Development and Evaluation of Biscuits made from Cassava-Sorghum-Soybean Composite Flour to Combat Acute Malnutrition in Children

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ABSTRACT

Background: *Biscuit is widely consumed by children as a popular snack across various socioeconomic classes. Due to its widespread acceptance and frequent consumption, it could serve as a suitable vehicle for food nutrients thereby helping to alleviate acute malnutrition in children.*

Objective: *The study developed and evaluated biscuits made from cassava-sorghum-soybean composite flour and assessed its potentialin combating acute malnutrition in children.*

Methods: *Cassava, sorghum and soybeanwere processed into flours and combined in different proportions of 50:40:10 (CSB), 50:30:20 (CTB), and 50:20:30 (CUB) to obtain composite flours.Biscuits were made from the composite flour andanalyzed for nutrient composition and acceptability using standard methods. Biscuit made from 100% wheat flour was used as control (WB).The data obtained were analyzed using SPSS, version 23 and significance was accepted at $p < 0.05$.*

Results: *The biscuit samples made with composite flours were significantly ($p < 0.05$) higher in protein (17.67-18.1%) and energy (14145.3-15165.3 KJ·kg^{-1}) compared to the control (9.7% and 13644.0 KJ·kg^{-1},respectively). They (CSB, CTB and CUB) had high amounts of calcium and iron, with appreciable amount of fibre, thiamine and riboflavin. The sensory scores of CSB, CTB and CUB were comparable to that of the control (WB). Sample CUB had the highest protein (18.1%), crude fibre (6.0%) and iron (3.62 mg) content and ranked highest in general acceptability. Its (CUB) protein content increased by 46.40% when compared to the protein content of the control (WB).One medium packet (40 g) of CUB contributed 51.7% and 34.8% of daily protein requirements of children aged 4-6 years and 7-10 years, respectively.*

Conclusion: *Cassava-sorghum-soybean composite flour could be used to produce protein and energy-dense biscuits with acceptable sensory properties, offering a cost-effective and nutritionally superior alternative to wheat flour biscuit.*

Keywords: *Biscuit, composite flour, soybean, cassava, sorghum, acute malnutrition*

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INTRODUCTION

Acute malnutrition is still a major public health problem among children in Africa and other developing countries and is associated with high mortality and a myriad of morbidities (1, 2). Acute malnutrition is prevalent in many parts of Africa partly because animal protein is too expensive for most populations (3). It is shown to be more common among the low socioeconomic households, and strategies beyond the health care setting have potential of significantly reducing its associated morbidity and mortality in Nigeria (2). Biscuits could be suitable vehicles for fortification and delivering proteins and energy to prevent and alleviate acute malnutrition in children because biscuits are ready-to-eat, convenient, popular food with long shelf-life and relatively inexpensive.Biscuit

is one of the most commonly consumed cereal food products, widely consumed by children and sometimes by adults as snacks or breakfast cereals (usually with beverage drink).

Wheat flour is commonly used in bakingbecause when mixed with water, it forms unique visco-elastic dough (4). Wheat cannot grow well under tropical climate; hence, Nigeria over the years has beendependent on wheat importation with its detrimental effect oneconomy of the nation, bakery industries and consumers (5). Consequently, substitution of wheat flour with composite flours made from major food crops that are grown in Nigeria is currently receiving attention in food industries (6). Studies have shown that use of composite flour improves the nutrient content of baked products (7, 8). The use of composite flours in baking has the added advantage of increasing utilizationof indigenous crops, thereby adding value to the crops and making baked products cheaper and more affordable to consumers, thereby contributing to food security of the people.

Cassava(*Manihot esculenta*) is a major staple crop in Nigeria and its products are found in the daily meals of Nigerians as a cheap source of edible carbohydrate (9). Cassava is drought-tolerant and does well in poor soils and low rainfall, and is a perennial crop that can be harvested as required; hence, it plays important role in agriculture in developing countries, especially in Sub-Saharan Africa (10).Sorghum (*Sorghum bicolor*) is one of the main crops produced in Nigeria. Nigeria is among the main producers of sorghum worldwide (11). Sorghum, like other cereals, is an excellent source of carbohydrate and is high in fibre, B group vitamins and iron, and consists of 10% protein. It is a gluten-free cereal which has significance in celiac disease (also referred to as gluten intolerance), an immunological response to the protein gluten found in wheat.

Soybean (*Glycine max*) is among the major industrial and food crops grown in every continent. It is the most important legume worldwide and is grown for its protein and oil rich seeds (12). The crop can be successfully grown in many states in Nigeria using low agricultural input. Soybean has an average protein content of 40% and is more protein-rich than any of the common vegetable food sources found in Nigeria (13). It also contains 30% carbohydrates and excellent amounts of dietary fibre, vitamins and minerals. Many leguminous crops provide some protein, but soybean is the only available crop that provides an inexpensive, high quality protein comparable to meat and egg (3). It isabundantly rich in essential amino-acids lysine and tryptophan thatare deficient in most cereal grains (14, 15). Soybean is therefore, a veritable food for prevention of malnutrition, particularly protein deficiency.

The thrust of this study was to investigate the potential of cassava-sorghum-soybean flour in biscuit production and evaluate the nutrient composition, acceptability and adequacy of the biscuits to protein and energy requirements of children aged 4-10years. It is hoped that the findings of this research will promote utilization of these local crops in production of cheaper and protein-energy densebiscuit that will help to prevent and ameliorate acute malnutrition in children.

MATERIALS AND METHODS

Procurement of samples

Wheat flour (all purpose), soybeans (*Glycine max*), sorghum (*Sorghum bicolor*), sugar, shortening, powdered milk, baking powder, and fresh eggs used for biscuit production were purchased from Ogige Market Nsukka. Freshly harvested mature cassava (*Manihot esculenta*) tubers were obtained from a private farm in Agbani Nsukka, all in Enugu State, Nigeria.

Food Sample Preparation

The cassava tubers were washed with tap water to remove dirt and sand particles from their surfaces prior to peeling. They were washed again after peeling, cut into pieces and soaked in clean water to ferment for three days. They were thereafter, sun dried for 96h (during dry season) and milled into flour using Attrition Mill (Globe P 44, China). Sorghum was sorted and cleaned manually to remove foreign materials and dirt. It was thereafter washed, sun dried for 72h and milled into fine flour using the Attrition Mill. The soybean flour was prepared according to the method described by Ihekoronye and Ngoddy (16). Soybeans were sorted to remove spoilt ones and foreign particles, then washed and soaked in tap water for 8h. The seeds were then drained, dehulled manually, boiled for 30min and sun dried for 96h. The dried seeds were milled into flour. All the flours were sieved through a 40mm mesh sieve and packaged in air tight containers.

Formulation of composite flours

Cassava-sorghum-soybean composite flours were formulated in the ratio of 50:40:10 (CSB), 50:30:20 (CTB) and 50:20:30 (CUB), respectively. The composite flours were produced by mixing cassava flour, sorghum flour and soybean flour together using a Heavy Duty universal spiral mixer at 450rpm for 20min when uniform blends were obtained. The

control sample was 100% wheat flour.

Production of Biscuit Samples

The production of biscuit samples was carried out in Dietary Laboratory of Department of Nutrition and Dietetics, University of Nigeria, Nsukka (UNN). The three formulated composite flours and wheat flour used as the control were incorporated into standardized recipe from preliminary experiment to produce four samples of biscuits following standard method. All the ingredients were accurately weighed. The shortening and sugar were creamed together in a large bowl until light and fluffy before each composite flour, milk and baking powder were added. The eggs were whisked and added to the flour mixture and mixed thoroughly until uniform dough was formed. The dough was rolled on a flat smooth wooden board and kneaded to get an evenly spread sheet. With a manual biscuit cutter, the sheet was cut into the same shape and size and baked in a pre-heated oven at 140°C for 30min when they became light brown in colour. After baking, the biscuits were allowed to cool at room temperature (25°C) for 30 min. The biscuits were then stored in labelled airtight plastic containers until further analysis.

Proximate Analysis

The proximate composition of the biscuit samples was analyzed using official methods of Association of Analytical Chemists (17). Moisture contents were determined by hot air oven method. The ash contents of the samples were determined by charring 2g of the sample in a preheated cooled crucible and incinerating it at 600°C for 6h in ash muffle furnace to obtain the ash. The crude fibre contents of the samples were determined by exhaustive extraction of soluble substances in the samples using H_2SO_4 and NaOH, after which the residue wasashed and the losses in weight recorded as crude fibre. The protein contents of the samples were determined using micro-Kjeldahl method, while fat contents were determined using Soxhlet extraction.Total carbohydrate contents of the samples were determined by difference.

Mineral And Vitamin Determination

Calcium, zinc and iron contents of the biscuit samples were analyzed using atomic absorption spectroscopy in line with AOAC (17). Thiamine and riboflavin contents of the samples were also determined using the method of AOAC (17).

Sensory Evaluation

Sensory evaluation of the biscuits was conducted using 9-point Hedonic scale (16). Thirty panelists (mothers)consisting of twenty-two staff and eight final year students of Department of Nutrition and Dietetics, UNN wereselected based on their experience through participation in previous studies and their willingness to participate in this study. The biscuit samples were evaluated for colour, taste, flavour, texture and general acceptability. The samples were coded and placed in flat plates on plain white background. A glass of water was provided for them to rinse their mouth after each evaluation to avoid carry-over effect.

Statistical analysis

The data obtained were analyzed using Statistical Product for Service Solution, version 22. The results were presented in mean and standard deviation. The means were separated using Duncan's new multiple range test at $p<0.05$.

RESULTS

The carbohydrate contents of the biscuits made with the composite flours ranged from 54.34 - 58.41% as (Table 1). The composite flour biscuits (CSB, CTB and CUB) had significantly ($p < 0.05$) higher protein content (17.67 - 18.04%) than the control (9.67%). The fat contentCSB, CTB and CUB ranged from 5.56 - 6.34% and was significantly higher than that of the control (2.02%).The energy content of CSB, CTB and CUB ranged from 1414.53 - 1516.53 KJ/100g which was significantly higher than that of control (1364.40 KJ/100g). The crude fibre and moisture content of CSB, CTB and CUB ranged from 5.54 - 6.00%and 9.76 - 12.19%, respectively.

Table 2 presents the percentage contribution of the biscuit samples to the protein requirement of children aged 4 -10 years. Forty grams of the composite biscuit samples (CSB, CTB and CUB) contained 7.07, 7.18, and 7.22g of protein, respectively. This quantity (40 g) of CSB, CTB and CUB contributed 49.15 - 53.17%, and 33.96 - 35.20% average protein requirements of children aged 4 - 6 years and 7 - 10 years, respectively. This was higher than the protein content supplied by WB.

The energy (KJ) content of 40 g biscuit samples and their contribution to average daily energy requirements of children 4 – 10 years are shown in Table 3. It revealed that 40 g of composite biscuits would contribute 9.21 - 10.76% of energy requirements of children aged 4 - 6 years and 7.02 - 7.80% for children aged 7 - 10 years. It was also observed that the energy contents of the composite flour biscuits increased above that of control by 3.54 - 10.03% (Table 3).

Samples CSB, CTB and CUB had significantly ($p < 0.05$) higher calcium contents (ranging from 100.00 - 115.20 mg/100g) than the control (64.00

Table 1: Proximate (%) and energy (KJ/100g) composition of the biscuit samples

Samples	Moisture	Protein	Fat	Crude fibre	Ash	Carbohydrate	Energy
WB	7.06±0.06^{a}	9.67±028^{a}	2.02±1.14^{a}	11.94±0.08^{c}	2.00±0.08^{a}	67. 31±0.54^{c}	1364.40^{a}
CSB	13.99±1.75^{c}	17.67±0.22^{b}	5.56±0.08^{b}	5.54±0.48^{a}	2.90±0.00^{b}	54.34±0.01^{a}	1414.53^{b}
CTB	9.76±0.06^{b}	17.94±0.62^{b}	6.34±0.64^{b}	5.63±0.40^{a}	1.92±0.03^{a}	58.41±0.35^{b}	1516.53^{c}
CUB	12.19±0.61^{bc}	18.05±0.22^{b}	6.14±0.75^{b}	6.00±0.14^{b}	2.85±0.07^{b}	54.77±2.93^{a}	1449.92^{b}

Values are mean ± SD of triplicate determinations. Values on the same column with different superscript are significantly different ($p<0.05$)

WB= 100% wheat flour biscuit
CSB= 50% cassava flour, 40% sorghum flour and 10% soybean flour biscuit
CTB= 50% cassava flour, 30% sorghum flour and 20% soybean flour biscuit
CUB= 50% cassava flour, 20% sorghum flour and 30% soybean flour biscuit

Table 2: Biscuit samples and their contribution to daily protein requirements for children

Samples	Protein content (g/100g)	Protein content (g/40g)	% increase in protein	% contribution to daily protein requirements (4–6 years)		(7–10 years)	
				Boys	Girls	Boys	Girls
WB	9.67	3.868		26.90	28.48	18.86	18.59
CSB	17.67	7.068	45.3	49.15	52.04	34.46	33.96
CTB	17.94	7.176	46.1	49.99	52.93	35.05	34.54
CUB	18.05	7.220	46.4	50.21	53.17	35.20	34.69

The percentage (%) contributions were calculated using the average protein requirement of 0.73g/kg/day for children aged 4–10 years. Specifically, this equates to 14.38g and 13.58g for body weights of 19.7kg for boys and 18.6kg for girls aged 4–6 years, and 20.51g and 20.81g for body weights of 28.1kg and 28.5kg for boys and girls aged 7–10 years, respectively (30, 31).

WB= 100% wheat flour biscuit
CSB= 50% cassava flour, 40% sorghum flour and 10% soybean flour biscuit
CTB= 50% cassava flour, 30% sorghum flour and 20% soybean flour biscuit
CUB= 50% cassava flour, 20% sorghum flour and 30% soybean flour biscuit

Table 3: Biscuit samples and their contribution to daily energy requirements of children

Samples	Energy (KJ/100g)	Energy (KJ/40g)	% increase in energy	% contribution to daily energy requirements (4 – 6 years)		(7 – 10 years)	
				Boys	Girls	Boys	Girls
WB	1364.40	545.76		8.88	9.65	6.77	7.01
CSB	1414.53	565.81	3.54	9.21	10.01	7.02	7.27
CTB	1516.53	606.61	10.03	9.87	10.73	7.52	7.80
CUB	1449.92	579.97	5.90	9.44	10.26	7.19	7.45

The percentage [%] contributions were calculated using the following energy intake values: 312KJ/kg/d (6146.40KJ) for boys aged 4-6 years with a body weight of 19.7 kg; 273KJ/kg/d (7780.5KJ) for boys aged 7-10 years with a body weight of 28.1 kg; 304KJ/kg/d (5654.4KJ) for girls aged 4-6 years with a body weight of 18.6 kg, and 273KJ/kg/d (7780.5KJ) for girls aged 7-10 years with a body weight of 28.5 kg (32).

WB= 100% wheat flour biscuit
CSB= 50% cassava flour, 40% sorghum flour and 10% soybean flour biscuit
CTB= 50% cassava flour, 30% sorghum flour and 20% soybean flour biscuit
CUB= 50% cassava flour, 20% sorghum flour and 30% soybean flour biscuit

Table 4: Micronutrient composition (mg/100g) of the biscuit samples

Samples	Calcium	Zinc	Iron	Thiamine	Riboflavin
WB	64.00±1.41^{a}	3.20±0.11^{b}	2.65±0.08^{b}	0.28±0.01^{b}	0.17±0.03^{c}
CSB	115.00±7.07^{b}	0.81±0.05^{a}	1.52±0.01^{a}	0.11±0.00^{a}	0.11±0.01^{b}
CTB	115.20±7.00^{b}	0.77±0.00^{a}	3.03±0.08^{c}	0.10±0.00^{a}	0.03±0.01^{a}
CUB	100.00±5.66^{b}	0.87±0.04^{a}	3.62±0.02^{d}	0.20±0.00^{a}	0.05±0.00^{a}

Values are means ± SD of triplicate determinations. Values on the same column with different superscript are significantly different at $P < 0.05$.

WB= 100% wheat flour biscuit
CSB= 50% cassava flour, 40% sorghum flour and 10% soybean flour biscuit
CTB= 50% cassava flour, 30% sorghum flour and 20% soybean flour biscuit
CUB= 50% cassava flour, 20% sorghum flour and 30% soybean flour biscuit

Table 5: Sensory evaluation scores of the biscuit samples

Samples	Colour	Taste	Flavour	Texture	General acceptability
WB	8.16±1.07^{b}	7.08±1.63^{b}	7.70±0.97^{b}	7.76±1.23^{b}	7.58±2.05^{c}
CSB	7.10±1.16^{a}	6.45±1.52^{a}	6.65±1.53^{a}	6.75±1.74^{a}	6.25±1.92^{a}
CTB	6.85±1.46^{a}	6.50±2.01^{a}	6.85±1.63^{a}	6.45±2.28^{a}	6.90±2.07^{b}
CUB	7.60±1.05^{ab}	6.80±1.52 ^{ab}	7.00±1.08^{ab}	7.25±1.48^{ab}	6.92±1.94^{b}

Values are means ± SD of scores of 30 panelists. Values on the same column with different superscript are significantly different at $P<0.05$.

WB= 100% wheat flour biscuit
CSB= 50% cassava flour, 40% sorghum flour and 10% soybean flour biscuit
CTB= 50% cassava flour, 30% sorghum flour and 20% soybean flour biscuit
CUB= 50% cassava flour, 20% sorghum flour and 30% soybean flour biscuit

mg/100g).The zinc contents of CSB, CTB and CUB ranged from 0.77 - 0.80 mg/100g with CUB ranking highest. It was also observed that the iron content of CSB, CTB and CUB ranged from 1.52 - 3.62 mg/100g while the thiamine content ranged from 0.10 - 0.20 mg/100gwhich was significantly lower than the thiamin content of WB (Table 4).
The sensory evaluation scores (Table 5) revealed that all the biscuit samples were ranked above 5 points on the 9 point Hedonic scale for all the sensory properties. The general acceptability scores ranged from 6.25 - 6.92.Among the three composite flour samples (CSB, CTB and CUB), CUB ranked highest in all the parameters and was ratedsecondafter the control

DISCUSSION

The high carbohydrate content of the biscuits made with the composite flours could be attributed to the carbohydrate content of cassava and sorghum which made up for the lower carbohydrate content of soybean.Thepattern of change in carbohydrate content with addition of sorghum in the present study disagrees with an earlier report which revealed progressive decrease in carbohydrate content with addition of sorghum flour (*18*).The protein contents of the biscuits increased with increase in quantity of soybean flour. The higher protein contents of the biscuits made with composite flours and the progressive increase in protein contents of the biscuits with increase in quantity of soybean were attributed to high protein content of soybeans. It had been shown that soybean has an average protein content of 40% and is more protein-rich than any of the common vegetable food sources found in Nigeria(13). The increase in protein content with increase in soybean flour agreed with earlier reports (*18-20*) and confirmed earlier observationthat addition of soy-flourin baking serves a complementarypurpose in increasing the protein content of the baked product (*18*).Addition of soy flour in baking also provides thelimiting amino acids (lysine and tryptophan) in cereals.
The fat contents of the biscuits also increased with the addition of soybean flour, this could be due to the

high fat content of soybean. Soybean contains about 20% oil on dry matter basis (13). As expected the energy content of the biscuits increased with addition of soyabean flour.Soybean contains about 20% oil (on dry matter basis) which is 85% unsaturated and cholesterol-free (13).Soybean contained biscuits may provide additional benefits for adults due to theiranticholesterolemic properties and reduced allergenicity. Soy protein reduces blood cholesterol concentration by enhancing excretion of faecal steroids (21). In addition, isoflavones contained in soybeans are effective cancer-preventive agents for lowering risks of various cancers; its phytoestrogen is involved in prevention of osteoporosis and neovascularization in ocular conditions (22).

The crude fibre contentof CSB, CTB and CUB were much higher than the range (0.24-0.94%) found in cookies made with maize and soybean composite flour(*18*) and 0.18-1.53% found in biscuit made with wheat and bambaranut composite flour (23), but similar to 3.16-5.10% found in wheat and potato composite flour biscuit (24).Fibre has a lot of health benefits ranging from prevention of constipation often associated with consumption of refined grain products to lowering of blood cholesterol and thus lowering risk of cardio-vascular diseases (21).The high ash contents of the composite biscuits (1.92–2.90%) agreed with an earlier report that composite flour-based food products are high in ash (25). Ash content of food, which is said to be high when it is more than 1%, is an indication of mineral constituents of the food because ash is the inorganic residue remaining after water and organic matter have been removed by heating in the presence of an oxidizing agent (26).

The moisture contents of biscuits made with composite flours were significantly higher than that of the control. Thiswas at variance with earlier reports of decrease in moisture content with increase in soy-flouraddition (18, 20). The moisture contents of all the biscuit samples were however, within the acceptable moisture level (not exceeding 14%) of cookies.The protein contents of the composite flour biscuits increased by 45.3–46.4% of the protein content of the wheat biscuit. Soybean is an inexpensivesource of high-quality protein comparable to meat and egg (3,13,15); hence, soybean supplementedbiscuits would be of nutritional importance in developing countries such as Nigeria where many people cannot afford animal foods due to theirhigh cost, and this supplementation with soybean would go a long way in ameliorating malnutrition in children who are the main consumers of biscuits.Inadequate nutrient intake in childhood is known to result in failure to gain weight and height which are associated with impaired immune defense and increased morbidity and mortality from infections.

The energy content of CSB, CTB and CUB was higher than that of control. High energy intake is very important for children to prevent diversion of protein to provide energy, sparing protein for body building and repairing body tissues (27). The increase in protein and energy contents of the biscuits with addition of soybean showed that biscuit made with soybean composite flour is a veritable food for prevention of acute malnutrition in children.The significantly higher calcium contents of the composite flour biscuits compared to wheat flour biscuit was in agreement with that of biscuit made with wheat-sweet potato composite flour earlier reported (24). The calcium contents found in this present study were higher than the values found in wheat-plantain-breadfruit-termite composite flour biscuits (6). A lasting effect of calcium intake during childhood and adolescence on bone mineral density and reduction in the risk of fractures at old age has been reported (28).

The zinc contents of the composite flour biscuits were significantly lower than that of wheat biscuit (3.20mg/100g) but higher than those found in wheat, yellow maize, beniseed composite flour biscuits (29). The lower zinc value of the composite flour biscuits was similar to those found in wheat-plantain-breadfruit-termite composite flour biscuits (6) and wheat, yellow maize, beniseed composite flour biscuit (29) but was at variance with higher zinc value found in biscuit made with maize-soybean composite flour (*18*).There was significantly lower iron content in the biscuit made with 10% soybean flour and progressive increase in iron with addition of soybean flour. Thiscould be attributed to low content of iron in cassava and sorghum and it showed that addition of iron-rich food such as soybean is required to make up for the deficit. These results agreed with earlier report of higher iron content of biscuit with addition of soybean in malted sorghum-soybean composite flour (8).The thiamine content of the biscuits made with the composite flour were lower than values found in some earlier studies of biscuits made with composite flours (6, 29) but the lower thiamine value of the composite flour biscuits compared to the wheat biscuit was in agreement with that found in a previous study (29). The riboflavin contents of the composite flour biscuits ranged from 0.03-0.11mg/100g and were significantly lower than 0.17mg/100g found in wheat biscuit. These values were lower than values (0.20-0.27mg/100g) reported in wheat-maize-

beniseed composite flour biscuit (29).
The biscuit samples were ranked above 5points on the 9pointHedonic scale for all the sensory properties with the general acceptability scores ranging from 6.25-6.92. These results were in line with results of some earlier studies on biscuits made with composite flours (6, 23, 29). The control had the highest ratings on all the parameters and this agreed with previous studies(6, 23). The uniqueness of wheat flour in biscuitproduction is attributed to its gluten proteins, which forms elastic dough during baking and gives highorganoleptic quality to the finished products (16).The biscuit made with cassava-sorghum-soybean at 50:20:30 ratio ranked highest in all the parameters and was closest to the wheat flour biscuit. The results indicate that addition of soybeans to composite flours improved the sensory properties of biscuits.

CONCLUSION

The composite flour biscuit samples were high in macronutrients, energy, calcium and iron, and contained appreciable amounts of fibre, thiamine and riboflavin. The study had shown that cassava-sorghum-soybean composite flour could be used to produce protein and energy-dense biscuits with good sensory properties as a cheaper alternative to 100% wheat flour biscuit and a veritable food for prevention of acute malnutrition in children. Incorporation of soybeanflour in composite flour serves a complementarypurpose of increasing nutrient density of baked products.

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