a 100ml volumetric flask and made up to the mark with distilled water. The distillation apparatus was set and rinsed for ten minutes after boiling. 20ml of 4% boric acid was pipetted into a conical flask, five drops of methyl red indicator was added to the solution and was later diluted with 75ml of distilled water. 10ml of the digest was made alkaline with 20ml of 20% sodium hydroxide and then distilled. The steam exit of the distillatory apparatus was closed and the change of colour of boric acid solution to green was timed. The mixture was distilled for fifteen minutes; the filtrate was then titrated against 0.1N hydrochloric acid. The percentage total was calculated thus:

% NITROGEN = $\frac{(100 \times N \times 14 \times Vf) T}{100 \times V_a} \times 100$

Where N=Normality of the titrate (0.1N)

V_f = total volume of the digest (100ml)

T = Titre value

V_a = aliquot volume distilled.

➢ *Crude Fat Content*

The fat content determination was carried out using a Soxhlet apparatus 2g each of the composite sample were wrapped in separate filter and place in a soxhlet reflux flask which is connected to a condenser on the upper side and to a previously weighed oil extractor flask containing 200ml 0f petroleum ether. The ether was set to boil and the vapour condensed into the reflux flask immersing the sample completely for extraction to take place on filling up the reflux flask siphons over carrying the oil extract back to the boiling solvent in the flask. The process of boiling, condensation and reflux was allowed to continue for 4hours after which the defatted sample was removed. The oil extract in the reflux was dried in the oven at 60^0 for 30min*utes* and then weighed. The percentage fat was calculated as follow:

% FAT = $\frac{weight\ of\ fat}{weight\ of\ sample} \times 100$

➢ *Carbohydrate Content Determination*

The carbohydrate content determination of the flour blends was calculated using the formula for food analysis and instrumentation:

%carbohydrate = 100 - %(protein + fat + ash + fibre + moisture content)

➢ *Energy Value*

A weighed amount of food sample is placed inside the calorimeter, in a crucible. It is filled with oxygen under pressure. The calorimeter is immersed in a known quantity of water. The sample is ignited by means of electric fuse and heat liberated is measured by the rise in temperature.

V. RESULTS

The results are shown in tables and figures below

➢ *Starch Analysis*

Calibration Curve for Starch

Table 2 Instrument Reading for Starch Standard

Starch (mg/l)	Absorbance
0	0
10	0.059
20	0.116
30	0.180
40	0.239
50	0.298
Sum of (X) =150	Sum of (Y) = 0.892
Slope Reciprocal (SR)	SR= ∑X/∑Y = 168.1614

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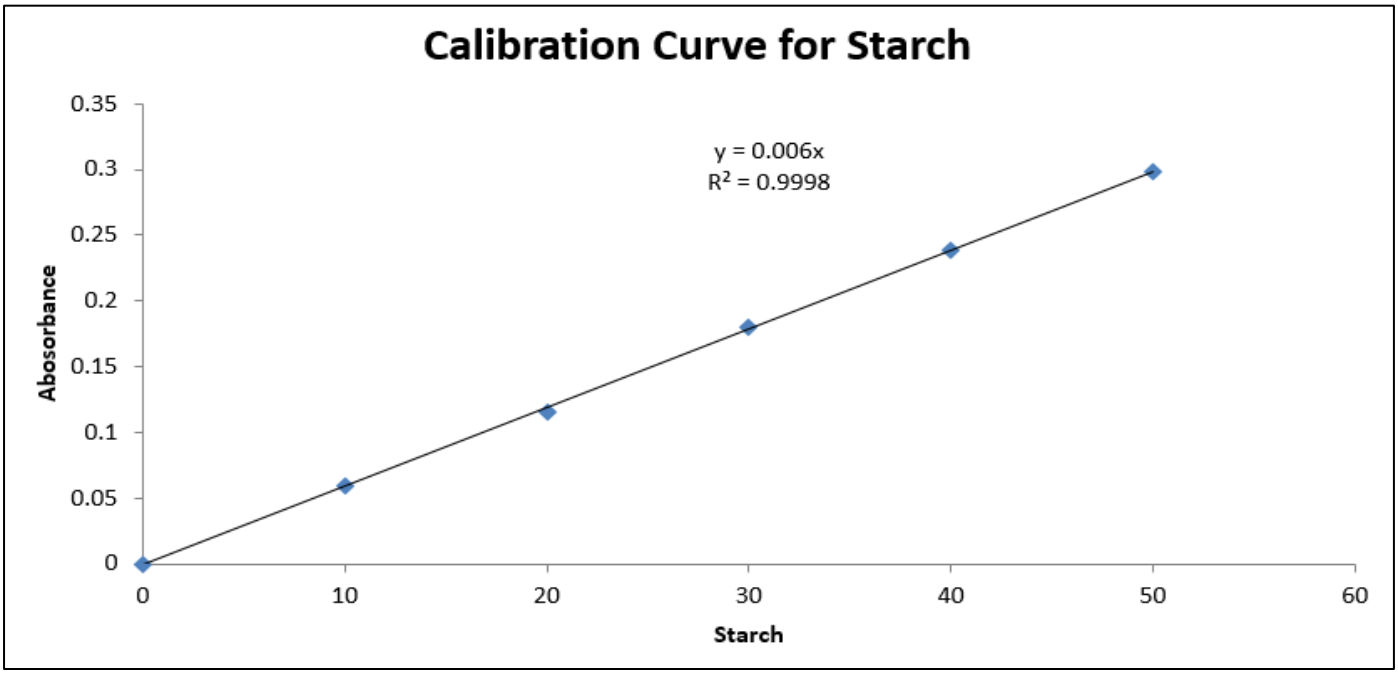

Fig 1 Starch Calibration Curve

➢ *Initial Starch Content*

Table 3 Starch Content before Grated Cassava Washing

Sample ID	Abs1	Abs2	Mean	mg/kg	mg/100g	g/100g	% Starch
0L	0.837	0.833	0.835	702073.8	70207.38	70.21	70.21
2L	0.787	0.790	0.789	662976.3	66297.63	66.30	66.92
4L	0.786	0.782	0.784	659192.7	65919.27	65.92	65.30
6L	0.777	0.775	0.776	652466.2	65246.62	65.25	65.25
8L	0.772	0.773	0.773	649523.4	64952.34	64.95	64.95
10L	0.772	0.772	0.772	649103.0	64910.30	64.91	64.95

Slope Reciprocal (SR) = 168.1614

Extraction Ratio (ER) = 100

Dilution factor (DF) = 50

Therefore the multiplying factor (MF) = SR x ER x DF = 840807

Starch (mg/kg) = Abs x MF

➢ *Proximate Analysis of Cassava and Corn Fiber Blends*

Table 4 Cassava and Corn Fiber Blend

Sample	Cassava	Corn
A	100	0
B	90	10
C	80	20
D	70	30
E	60	40

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Table 4 Results for Proximate Analysis

SAMPLE	MOISTURE (%)	PROTEIN (%)	FAT/OIL (%)	ASH (%)	FIBRE (%)	CARBOHYDRATE (%)	ENERGY (Kcal)
A (100)	13.80	1.10	1.60	0.9	2.70	80.90	342.40
B (90-10)	13.60	1.65	1.70	1.10	2.90	79.05	338.10
C (80-20)	13.40	4.68	1.80	1.45	3.70	74.97	334.80
D (70-30)	13.40	5.86	2.00	1.65	3.80	73.39	334.00
E (60-40)	13.40	6.84	2.00	1.80	3.95	72.01	333.40

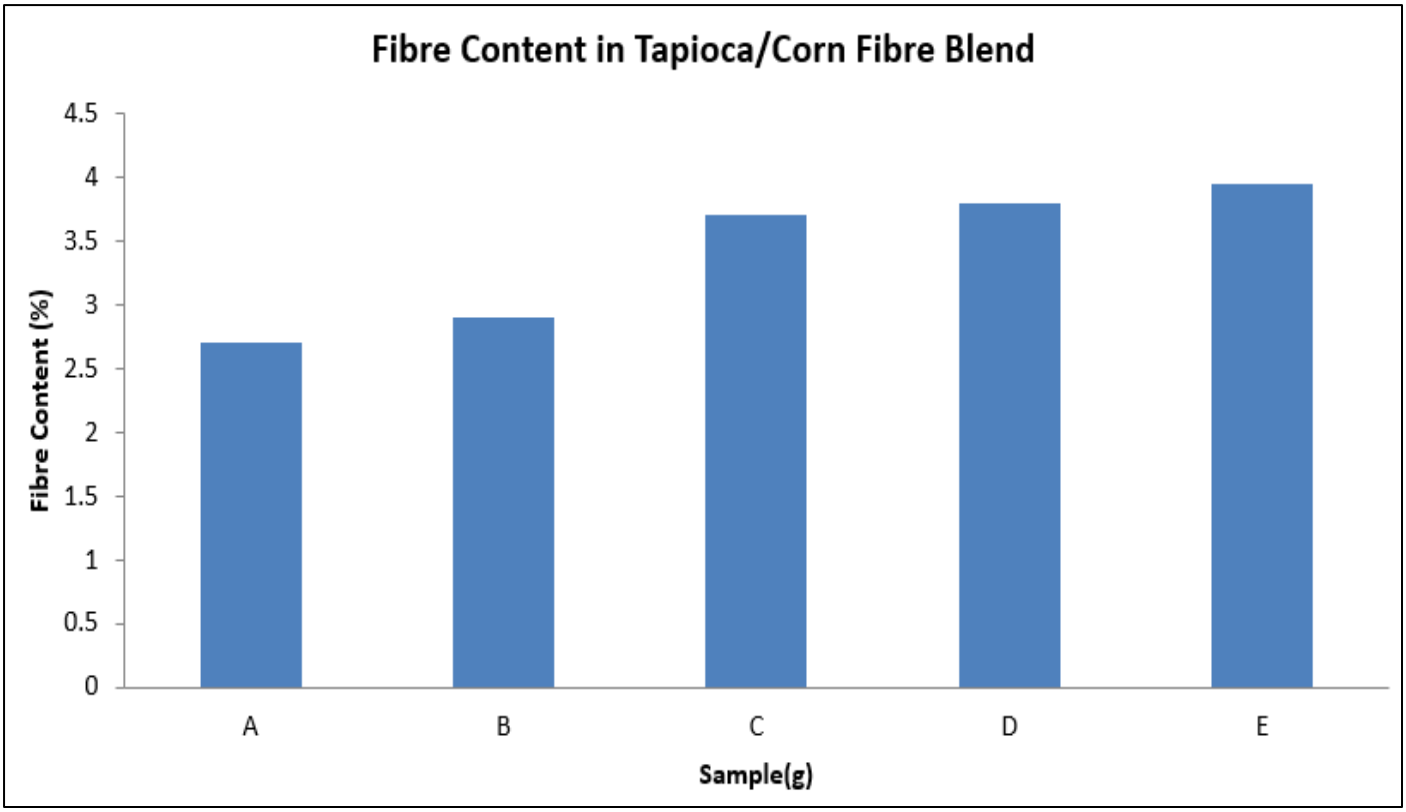

Fig 2 Fiber Content in Tapioca/Corn Fibre Blend

Fig 3 70g Cassava (Tapioca) with 30g Corn Fiber, Showing Binding Properties.

Fig 4 60g Cassava (Tapioca) with 40g Corn Fiber, Does not Show Binding Properties.

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VI. DISCUSSION

The data presented in Table (2) indicates that prior to washing the grated cassava, the starch content was measured at approximately 70.21%. Following the washing process with varying amounts of water, the starch content decreased to around 66.92% with 2 liters of water, 65.30% with 4 liters, 65.25% with 6 liters, and 64.95% with 8 liters and 10 liters, demonstrating consistency. This suggests a standardization of starch content by washing with 8 liters of water for every 500 grams of grated cassava before the addition of fiber supplement and cooking.

Examining Table (4), the proximate composition data reveals a decrease in the carbohydrate content of cassava and corn fiber blend, indicating no contribution of carbohydrates from the corn fiber. Conversely, the percentage of fiber increased from 2.7% to 3.95% as the level of substitution increased, suggesting that corn fiber led to higher fiber levels in tapioca. The fiber content also contributed to lowering the moisture content of the blends due to the significant presence of both soluble and insoluble fibers. Moreover, the protein and fat content increased with the addition of fiber blend, while the ash content indicated an increase in inorganic content from the fiber. The energy value decreased in the blend samples.

Analysis of Fig (2), Fig (3), and Fig (4) highlights the importance of not only increasing fiber content but also considering binding capacity and crunchiness. The diagrams show that optimal binding and crunchiness are achieved at sample C, consisting of 70g of cassava to 30g of corn fiber.

VII. CONCLUSION

This research suggests that incorporating corn fiber into food products can enhance their fibre content without compromising essential properties such as binding capacity and taste. By adding corn fibre as a supplement, the percentage of substituted cassava in the mixture can increase from 2.7% to around 3.95%, with an optimal binding ratio of 70g tapioca to 30g corn fibre. This new blend boasts a fiber content of approximately 3.8%, although it does result in a decrease in energy value and carbohydrate content. The lowered moisture content due to the addition of corn fibre may extend the shelf life of the product. Furthermore, this study sheds light on the potential for utilizing high-quality corn fibre in various food items to boost their fiber content.

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REFERENCES

[1]. Adebowale AA, Sanni LO, Awonorin SO (2005). Effect of texture modifiers on the physicochemical and sensory properties of dried fufu. Food Sci. Technol. Inter. 11(5): 373-382.

[2]. Adebowale AA, Sanni LO, Awonorin SO, Daniel IO, Kuye A (2007).Effect of cassava varieties on the sorption isotherm of tapioca grits.Inter. J. Food Sci. Technol. 42 (4): 448-452

[3]. Adebowale AA, Sanni LO, Kuye A (2006). Effect of roasting methods on sorption isotherm of tapioca grits. Electronic J. Environ. Agric. Food Chem. 5 (6): 1649-1653

[4]. Afshin A, Sur PJ, Fay KA, Cornaby L, Ferrara G, Salama JS, et al. Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. 61–67.

[5]. Alessi, M. O., Raupp, D. S., & Gardingo, J. R. (2003). Caracterização do processamento da farinha de milho biju para o aproveitamento dos subprodutos. Publication UEPG: Ciências Exatas e da Terra, Ciências Agrárias e Engenharias, 9(2), 31-39.

[6]. AOAC (2000). Official methods of Analysis (16th Ed), Association of Official Analytical Chemists, Washington DC, USA.

[7]. Blagbrough, I.S., Bayoumi, S.A.L., Rowan, M.G., Beeching, J.R., 2010. Cassava: an appraisal of its phytochemistryand its biotechnological prospects - review. Phytochemistry. 71, 17-18

[8]. Botelho,l.; conceicao, a.; carvalho,v.d. (2002). Caracterizacao de fibras alimentares da casca e cilinndro central do abacaxi ‘’smooth cayenne’’. Cienc. Agrotec, v.26,p.362-367,2002.

[9]. Callegaro, M. G. K., Dutra, C. B., Huber, L. S., Becker, L. V., Rosa, C. S., Kubota, E. H., & Hecktheur, L. H. (2005). Determinação da fibra alimentar insolúvel, solúvel e total de produtos derivados do milho. Ciência e Tecnologia de Alimentos, 25(2), 271-274. http://dx.doi.org/10.1590/S0101-20612005000200015.

[10]. Cleave, t.l. – campell, g.d. – painter, n.s.(1969). Diabetes, coronary thrombosis and the saccharine disease. Bristol: john wright & sons ltd., 1969.

[11]. Duarte, A. C. G. O., Fonseca, D. F., Manzoni, M. S. J., Soave, C. F., SeneFiorese, M., Damaso, A. R., & Cheik, N. C. (2006). Dieta hiperlipídica e capacidade secretória de insulina em ratos. Revista de Nutrição, 19(3), 341-348

[12]. Figuerola, f.; hurtado, m.l.; Estevez, a. M.; chifelle, i.; asenjo,f. (2005). Fibre concentrates from apple pomace and citrus peel as potential fibre sources for food enrichment. Food chemistry 91: 395 – 401.

[13]. Gibson G.R., Probert H.M., van Loo J., Rastall R.A., Roberfroid M.B. Dietary modulation of the human colonic microbiota: Updating the concept of prebiotics. Nutr. Res. Rev. 2004;17:259–275. doi: 10.1079/NRR200479. [

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV513

[14]. Gibson G.R., Scott K.P., Rastall R.A., Tuohy K.M., Hotchkiss A., Dubert-Ferrandon A., Gareau M., Murphy E.F., Saulnier D., Loh G., et al. Dietary prebiotics: Current status and new definition. Food Sci. Technol. Bull. Funct. Foods. 2010;7:1–19.

[15]. Gonçalves, R. A., Santos, J. P., Tomé, P. H. F., Pereira, R. G. F. A., Ascheri, J. L. R., & Abreu, C. M. P. (2003). Rendimento e composição químicade cultivares de Milho em moagem a seco e produção de grits.Ciência e Agrotecnologia, 27(3), 643-650. http://dx.doi.org/10.1590/S1413-705420030003000 20

[16]. Halpern, Z. S. C., Rodrigues, M. D. B., & Costa, R. F. (2004). Determinantes fisiológicos do controle do peso e apetite. Revista de Psiquiatria Clínica, 31(4), 150-153.

[17]. Holscher HD, Doligale JL, Bauer LL, Gourineni V, Pelk-man CL, Fahey GC, Swanson KS. Gastrointestinal toler-ance and utilization of agave inulin by healthy adults.Food Funct 2014; 5:1142-9; PMID:24664349; http://dx.doi.org/ 10.1039/c3fo60666j

[18]. Larrauri, J. A. -Ruperez, P. -Borroto, B. -Saura-calixto, F.: Mango peel as a new tropical fibre: Preparation and characterization. Lebensmittel Wissenschaft Und Technology, 29, 1996, pp. 729-733.

[19]. Larrauri, J. A.: New approaches in the preparation of high dietary fibre powders from fruit by-products. Trends in Food Science and Technology, 10, 1999, pp. 3-8.

[20]. Larrauri, j.a.(1999). New approaches in the preparation of high dietary fibre powders from fruit by – products. Trends in food science & technology, 10, 1999, pp. 3-8,

[21]. Love-Osborne, K. A., Nadeau, K. J., Sheeder, J., Fenton, L. Z., & Zeitler, P. (2008). Presence of the metabolic syndrome in obese adolescents predicts impaired glucose tolerance and nonalcoholic fatty liver disease. The Journal of Adolescent Health, 42(6), 543-548. http://dx.doi.org/10.1016/j.jadohealth.2007.11.136. PMid:18486862

[22]. Moraes, F. P., & Colla, L. M. (2006). Functional foods and nutraceuticals: definition, legislation and health benefits. Revista Eletrônica de Farmácia, 3(2), 99-112.

[23]. M. R. Kurt, D. L. James and D. F. Stickle, "Quantitative Assay for Starch" Journal of Chemical Education, vol. 81, no. 5, pp. 702-704, 2004.

[24]. Paes, M. C. D. (2008). Aspectos físicos, químicos e tecnológicos do grão de milho. In J. C. Cruz, D. Karam, M. A. R. Monteiro & P. C. Magalhaes (Ed.), A cultura do milho (Cap. 2, pp. 47-61). Sete Lagoas: Embrapa Milho e Sorgo

[25]. Rique, A. B. R., Soares, E. A., & Meirelles, C. M. (2002). Nutrição e exercício na prevenção e controle das doenças cardiovasculares. Revista Brasileira de Medicina do Esporte, 8(6), 244-254. http://dx.doi.org/10.1590/S1517-86922002000600 006.

[26]. Rodrigues, R. A. J. – Fernandez-Bolanos J.Guillen R. –Heredia A. [2006]. Dietart fribre from vegetables Products as a source of functional imgredients. Trends in Food Science and Technology, 17, 2006, pp. 3-15

[27]. Sugawara, M., Sato, Y., Yokoyama, S., & Mitsuoka, T. (1991). Effect of corn fiber residue supplementation on fecal properties, flora, ammonia, and bacterial enzyme activities in healthy humans. Journal of Nutritional Science and Vitaminology, 37(1), 109-116.

[28]. Snyder EE, Walts B, Perusse L, Chagnon YC, Weisnagel SJ, Rankinen T, Bouchard C. The human obesity gene map: the 2003 update. **Obes Res**. 2004; *12*: 369–439

[29]. WHO/FAO. (2003). Food energy – methods of analysis and conversion factors. Report of a technical work shop, FAO Food and nutrition paper- 77, Rome, 2003

[30]. WHO Global Strategy on Diet, Physical Activity and Health; World Health Organization:Geneva, Switzerland,2007.Availableonline:https://apps.who.int/iris/handle/10665/43612

[31]. World Health Organization Diet, Nutrition and the Prevention of Chronic Diseases. Geneva: WHO. 2003.