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Effect of Different Particle Sizes on The Akara Making Potentials of Pigeon Pea Flour

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***ABSTRACT* - The study evaluated the potentials of Pigeon pea (*Cajanus cajan*) flour in the production of akara (fried cake). The flour samples were produced by soaking the seeds in water, dehulled, oven dried and ground to flour and divided into 4 units. The flour was passed through sieve of different size while the control was not sieved. Physicochemical and sensory analyses were conducted for the flour and *akara* using standard methods and results were presented as mean ± standard deviation using ANOVA. Significance was accepted for p≤0.05 by Duncan multiple range test. Result of functional properties showed that the sieved pigeon pea bulk density, emulsion capacity and foam capacity increased with increase sieve aperture in the range 0.73 to 0.81(g/mg), 43.08 to 46.66, and 44.35 to 46.14 respectively, while wettability (1.53 to 1.88) and gelation capacity (11.10 to 11.17) decreased. The results of the proximate composition of the *akara* showed values for pigeon pea and cowpea flours in moisture content, ash, fibre, protein and carbohydrates. The Sensory evaluation results showed that all the sensory parameters evaluated increased with decreased sieve aperture and differed significantly with respect to overall acceptability.**

Keywords: **proximate analysis, sensory, quality, cowpea.**

I. INTRODUCTION

Akara is one of Nigerian's national treasures prepared from cowpea (Vigna unguiculata), grated onions, pepper, and salt and deep- fried in groundnut oil. It is a very popular snack that can be eaten anytime of the day. Although akara is a popular breakfast meal, it can also be taken with pap (ogi), custard or agidi (eko) as a light dinner [1]. Originally from West Africa, akara which is now regarded as one of Nigerian's and Brazil's national treasures [1], is a cultural and tourism icon in Salvador (Bahia, Brazil) and is sold in the streets by typically clothed women called Baianas de acaraje. The dish is prepared with several varieties of cowpea (Vigna unguiculata L. Walp) such as Fradinho, Macassara, Olhode Pombo, Costela de Vaca and Bocarpreta [2]. To prepare akara, the beans are split, decorticated and macerated into paste. After being seasoned with grated onions and salt, this paste is whipped, shaped into balls with a spoon and deep- fried in groundnut oil [3]. Therefore, this work was to assess the effect of production method (different particle sizes) on the chemical, functional as well as the sensory evaluation of "*akara*" from pigeon pea (*Cajanus cajan*). The outcome of this research will help popularize pigeon pea and also stabilize its wide acceptance.

II. MATERIALS AND METHODS

A. Sample Procurement

The raw materials used were seeds of Vigna unguiculata (L.) Walp (Cowpea), which is popularly known as beans and Pigeon pea

(*Cajanus cajan)*, (locally called fio-fio) used for this study were obtained from Ogbete main Market in Enugu State Nigeria, while the cowpea (*Vigna unguiculata* (L.) Walp) was bought from Ahia Eke in Umuahia, Abia State. All reagents used were of analytical grade and research was conducted at Food and Analytical Laboratories of Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Nigeria.

B. Preparation of Akara

Production of Pigeon pea flour

A thousand gram of pigeon pea seeds was cleaned and soaked in one hundred and fifty centilitres (150 cl) of clean water for twenty four (24h) hours. The soaking water was changed at six hours intervals to avoid fermentation of the product. The seeds were then manually dehulled after 24h of soaking by rubbing between palms and dried in the oven at 1000C until a constant weight was gotten through intermittent weighing. The dried seeds were milled into flour and passed through sieve apertures of 0.5mm, 1mm, and 2mm.

Production of Cowpea Flour

The cowpea seed was sorted to remove stone and unhealthy seeds. One thousand five hundred cleaned seeds were weighed and soaked in one hundred and fifty centilitres of water for five minutes. They were dehulled by rubbing between palms and oven dried at 60^{O}C to a constant weight. The dried seeds were milled into flour.

Processing of Akara from Pigeon pea and Cowpea fours

The method described by [1] was adopted for the akara preparation with slight modifications. Seven hundred and fifty millilitres of water was added to the five hundred grams of cowpea /or pigeon pea flour in a mortar and was whipped until fluffy. It was allowed to stand for ten minutes for the flour to absorb water. One and half litres of vegetable oil were heated to 190^{o}C. To five hundred grams portion of the whipped paste was added one hundred and twenty grams of sliced onions, sixty grams of sliced fresh pepper, and 30 grams of salt and mixed gently. The mixture was dispersed with a table spoon into the hot vegetable oil. Both sides were fried until golden brown colour was obtained which took about 6 minutes over a moderate heat. It was removed from the oil with a perforated spoon and further drained in a colander. The recipe was *akara* is presented in Table 1.

Table 1: Recipe for Akara (Fried cake)

INGREDIENTS	QUANTITY
Cowpea flour/paste	500g
Onions (sliced)	120g
Fresh pepper	60g
Salt	30g
Water	750ml
Vegetable oil for frying	1.5litres

C. Chemical Analysis of samples

Functional Properties

The method described by [4] was used for the determination of bulk density, foam capacity and stability/ whippability, emulsification capacity, wettability and gelatinization temperature.

Proximate Composition

The moisture, ash, crude fibre, crude fat, and crude protein of the samples were determined according to the method described by [4]; while carbohydrate was determined by difference.

Sensory Evaluation

Sensory evaluation of the pigeon and cowpea Akara was conducted using a randomly selected 20 member semi-trained panellist [5]. The sensory attributes of the samples tested included appearance, taste, texture, flavour and general acceptability. The panellists were required to observe and taste each coded samples and grade them on a 9-point Hedonic scale which ranged 1= like extremely and 9 = dislike extremely with 5 as neither like nor dislike.

D. Statistical Analysis

Statistical Program for Social Science SPSS version 21.0 (IBM SPSS inc., Chicago, IL) was used to obtain mean, standard deviation and analysis of variance (ANOVA). Duplicate values were obtained for each treatment and results presented as mean ± standard deviation, whereas significance was accepted for $p \leq 0.05$ by Duncan multiple range test.

III RESULTS AND DISCUSSIONS

A. Functional properties of the pigeon pea flour

The result of functional properties of the flours is presented in Table 1.

The bulk density of the pigeon pea flours ranged from 0.73 to 0.81g/ml. The values were lower compared to that 50.12 to 62.30 g/ml reported by [6] for flours from three pigeon pea varieties with seeds. [7] reported a bulk density value of 0.45 to 0.48 g/cm3 and 0.63 to 0.66 g/cm3 for loose and pack bulk densities, respectively for pigeon pea-cowpea composite flours. The high bulk densities observed in pigeon pea flours from this study indicates that their flours are heavy [8]. P110 (pigeon pea without sieving) had the highest bulk density, but was not significantly different ($p > 0.05$) from P314 (pigeon pea flour through 0.5 mm) and control (bean flour without sieving) with bulk density values of 0.80 g/cm3, respectively; while the pigeon pea flour through 0.5 mm (P314), had the highest bulk density value (0.80 g/cm3) among the sieved flours. High bulk density is desirable for greater ease of dispersibility of flour while low bulk density would be an advantage in the formulation of complementary foods [9].

The water absorption capacities of the pigeon pea flour ranged from 1.53 to 2.10g/g. Water absorption and holding capacity is mainly attributed to starch, pectic substances and other macro molecules but the chief water absorption capacity is protein [10]. [11] observed that the change in the water absorption capacity within the same product type is the result of changes in the theoretical surface area. He also recorded that alteration in physical structure affected the water imbibing properties of flour because the space available for free water in the fibre matrix were no longer present. P314 (pigeon pea flour through 0.5mm), P405 (pigeon pea flour through 1mm) were not significantly different ($p > 0.05$) in their water absorption capacities. Water holding capacity of pea hulls was seen to increase after grinding probably because of an increase in surface area and in the volume of pores [12]. [13] reported that fifteen minutes of hydration time was sufficient for making good quality akara. They also reported that flour paste had the least water holding capacity followed by wet milled paste.

The emulsification capacity of the flour samples ranged from 43.08 to 51.57 %. The control (Bean flour without sieving) had the highest emulsion capacity (51.57%), followed by pigeon pea without sieving (P100) (48.39%). While, P314 (pigeon pea flour through 0.5mm) had the highest emulsion value (46.66%) among the sieved samples, followed by P405 (pigeon pea flour through 1mm sieve and P300 (pigeon pea flour through 2mm sieve) respectively (Table 4). The emulsion capacity of the flour samples were generally high and could be attributed to the protein in the flour, since the flour samples exhibited high percentage of protein, more units of the protein may migrate to the interface and absorb more oil and water [14].

The foam capacity of the flour samples ranged from 35.82-47.00%. The pigeon pea without sieving (P100) had the highest foam capacity (47.00%), followed by P405 (pigeon pea through 1mm sieve) (46.51%) which was not significantly different ($p>0.05$) from P314 (pigeon pea flour through 0.5mm sieve) (46.14%). The control (Bean flour without sieving) however, had the lowest foam capacity value (35.82). Foam capacity, hydration properties and flow characteristics of paste are the most important indicators of paste functionality in akara preparation [15]. Protein that have the ability to cohere and the mechanical strength to prevent coalescence, form the best foam [16]. Cowpeas are expected to produce good foam because of their high protein content. [17] reported an increase in protein solubility with reduction in particle size of flour. Foaming properties of protein are influenced by protein source, method of preparation, composition, concentration, pH, temperature, presence of salt, lipids, sugar, solubility, and duration of heating [18]. The high foam is an indication that they can be used as foam enhancer in food systems, and as aerating agents in foods such as koose (Cowpea fritters) [19].

The percentage gelation capacity of the pigeon pea flour samples ranged from 11.10-11.37%. No significant difference ($p > 0.05$) was observed among the samples. P405 (Pigeon pea flour through 1mm sieve) hand the lowest gelatinization capacity (11.10%), followed by P314 (Pigeon pea flour through 0.5mm sieve) (11.12%) and P300 (Pigeon pea flour through 2mm sieve) (11.17%). The pigeon pea flour without sieving (P110) however, had the highest gelatinization capacity (11.26%) among the pigeon pea flour samples, while the control (Bean flour without sieving) had the highest gelatinization capacity (11.37%)

among the samples. The low gelation capacity of the sieved flour samples could be attributed to the effect of sieving which might have led to the removal of non-starch substances, reduction in the particle size and of course breakdown in the starch structure of the flour samples thereby making the starch more available and resulting in low gelatinization capacity. [20] for composite flour of wheat, rice, green gram and potato flour.

Table 1: Functional Properties of Pigeon Pea Flour

Sample	Bulk density	WAC	Emulsion capacity	Foam capacity	Gelation capacity
C201	0.80^{a}±0.04	2.85^{a}±0.70	51.57^{a}±0.61	35.82^{d}±0.25	11.37^{a}±0.08
P110	0.81^{a}±0.04	2.10^{b}±0.14	48.39^{b}±0.78	47.00^{a}±0.21	11.26^{a}±0.01
P314	0.80^{a}±0.01	1.63^{cd}±0.01	46.66^{c}±0.49	46.14^{b}±0.13	11.12^{a}±0.01
P405	0.75^{ab}±0.01	1.53^{d}±0.04	45.53^{c}±0.60	46.51^{ab}±0.70	11.10^{a}±0.13
P300	0.73^{b}±0.03	1.88^{bc}±0.2	43.08^{d}±2.99	44.35^{c}±0.35	11.17^{a}±0.27

Values are means ± standard of duplicate determinations. a-e Means bearing different superscripts down the column are significantly different (p<0.05). Where: C201 Control (Bean flour without sieving), P110 pigeon pea without sieving, P314 pigeon pea flour through 0.5 mm sieve, P405 pigeon pea flour through 1 mm sieve, P300 pigeon pea flour through 2 mm sieve

B. Proximate composition of pigeon pea flour

The result of the proximate compositions of the pigeon pea flour is shown in Table 2. The moisture content of the flour sample ranged between 8.79-7.28 %. The moisture content of all the samples was lower than the 15% standard value [21]. The control (cowpea flour) had the lowest moisture value (7.28 %), this could be attributed to the structure and thickness of the seed coat which have a significant effects on water absorption and dehulling characteristics of the seed. [13] reported that cowpea seed contains a micropyle and hilum, which plays a major role in hydration properties of the seed by allowing moisture absorption. P110 (pigeon pea flour without sieving) had the highest moisture value (8.79 %), but was not significantly different (p>0.05) from P300 (pigeon pea flour through 2 mm sieve). P314 (pigeon pea flour through 0.5mm) and P405 (through 1mm) did not vary significantly (p>0.05) from each other. Moisture content of flour sample is crucial in determining the keep-ability and shelf-life of the products. According to [21], flour sample is considered adulterated if the final moisture content of the product exceeds 15%. The result thus obtained is an indication that the flour samples will keep well [22]. Moisture content depends on the particle size of the flour and on the amount of water added to it [15].

The ash content of the samples ranged between 1.88-3.86%. C201 (control sample) had the highest ash value (3.86%); while P300 (pigeon pea flour through 2 mm sieve) had the least ash value (1.88%). All samples varied significantly (P<0.05) except for C201 (control: bean flour without sieving) and P110 (pigeon pea flour without sieving) which showed no significant difference from each other. The ash content of cowpea flours 1.88 to 3.67% were in line with the results of [23] reported ash content of 3.50 and 3.1% respectively for cowpea flours and 2.15 to 3.35 % values reported by [7] for pigeon pea-cowpea composite flours. Generally, the sieving process had a significant effect on the ash content of the flour samples as their ash values were observed to decrease with increase in sieve size.

The fat content of pigeon pea flour ranged from 1.44 to 2.24 %. P110 (pigeon pea without sieving) had the highest fat value (2.24 %), and also varied significantly from other samples; but lower than C201 (control: bean flour without sieving) sample value (2.74 %). The result obtained for pigeon pea flour samples corresponded with the range (1.95 to 2.35 %) reported by [7] for pigeon pea-cowpea composite flours.

The fibre content of the pigeon pea flours ranged between 0.50 to 0.67 %. These values were significantly lower than that of the control (3.42 %). The low fibre content recorded for pigeon pea is however lower than the range reported by [24] of 1.24 to 1.56 for full fat flour and pigeon pea flour samples but within the range of 0.43 reported by [25]. Higher values of crude fibre recorded for cowpea is an indication that it will help in the functioning of gastrointestinal tract and aid digestion. The major portion of the dietary fibre is present in the cell wall material of the seed [26]. Dry milling greatly reduces the fibre content. This reduction in fibre adversely affects both its water absorption capacity and gelatinization temperature [27]. If the fibre structure is modified, the ability of entrap water within the fibre matrix is also affected. However, no significant difference ($p \geq 0.05$) was observed in the crude fibre content of pigeon pea flour samples.

The protein content of the pigeon pea flour samples range from 22.78-23.71 %, P110 (pigeon pea flour without sieving) varied significantly form other samples. These values were in range with that 20.85 to 23.65 % values reported by [7] for pigeon pea-cowpea composite flours, but lower than 18.34 to 25.21 % obtained by [6] for flours from three pigeon pea varieties with seeds. The high protein content recorded for the pigeon pea flours samples could be attributed to the plant's specie (leguminous) which is portentous in nature and thus has been used to increase the protein content of other food crops, [22]. The protein (23.71 %) content of P110 (pigeon pea flour without sieving) was however observed to be higher than that (23.49 %) of the C201 (control flour), but was not significantly different ($p \geq 0.05$) from each other.

The carbohydrate content of the pigeon pea flours ranged from 60.94 to 64.85 %. These values were in line with the range (59.54 to 63.85 %) reported by [7] for pigeon pea-cowpea composite flours. P110 (pigeon pea flour without sieving) had the lowest carbohydrate value (60.94 %) among the pigeon pea flour samples; the carbohydrate content of the sieved flour samples were however observed to increase with increase in sieve size, while C201 (control flour) recorded the lowest carbohydrate value (59.42 %). High carbohydrate values indicate high energy value for the flour samples.

Table 2: Proximate composition of pigeon pea flour

Samples	Moisture	Ash	Fat	Fibre	Protein	CHO
C201	$7.28^{c}\pm0.05$	$3.86^{a}\pm0.01$	$2.74^{a}\pm0.15$	$3.42^{a}\pm0.28$	$23.49^{a}\pm0.39$	$59.42^{d}\pm0.02$
P110	$8.79^{a}\pm0.05$	$3.67^{a}\pm0.02$	$2.24^{b}\pm0.01$	$0.67^{b}\pm0.08$	$23.71^{a}\pm0.01$	$60.94^{c}\pm0.06$
P314	$8.44^{b}\pm0.02$	$3.05^{b}\pm0.07$	$1.10^{c}\pm0.12$	$0.50^{b}\pm0.01$	$23.07^{ab}\pm0.06$	$63.86^{b}\pm0.01$
P405	$8.11^{b}\pm0.16$	$2.28^{c}\pm0.32$	$1.46^{c}\pm0.08$	$0.52^{b}\pm0.02$	$23.33^{ab}\pm0.46$	$64.32^{ab}\pm0.52$
P300	$8.55^{a}\pm0.61$	$1.88^{d}\pm0.08$	$1.44^{c}\pm033$	$0.50^{b}\pm0.01$	$22.78^{b}\pm0.25$	$64.85^{a}\pm0.12$

Values are means ± standard of duplicate determinations. a-e Means bearing different superscripts down the column are significantly different ($p<0.05$).

Where: C201 Control (Bean flour without sieving), P110 pigeon pea without sieving, P314 pigeon pea flour through 0.5 mm sieve, P405 pigeon pea flour through 1 mm sieve, P300 pigeon pea flour through 2 mm sieve

C. Proximate composition of Akara from pigeon pea flour

The result of the proximate composition of akara from pigeon pea flour is shown in table 3. The moisture content of the akara samples ranged from 33.00 to 39.20 with control (bean flour without sieving) recording highest value (39.20). This range corresponded to the range (35.30 to 39.40 %) reported by [7] for Akara from pigeon pea-cowpea composite flours. This result showed that cowpea flours absorbed more water during paste reconstitution. [13] reported that cowpea seed contains a micropyle and hilum, which plays a major role in hydration properties of the seed by allowing moisture absorption. It was however observed that the moisture values of the sieved samples increased with increase in sieve size and could be attributed to sieving effect which might have led to decrease in the fibre content of the flours thereby reducing their ability to absorb moisture. [27] reported that dry milling greatly reduces fibre content; this reduction in fibre adversely affects both its water absorption capacity and gelatinization temperature. If the fibre structure is modified, the ability of entrap water within the fibre matrix is also affected [11]. Generally, the moisture values of akara samples were relatively high; this implies that the sample would be susceptible to mould attack as high moisture content encourages mould growth.

The ash content of akara from pigeon pea flour ranged from 1.16 to 2.83 %. This was within the range (2.20 to 3.00 %) reported by [7] for akara from pigeon pea-cowpea composite flours. The sieved samples varied significantly from each other with P314 (akara pigeon pea flour through 0.5 mm0 having the highest ash value of 2.83 %.

Fat content of the akara samples ranged between 30.02 to 33.91 %. These values were higher than that (17.00 to 20.90 %) reported for akara from jack beans and cowpea flour blend [7] but within the range reported by [15]. The fat content of the pigeon pea Akara samples were however higher than that of the control (cowpea flour), and could be attributed the fact that the Akara from pigeon pea flour was observed to have absorbed more oil during frying.

The Crude fibre content of the Akara samples from pigeon pea flour ranged between 0.23 to 0.68 %. These values were less than that (0.50 to 1.15 %) reported by [7] for Akara from pigeon pea-cowpea composite flours. P405 (pigeon pea flour through 1 mm sieve) had the lowest fibre value (0.27 %) among the sieved samples, but was not significantly different (p >0.050 from P110 (pigeon pea flour without sieving).

The Protein content of Akara samples ranged from 16.56 to 21.45 %. This was observed to be higher than the range 12.15 to 13.75% reported by [7] for Akara from pigeon pea-cowpea composite flours. The pigeon pea flour without sieving (P110) had the lowest protein value (16.56 %), but was not significantly different (p>0.05) from the control, C201 (bean without sieving) (16.20 %); while P405 (pigeon pea flour through 1 mm sieve) had the lowest protein value (17.11 %) among the sieved samples, but was not significantly different from P300 (pigeon pea flour through 2 mm sieve) (17.08 %). P314 (pigeon pea flour through 0.5 mm sieve) however, had the highest protein value (21.45 %) among the sieved samples.

The carbohydrate content of the Akara from pigeon pea flour ranged from 12.74 to 15.60. The values were lower than (17.01 %) of the control (akara cowpea flour) and the range 22.70 to 32.20% recorded by [7] for akara from pigeon pea-cowpea composite flours.

TABLE 3: Proximate composition of "Akara" from pigeon pea flour

Sample	Moisture	Ash	Fat	Fibre	Protein	CHO
C201	39.20^{a}±0.94	2.51^{a}±0.23	24.51^{d}±0.72	0.59^{ab}±0.01	16.20^{c}±0.62	17.01^{a}±0.60
P110	33.51^{d}±0.11	1.16^{d}±0.24	33.91^{a}±0.15	0.23^{c}±0.07	16.56^{c}±0.03	14.35^{c}±0.26
P314	33.00^{d}±1.34	2.83^{a}±0.24	30.02^{c}±0.02	0.68^{a}±0.11	21.45^{a}±0.65	14.04^{c}±2.11
P405	33.44^{d}±0.62	1.29^{c}±0.06	32.31^{b}±0.29	0.27^{c}±0.07	17.11^{b}±0.14	15.60^{b}±0.90
P300	35.39^{c}±0.30	1.56^{b}±0.62	33.02^{ab}±1.20	0.51^{b}±0.09	17.80^{b}±0.29	12.74^{d}±0.08

Values are means ± standard of duplicate determinations. a-f Means bearing different superscripts down the column are significantly different (p<0.05). Where: C201 Control (akara from cowpea flour), P110 akara from pigeon pea without sieving, P314 akara from pigeon pea flour through 0.5 mm sieve, P405 akara from pigeon pea flour through 1 mm sieve, P300 akara from pigeon pea flour through 2 mm sieve

D. Sensory evaluation of Akara from pigeon pea flour

The sensory evaluation of the pigeon pea flour is shown in Table 4. The control akara had the best score for all the sensory parameters, while among the pigeon pea flour samples, P314 (pigeon pea flour through 0.5 mm sieve) had the best score for all the parameters. P300 (pigeon pea flour through 2mm sieve) however had the least score for all the parameters measured. The appearance of a sample expresses the level of sensation the products provided on the eyes by the rays of light [16]. [15] reported that colour of akara may be due to heat treatment.

Acceptability of a product is very important for it to be produced economically and be useful. [28] studied acceptability of akara by teenage American consumers as a fast food alternative. They discovered that akara could be targeted towards young consumers who eat at fast food establishment more often. They also suggested that akara should be promoted as a nutritious fried food.

Table 4: Sensory evaluation of "Akara" from pigeon pea flour

Sample	Appearance	Taste	Texture	Flavour	General acceptability
C201	8.65^{a}±0.90	7.90^{a}±1.10	7.75^{a}±0.14	7.40^{ab}±0.10	8.00^{a}±0.11
P300	3.40^{c}±0.90	4.25^{e}±1.01	4.95^{cd}±0.05	4.35^{d}±0.90	3.85^{d}±0.12
P314	5.85^{b}±0.05	5.70^{c}±1.00	5.80^{b}±0.00	6.15^{c}±0.09	5.55^{b}±0.97
P405	3.90^{b}±0.09	4.85^{d}±1.01	5.15^{c}±0.40	4.65^{d}±0.09	4.50^{d}±0.42
P110	5.75^{b}±0.11	6.00^{bc}±1.01	5.35^{c}±0.04	5.90^{bc}±1.00	5.40^{cd}±0.0.11

Values are means ± standard of duplicate determinations. a-e Means bearing different superscripts down the column are significantly different (p≤0.05). Where: C201 Control (Bean flour without sieving), P110 pigeon pea without sieving, P314 pigeon pea flour through 0.5 mm sieve, P405 pigeon pea flour through 1 mm sieve, P300 pigeon pea flour through 2 mm sieve.

IV CONCLUSION

The results of the physiochemical analysis showed that pigeon pea flour compared favourably with cowpea flour in proximate and functional compositions and thus pigeon pea can be used in the production of akara rather than depending wholly on cowpea. However, based on the sensory evaluation results, akara samples from cowpea flour and paste were mostly acceptable in terms of appearance, taste, texture and flavour by the panellist. It is therefore recommended, that akara be produced from blends of cowpea and pigeon pea flour for further studies since it has been shown that hundred percent pigeon pea did not produce an acceptable akara.

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