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GLYCEMIC INDEX AND LOAD OF INSTANT FUFU POWDER BLENDS FROM ORANGE-FLESHED SWEET POTATO AND CASSAVA STARCH EXTRUDATES

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Abstract: **Interest on GI and GL of carbohydrate-rich foods is rapidly growing due to the role it plays in the prevention and management of diabetes mellitus, a disease that is rapidly spreading worldwide. The glycemic index and load of instant fufu powder from orange-fleshed sweet potato (OFSP) and cassava starch (CS) composite extrudate blends was investigated. The instant fufu powder was produced from OFSP and CS through extrusion cooking using conventional standard method. The glycemic index ranged from low (47.26 %) to very high (96.40 %) values with sample ABC (90:10 for OFSP and CS) being the lowest and MNO (60:40) the highest. The glycemic load of the composite blends ranged from 18.45 to 36.55 %, with sample ABC (90:10) having the lowest value which is an indication of quality product from the blends of OFSP flour and CS starch. Nonetheless, all the composite blends had relatively low glycemic index and load except sample blends MNO (60:40) and YZ (100:0). These showed that the instant fufu blends GI and GL increased with increase in CS and decrease with increased OFSP. This implies that the fufu from OFSP could be said to be safe for the consumption of people with metabolic disorder such as diabetes mellitus. The results clearly showed that sample blend 90:10 for OFSP and CS is the best among the other samples.**

Keywords: **Glycemic index, Glycemic load, OFSP, Extrudate, Cassava Starch, Extrusion.**

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1. INTRODUCTION

Fufu is a thick paste made by boiling cassava flour in water, stirring vigorously with a wooden paddle until a desired consistency is formed (Sanni *et al., 2018)*. Fufu flour could be prepared from cassava, yam, potatoes, cocoyam, cereals etc. The composition of fufu depends on the raw material used for its preparation. Cassava fufu is widely consumed in all the parts of Nigeria and it is the most popular fufu product (Akubor and Ukwuru 2013). The methods for the preparation of cassava flour that is used for making cassava fufu vary widely among the various tribes in Nigeria. Generally, cassava flour is prepared by washing fresh cassava roots, peeling, and washing, soaking in water for 3 days, shredding, sun drying, milling, and sieving. The traditional method of processing cassava reduces the toxic cyanogenic glycosides (Achi and Akoma, 2006). The microorganisms involved in the fermentation of cassava flour include species of *Bacillus Klebsiella*, Leuconostoc, Corynebacterium, Candida, and Lactobacillus (Oyedeji *et al., 2013*).

Instant fufu is a pre-gelatinized product made by extrusion of cassava flour at relatively low temperature (Colonna *et al., 2019*). Pre-gelatinized starches or flours are paste forming products in the presence of cold water or (partially or totally) soluble products in hot water (Colonna *et al., 2019*).

Sweet potatoes are native to the tropical Americas and were first cultivated at least 5,000 years ago (Ahn *et al.*, 2010). They spread very early throughout the region including the Caribbean now known as southeastern United States (Zhang *et al.*, 2015). They were brought to Europe by Spanish and Portuguese explorers and sweet potato cultivation quickly spread throughout much of the Old World up to Africa. There are various varieties of sweet potatoes like the purple sweet potato known as *'okinawan' the o'henry* sweet potato which is white with a cream-colored flesh (Woolfe, 2017). The most important variety of interest is the orange fleshed sweet potato (OFSP) which is known to be very rich in vitamin A (Woolfe, 2017). Scientifically, the orange fleshed sweet potato also known as *Ipomoea batatas*is a member of the *Convolvulaceae* family of flowering plants (Austin, 2018). In Uganda, about 19 OFSP clones are believed to have been introduced from CIP Lima and Peru in February 2001 (Mwanga *et al.,* 2014), but two landrace cultivars of OFSP, designated as 'SPK004' *('Kakamega')* and 'Ejumula' are the ones widely grown because of farmer-to-farmer exchange or purchase of planting materials and promotions by non-government organizations, schools, farmer groups and government departments. From a dietary point of view and nutritional perspective, OFSP is ranked as number 1 among all tubers. OFSP tubers are considered as a significant dietary resource of VAC and NPVAC (Mohammad *et al*., 2016). OFSP is appreciated due to the vitamin A (VA) contribution and role in vitamin A deficiency (VAD) eradication in developing countries (Girard *et al*., 2017). Due to the many positive aspects related to agriculture, nutritional security and food security are resulted in intensified research on OFSP in present decade to augment its production and consumption in different countries. The OFSP possesses the characteristic of attractive sweet taste and eye-pleasing yellow to orange colour to children in comparison with white-fleshed sweet potato (WFSP) (Kaguongo, 2012); hence, OFSP has reported potential role to tackle calorific and VAD malnutrition problems of children in targeted communities. OFSP is a good source of non digestible dietary fiber, specific minerals, different vitamins, and antioxidants (Endrias *et al*., 2016). Phenolic compounds and carotenoids are responsible for distinguishing flesh and skin colors (deep yellow, red to orange, purple, and pale) of SP along with antioxidant properties (Steed and Truong, 2018). Scientists established the role of OFSP in health, and this accredited to its rich nutritional components with anti-carcinogenic and cardiovascular disease (CVD) preventing attributes (Chandrasekara and Josheph, 2016). Recent scientific reports concluded the anti-oxidative and free radical scavenging activity of phenolic acid components in OFSP with beneficial health-promoting activities (Bovell, 2017). However, OFSP varieties with identical flesh color reported variations in phenolic content, individual phenol acid profile, and antioxidant activity (AA) agents' concentrations. Reports on the OFSP incorporation in staple foods and its role in national food security and well-being are readily available (Rumbaoa *et al*., 2019).

Starch is the major food reserve of cassava. It is approximately 21.5 % of fresh cassava root (IITA, 1990). Like cassava flour, cassava starch is prepared from either wet mash or dry chips. Starch extraction is easier and economical with wet mash. It also gives consistent and better quality starch. Particle size and purity are important quality indices for starch (Sriroth et al., 2000). Cassava starch extraction follows similar pattern with production of cassava flour, except that starch milk is passed through a screen of 150-180 microns aperture size to separate starch from fibres and other impurities (Sriroth et al., 2000).

Extrusion cooking, a process of forcing a material to flow under a variety of conditions through a shaped-hole (die) at a predetermined rate to achieve various products. Extrusion cooking of foods has been practiced over 50 years. The food extruder which was initially limited to mixing and forming macaroni and ready - to - eat cereal pellets is now considered a high temperature-short time bio-reaction that transforms raw ingredients into modified intermediate and finished products. During extrusion, thermal and shear energies are applied to raw food materials causing structural, chemical, and nutritional transformations such as starch gelatinization and degradation, protein denaturation, lipid oxidation, degradation of vitamins, anti-nutritional factors and phytochemicals, formation of flavors, increase of mineral bioavailability and dietary fiber solubility (Riaz *et al*., 2019). Extrusion technology has led to production of a wide variety of cereal-based foods, protein supplements, and sausage products. Presently, several products are developed by extrusion i.e., instant fufu, pasta, breakfast cereals, breadcrumbs, biscuits, crackers, croutons, baby foods, snack foods, confectionery items, chewing gum, texturized vegetable protein, modified starch, pet foods, dried soups, and dry beverage mixes (Chang and Ng, 2011).

Glycemic index (GI) refers to a number (index) used to rank carbohydrate-rich foods depending on how they raise the blood sugar levels (FAO/WHO, 1998). Carbohydrates are the major influential dietary component since it's comprised of sugars and starches that are broken down in the digestive system into glucose that enters the blood stream (FAO/WHO 1998). Of particular importance is the rate at which these carbohydrates are broken down to glucose as indicated by the GI which has been found to differ among different foods (Bahado Singh *et al.*, 2011; Eli-Cophie, *et al.*, 2017). Foods which is low in GI have been suggested to reduce both post prandial blood glucose and insulin responses as opposed to those with a high GI (Brand-Miller *et al.*, 2009). The GI has been found to vary depending on their origin, variety, processing and preparation, maturity, other nutrients consumed with the food, the time of the day the GI is measured, other nutrients consumed with the food, the time of the day the GI is measured, the method used to measure the GI as well as the physicochemical characteristics of the foods (Arvidsson-Lenner *et al.*, 2004; Lin *et al.*, 2010; Bahado Singh *et al.*, 2011; Eli-Cophie *et al.*, 2017).

Glycemic load (GL) has been advocated as an alternative measure of blood sugar response. It is computed by dividing the GI of the food by the available carbohydrate and multiplying by 100 (Jenkins *et al.*, 1981). A high dietary glucemic load from carbohydrates has been associated with increased risk of diabetes mellitus and heart disease (Choudhary, 2004; FAO, 1998a; Liu *et al.*, 2000). GI and GL concepts have taken into consideration the carbohydrate quality and quantity in influencing post prandial glucose levels (Wheeler and Pi-Sunyer, 2008). However, in order to guide food choices, it is advisable not to consider the GI alone but in relation to other nutritional components of the food (Arvidsson-Lenner *et al.*, 2004; Venn and Green, 2007; Ricardi *et al.*, 2008).

Although the GI of fufu has been investigated elsewhere, the same has not been conducted on extruded composite blends of OFSP and CS starch; considering the variations in origin, variety and preparation methods. Thus, the study investigated the GI and GL of instant fufu powder blends form OFSP and CS extrudates.

2. MATERIALS AND METHODS

Sources of Raw Materials

Matured orange-fleshed sweet potato tubers (Carrot C and Ejumula) and cassava roots (H-226 and H – 165) were bought from Zadok Farms Limited, Yenagoa, Bayelsa State, Nigeria. The raw materials were transported in a polyethylene sac and processed. Other items that were used include glucometer, glassware, digital weighing balance and packaging materials.

Experimental Design

Completely Randomized Design was used in this work using Design Expert software version 12. The experimental space had a total of 6 runs.

Production of OFSP flour

The flour was produced using the method described by Shittu *et al.* (2002). The tubers (3 kg) were washed with clean water and peeled with sharp stainless knife. The tubers were rewashed to remove adhering dirt and unremoved skin during peeling (Oluwole and Adio, 2013). The washed, and peeled potato tubers were chipped into thin layers (0.2 cm), dried at 70 ^oC for 9 h in a cabinet dryer and milled. The milled potato was sieved with a sieve of aperture size of 180 micron (0.180 mm). The resultant intermediate flour was weighed (1.23 kg) and packaged in a polyethylene bag.

Production of cassava starch

The cassava starch was produced according to the method of Sriroth *et al.* (2000). The cassava root was washed with clean water to remove soil, sand, and other impurities. Exactly 1.5 kg of cassava root was peeled manually. The peeled root was cut and grated (rasped) into smaller pieces. Rasping was achieved by crushing the root in a giant blender to produce pulp. The pulp (500 g) was suspended in potable water (200 mL), mixed properly and allowed to stand for 6 h at room temperature (31.0 ^oC). The quantity of water used contained 0.05 % of sulphur dioxide for 500 g of pulp. The starch milk was passed through a sieve size of 180 micron. The starch milk was allowed to settle in a container (settling tank) for about 18 h. The supernatant (effluent) was gently removed to separate out the starch cake from the water. The resultant compact mass was called starch cake. The starch cake was then dried to a moisture content of 10-14% using a cabinet dryer at 70 ^oC for 15 h. The temperature of the dried cake was reduced at room temperature to avoid caking during milling operation. Milling was done to expose the fibers and the starch cake for further processing. The milled starch was sieved, weighed (0.5 kg) and packaged.

Production of instant fufu powder

The instant fufu powder was produced as described by Odoh et al. (2019). The extrusion cooking process was performed using a pilot scale co-rotating twin screw food extrusion cooker (SLG65-111 Model China). The extruder has a feeder at the top with variable manual feed rate, it also has a control panel board where the barrel temperature was set. The machine has constant screw speed of 150 rpm and a die diameter of 3 mm. The twin screw within the barrel is surrounded with heaters controlled at the control panel board. The temperature of the three zones of the extruder was controlled by Eurotherm controller and was read on the same control panel board. Each of the flour was reconstituted with 20 % of 500 g flour; the paste formed was fed into the extruder through the feed zone at 80 ºC for 150 rpm. Extruded samples were collected when the extrusion process parameters reached steady state - when there was no visible drift in torque and die pressure. Necessary calibration and adjustment of the barrel temperature of the extruder was performed prior to the main extrusion cooking process. The feed composition was varied at 90:10, 80:20, 50:50, 60:40, 70:30 and 100:0 ratio of OFSP and cassava starch extrudates, respectively. The resultant extrudate was dried at 70 ºC for 10 h in a cabinet dryer. The dried extrudate was crushed using a crusher; then milled.

Determination of Glycemic Index and Load

Acclimatization of animals (Albino mice)

The method as described by Wolever et al. (2008) was adopted for the test animals acclimatization. Eight-week-old female Albino mice were obtained from the Animal House of the Department of Pharmacology, Faculty of Pharmaceutical Sciences, Enugu State University of Science and Technology. The animals were fed with pelletized feed (Vital Feeds, Nigeria) and had access to water *ad libitum*. Housing of the animals was done in standard cages. The animals were allowed to acclimatize for 5 days before they were used for the study. All animal experiments were conducted in compliance with NIH Guide for the Care and Use of Laboratory Animals and were approved by the Enugu State University of Science and Technology Animal Ethics Committee protocol approval number ESUT/AEC/0186/AP107.

Experimental Protocol

Using the method as described by Abiche et al. (2019). The animals were fasted overnight before the test and their fasting blood glucose levels were measured (FBG). The test meal was given orally to the animals in each group. Glucose control group was also given glucose orally. Blood samples were taken by tail milking at 0, 15, 30, 45, 60, 90 and 120 minutes after test meals glucose administration and the blood glucose concentrations were determined using One-touch ultra-glucometer. Incremental area under the blood glucose curve was used to determine the glycemic index.

The general formula for calculating area under curve (AUC) is as follows:

At times t_0, $t_1 \ldots t_n$(equaling 0, 15 . . . 120 min, respectively), the blood glucose concentrations are G_0, $G_1 \ldots G_n$, respectively:

$$\text{UC} = \sum_{n}^{x=1} \text{AX}$$

Where Ax is the AUC for the Xth time interval, and the xth time interval is the interval between times t_{x-1} and t_x.

For the first time interval (i.e. x = 1):

If $G_1 > G_0$, $A_1 = (G_1 - G_0) \text{ x } (t_1 - t_0)/2$

Otherwise, $A_1 = 0$.

For other time intervals (i.e. x >1):

If $G_x > G_0$ and $G_{x-1} > G_0$, $Ax = (((G_x - G_0)/2) + (G_{x-1} - G_0)/2) \text{ x } (t_x - t_{x-1})/2$;

If $G_x > G_0$ and $G_{x-1} < G_0$, $Ax = ((G_x - G_0)^2/(Gx - Gx\text{-}1)) \text{ x } (t_x - t_{x-1})/2$

If $G_x < G_0$ and $G_{x-1} > G_0$, $Ax = ((G_{x-1} - G_0)^2/G_{x-1} - G_x)) \text{ x } (t_x - t_{x-1})/2$

If $G_x < G_0$ and $G_{x-1} < G_0$, $Ax = 0$

$$\text{Glycemic index (GI)} = \frac{\text{AUC of test food}}{\text{AUC of standard glucose}} \text{ x } 100$$

$$\text{Glycemic Load (GL)} = \frac{\text{GI x Available Carbohydrate}}{100}$$

Calibration of One Touch Glucometer

The one touch glucometer was calibrated each time a new batch of strip was to be used according to the producer's instruction manual. This was performed with each vial of test strips. The strip was inserted at the back of the meter and the code number was displayed which was the same as shown on each test strip of the batch.

Determination of Area under Curve (AUC)

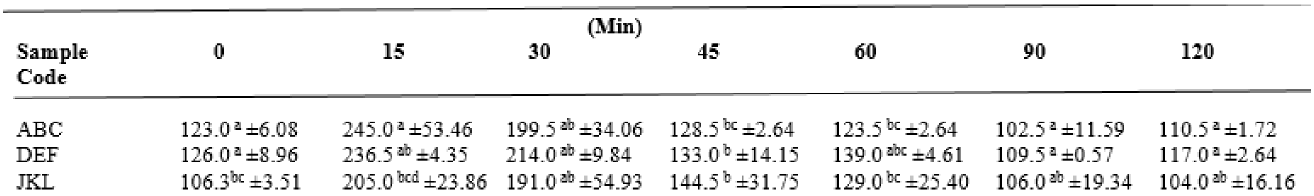
The area under curve was determined using trapezoid method of different time intervals (David, 2002). A plot of concentration against time was used for the calculation, AUCs Concentration 2 + conc, 2 x $(t_2 - t_1)$.

3. RESULTS

Variation of blood glucose concentration (mg/dl) of subjects after consumption of instant fufu powder; and Glycemic index and load of instant fufu powder blends (%)

The in-vivo blood glucose concentrations of albino mice fed with the formulated instant fufu powder blends as well as 100 % glucose estimated at 0, 15, 30, 45, 60, 90 and 120 minutes using the oral glucose tolerance test are shown in Table 1 while the glycemic index and load of instant fufu powder blends is shown in Table 2.The result revealed the relationship between the meals after consumption to the level of blood glucose concentration.

Table 1: Variation of blood glucose concentration (mg/dl) of subjects after consumption of instant fufu powder.



Sample Code	(Min)						
	0	15	30	45	60	90	120
ABC	$123.0^{a} \pm 6.08$	$245.0^{a} \pm 53.46$	$199.5^{ab} \pm 34.06$	$128.5^{bc} \pm 2.64$	$123.5^{bc} \pm 2.64$	$102.5^{a} \pm 11.59$	$110.5^{a} \pm 1.72$
DEF	$126.0^{a} \pm 8.96$	$236.5^{ab} \pm 4.35$	$214.0^{ab} \pm 9.84$	$133.0^{b} \pm 14.15$	$139.0^{abc} \pm 4.61$	$109.5^{a} \pm 0.57$	$117.0^{a} \pm 2.64$
JKL	$106.3^{bc} \pm 3.51$	$205.0^{bcd} \pm 23.86$	$191.0^{ab} \pm 54.93$	$144.5^{b} \pm 31.75$	$129.0^{bc} \pm 25.40$	$106.0^{ab} \pm 19.34$	$104.0^{ab} \pm 16.16$
MNO	$76.0^{d} \pm 5.77$	$152.0^{d} \pm 4.00$	$191.3^{ab} \pm 23.50$	$150.6^{b} \pm 52.00$	$144.0^{ab} \pm 25.40$	$96.0^{ab} \pm 13.85$	$85.0^{bc} \pm 5.77$
STU	$92.0^{c} \pm 9.23$	$183.5^{bcd} \pm 19.05$	$177.5^{ab} \pm 39.83$	$113.5^{b} \pm 11.15$	$109.5^{bc} \pm 4.04$	$93.5^{ab} \pm 0.57$	$85.0^{bc} \pm 2.30$
YZ*	$70.5^{e} \pm 11.23$	$168.5^{abc} \pm 47.79$	$183.5^{b} \pm 22.36$	$138.0^{b} \pm 37.16$	$118.5^{bc} \pm 32.92$	$83.0^{b} \pm 26.55$	$90.5^{cd} \pm 10.26$
Glucose	$64.5^{de} \pm 8.66$	$215.0^{abc} \pm 46.70$	$163.0^{b} \pm 20.78$	$128.0^{b} \pm 34.64$	$120.0^{bc} \pm 32.33$	$82.0^{b} \pm 26.55$	$66.0^{cd} \pm 10.40$

Values are means ± std. values across the column with different superscripts are insignificantly different ($p>0.05$).

ABC = 90 g OFSP extrudate: 10 g CS extrudate

DEF = 80 g OFSP extrudate: 20 g CS extrudate

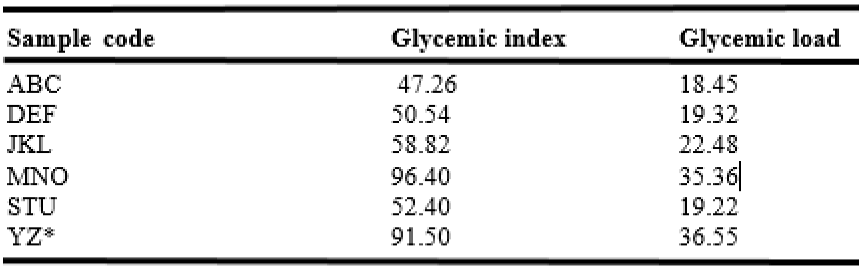
JKL = 50 g OFSP extrudate: 50 g CS extrudate

MNO = 60 g OFSP extrudate: 40 g CS extrudate

STU = 70 g OFSP extrudate: 30 g CS extrudate

YZ* = 100 g OFSP extrudate: 0 g CS extrudate

Table 2: Glycemic index and load of instant fufu powder blends (%)



Sample code	Glycemic index	Glycemic load
ABC	47.26	18.45
DEF	50.54	19.32
JKL	58.82	22.48
MNO	96.40	35.36
STU	52.40	19.22
YZ*	91.50	36.55

ABC = 90 g OFSP extrudate: 10 g CS extrudate

DEF = 80 g OFSP extrudate: 20 g CS extrudate

JKL = 50 g OFSP extrudate: 50 g CS extrudate

MNO = 60 g OFSP extrudate: 40 g CS extrudate

STU = 70 g OFSP extrudate: 30 g CS extrudate

YZ* = 100 g OFSP extrudate: 0 g CS extrudate

4. DISCUSSION

The results of Table 1 revealed the time interval between 0 to 120 min of consuming samples by the subjects (albino mice). There was sharp increase from 123.00 to 245 mg/dL (6.83 to 13.61 mml/L) between 0 to 15 min in the level of the blood glucose; though there was reduction in the blood glucose level of the experimental animals from 30 to 60 min and sharp reduction at 90 min to 120 min in group ABC (90:10). The group fed with sample DEF (80:20) recorded similar occurrence; where sharp increase was observed in the blood glucose level of 126.33 to 236.50 mg/dL (7.02 to 13.14 mmol/L) within the first 15 min of sample consumption. There was sharp reduction at 45 min and slowly increased to 139.0mg/dL (7.72 mmol/L) at 60 min. The blood glucose concentration of the group 3 rats containing sample JKL (50:50) started from 106.33 to 205.0 mg/dL (5.90 to 11.40 mml/L) in the first 15 min after administering the samples and afterwards there was a reduction from 191.33 to 104.00 mg/dL (10.63 to 5.78 mmol/L) at 30 to 120 min.

The blood glucose level of the group of rats fed with MNO (60:40) rose from 76.00 to 152.00 mg/dL in the early min (0 to 15). At 30 to 120 min, there was gradual decrease in the glucose level with 120 min having the least blood sugar level (85.00 mg/dL) while the highest value was recorded at 30 min (191.0 mg/dL). Sample STU 70:30, and YZ* (100:0) had similar records with other samples. These observations are in consonance with the findings of Nyangono *et al*. (2022) who reported gradual decrease in the blood glucose level 63.5 to 130.00 mg/dL of rats fed with tapioca-finger millet-soy cake composite flour meal after 30 min. These variations and reductions may be due to the low metabolizing rate of the glucose in the rats. This connotes that the low blood glucose concentration cannot be experienced in the body system Nyangono *et al.* (2022). The relatively high blood glucose decreasing properties of these experimental samples could also be attributed to the hydrolysis of starch into amylose and amylopectin. Jenkins *et a*l. (2001) reported also that high fibre foods have been shown to have low glycemic index and are slowly digested.

Table 2 shows the percentage glycemic index of instant fufu powder blends from OFSP and cassava starch extrudates. The glycemic index of the instant fufu powder blends ranged from 47.26 to 96.40 %. The highest and lowest values were recorded in sample (MNO) 60:40 and (ABC) 90:10, respectively. The result from the glycemic indices showed a significant differences among all the samples. This supports the contribution made by Taiwo (2006) that starch-based foods are easily digestible and are regarded as the most important domestic food products. The results obtained in this study agreed with the reported values 78.67 to 92.36 % by Ogbuji and David-Chukwu (2016) for glycemic indices of different cassava food products. It was also observed that the values recorded in this study are higher than the reported values 4.17 to 18.18 % by Nyangono *et al.* (2022) for glycemic index of some Cameroonian Local Meals. Glycemic index is a measure providing details on the biological response following the ingestion of carbohydrates. (Nyanogo *et al.*, 2022). The variation in the glycemic index of foods is dependent on the quality and quantity of meal ingredient or composition (Pucheu, 2005). Foods rich in proteins, lipids, water, carbohydrates, mineral salts, and fibres would influence the kinetics of glycemic index. Thus, the more carbohydrate a meal has, the more its glycemic index tends to increase (Nyangono *et al.*, 2022).

Based on standard as stated by Nyanogo et al. (2022), the glycemic index of all the selected components varied from medium to very high when compared to the standard (white bread/glycose food) value which is GI < 55. Overall, out of six meals tested in this study, three had GIs < 55; one had relatively high GI > 55 and two had very high values GI > 55. High Gi is an indication of increased post prandial blood glucose which is undesirable while low GI is better in a diet/meal.

The GI of this study is consistent with the findings of Mendosa (2008). However, GI values of this study of extrudate blends slightly varied from the previous studies conducted by Allen et al (2012); this may be due to different portion of foods. The variation of GI values of the extrudae blends may further be due to cultivar, grown location, sugar contents and extrusion cooking (Allen et al., 2012).

By standard, GL values ranged from 0 to 100 and can be classified as follows:

Low GL: 0-10

Moderate GL: 11-19

High GL: 20 - above

A low GL diet is one that seeks to minimize blood sugar spikes by consuming foods with low GL values as in the case of sample blends ABC, STU and DEF, respectively. This types of diet works by limiting the amount of quickly-digested carbohydrates that are consumed while emphasizing the consumption of slow-digested carbohydrates. On the other hand, sample blends JKL, MNO and YZ* were significantly higher than the recommended values.

5. CONCLUSION

The GI and GL of all the selected components varied from low to very high when compared to the standard (Glucose food). Overall, out of six meals tested in the study, three had GI, and GL; < 55 and 20; one had relatively high GI, and GL > 55 and 20, and two had very high values GI and GL > 55 and 20, respectively. This gives a better appreciation of the quality of meals from OFSP and CS extrudates with sample ratio 90:10 having the least GI and GL, respectively. High GI is an indication of increase post prandial blood glucose which is undesirable while low GI is better in a diet. However, people suffering from diabetes mellitus should therefore consume these foods in moderation.

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