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Chemical Composition, Functional and Sensory Qualities of Maize-Based Snacks (Kokoro) Fortified With Pigeon Pea Protein Concentrate

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Abstract: *Quality evaluation of snacks produced from blends of maize flour supplemented with protein concentrate from pigeon pea at 100:0 (control), 97.5:2.5, 95:5, 90:10, 85:15 and 80:20 was investigated. The blends were reconstituted into a thick paste, manually molded into 'kokoro' stick and deep fried in hot vegetable oil. Flour blends were evaluated for functional and pasting properties while snacks were analyzed for chemical composition and sensory qualities. Chemical analysis results revealed significant (p<0.05) increase in protein (5.38-13.38%), ash (1.33-1.49%) and fat (10.37-18.01%), content while fiber (1.90-1.67%), carbohydrate (74.34-61.04%)and peroxide value (6.31-4.19meqlkg oil)content decreased with addition of protein concentrate. The functional properties reflected that water absorption, oil absorption, emulsion capacity & dispersibility significantly decreased with increase in pigeon pea-protein concentrate. No significant difference (p<0.05) was observed in the swelling capacity. No significant difference (P<0.05) occurred in the sensory attributes of products from 100 % maize and 97.5:2.5 flour blend. Hence, acceptable "kokoro" snacks from 97.5:2.5 (maize: protein concentrate) blend have been formulated, this compared favourably with whole maize product.*

Keywords: *kokoro, maize flour, pigeon pea, protein concentrate, functional properties.*

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I. Introduction

Maize *(Zea mays)* or corn is a cereal crop that is grown widely throughout the world in a range of agro ecological environment. It is a major staple food in developing countries especially in Nigeria, where it serves as raw materials for the production of some staple food such as traditional fermented maize porridge (ogi), maize flour (tuwo) and different traditional snacks (robo, adun, donkua and kokoro). Maize is predominantly starch (60-75%), in the form of

amylose and amylopectin. The protein content of maize is low, constituting only 9-12% when compared with legumes. It is however, known to be rich in methionine and cysteine [1] but lacks lysine and tryptophan. Such amino acid that are lacking can be supplied to the food by complementing the maize with legumes such as peanuts or pigeon peas, which are better sources of such amino acids [2], [3].

Kokoro is a snack traditionally produced from thick coarse corn paste for, adult and children [4]. People that consume kokoro in large quantities are faced basically with a large intake of carbohydrate, but low protein content in kokoro is very evident, with a shortage of tryptophan and lysine together with its low niacin content may contribute further toward the incidence of pellagra in maize-consuming areas[5], [6].

Pigeon pea (*Cajanus Cajan*) is considered a most important grain legume for human nutrition in many protein deficient tropical countries, including Nigeria [7]. Pigeon pea, with its protein content which range between 21 and 26% [8]; [9], is highly desirable as a protein supplement to cereal based diet. Food supplementation is the process of increasing the level of some specific nutrient previously identified as lacking using a source rich in that nutrient.

The possibility of producing acceptable 'kokoro' with better nutritional content and sensory quality from maize flour mixed with protein concentrate from pigeon pea (*Cajanus Cajan*) seed was therefore investigated. We hoped, this would be acceptable and also add value to the use of pigeon pea flour in making 'kokoro'.

II. Materials and Methods

The main materials, Dried white maize *(Zea mays)* and pigeon pea (*Cajanus Cajan*) were obtained from Sayedero market, Ilaro. Other ingredients which include onion (fresh), salt, (Dangote lodized brand) and vegetable oil (Turkey T.m brand) were purchased from a retail market at Sango, Ogun State, Nigeria.

2.1 Methods- Preparation of protein concentrate from pigeon pea.

The defatted pigeon pea powder was produced as described by [10]. The method of [11] was used for the alkaline extraction-methanol precipitation of pigeon pea protein concentrate.

2.2 Production of Maize Flour

Maize flour was produced by method of[12]. The maize grains were dried, sorted and cleaned to remove dust, dirt and foreign matters. The cleaned maize was then milled using a laboratory hammer mill and allowed to pass through a 250 micrometer mesh sieve.

2.3 Formulation and Production of Kokoro with Protein Concentrate

Blends of maize flour substituted for protein concentrate were prepared at different concentrations ranging from 2.5,5,10,15 & 20%, protein concentrate.The control was made from maize alone.In each case, the blends of the maize flour and protein concentrate were mixed, equal amount of salt (1g) and onion (2g) were added to the mixture. The blends were made into a thick dough by adding 100ml of boiling water, then manually kneaded and cut into pieces and the piece were rolled on a cutting board into a ring-like shape. The dough was deep-fried in refined hot vegetable oil. The fried pieces were drained overnight, after which second frying was done until the pieces were golden yellow in color. The fried pieces were left to cool, drained and transferred to a basket lined with paper. They were then packed in polyethylene bags and sealed.

2.4 Determination of Proximate Composition of 'Kokoro' Snacks

Determination of moisture, protein, ash, fat, fiber, pH and peroxide values were carried out according to [13]. Carbohydrate content was determined by difference (100-{sum of moisture protein ash, fat and fiber content}).Atwater factor was used to estimate the energy values (4 x % carbohydrate + 4 x % protein + 9 x % fat) in kcal/100g.

2.5 Determination of Functional Properties

Water absorption capacity (WAC) and oil absorption capacity (OAC) were determined using the method reported by [14].

The procedure by [13] was used to determine bulk density andpacked density. The swelling capacity was determined using the method described by [15]. Emulsion, capacity was determined by the procedure of [16]. The procedure of [10] was used to determine foaming capacity and stability.The method reported by [12] was used to determine dispersibility

2.6 Pasting Characteristics Determination

The pasting profile was determined using a Rapid Visco Analyser(RVA) (model 3D RVA New port Scientific Pvt Ltd Narrabeen, Australia).The sample 4.0 g was weighed and 25ml of distilled water was dispensed into a canister, inserted into the tower which was lowered into the system. The 12 minute profile was used, the suspension was heated from 50 to 95^0C and then cooled back to 50^0C, the can was rotated at a speed of 160 rpm with continuous stirring of the contents with a plastic paddle. Parameters determined were peak viscosity, trough, breakdown, setback, final viscosity, peak time and pasting temperature. All measurements were taken in triplicates..

2.7Sensory Evaluation

The sensory attributes of the 'kokoro' samples were evaluated by the multiple comparison difference test as described by [17]. This was achieved by evaluating the samples with 30 panelists. The panelist were supplied with a form and asked to score the samples using a 9-point hedonic scale with respect to taste,color, crispiness, flavor and overall acceptability.

Statistical Analysis

Data generated were subjected to appropriate statistical analysis using ANOVA to detect differences in the means score and Duncan multiple range test [18] to separate the differencesin the means.

III. . Results &Discussion

Table 1 Functional Properties of Maize-Protein Concentrate Flour Blends

Samples	DFB	BDE	MNO	XYZ	PQR	DEF
Parameters						
Swelling capacity (%)	4.64^{a}±0.01	4.41^{a}±0.127	4.23^{b}±0.01	4.13^{b}±0.0057	4.0^{b}(±0.0057)	3.95^{b}±0.0115
Emulsion capacity %	48.39^{a}±0.01	46.22^{b}±0.01	45.43^{c}±0.01	43.61^{d}±0.01	41.27^{e}±0.01	39.85^{f}±0.01
Foaming capacity %	3.85^{f}±0.02	4.95^{e}±0.020	5.32^{d}±0.04	6.74^{c}±0.02	7.53^{b}±0.01	8.43^{a}±0.02
Foaming stability (%)	2.43^{f}±0.03	3.45^{e}±0.01	3.75^{d}±0.03	4.15^{c}±0.01	4.85^{b}±0.02	5.15^{a}±0.01
Dispersibility (%)	71.88^{a}±0.01	69.95^{b}±0.01	66.62^{c}±0.02	64.25^{d}±0.05	61.46^{e}±0.01	57.77^{f}±0.02
Bulk density (g/ml)	0.50^{a}±0.01	0.49^{a}±0.02	0.47^{b}±0.01	0.41^{c}±0.01	0.39^{d}±0.01	0.31^{e}±0.01
Packed density (g/ml)	0.71^{a}±0.01	0.69^{b}±0.01	0.66^{c}±0.01	0.53^{d}±0.01	0.51^{d}±0.02	0.47^{e}±0.01
Water absorption capacity (g/g)	198^{a}±0.04	175^{b}±0.01	165^{c}±0.02	160^{d}±0.01	154^{e}±0.02	150^{f}±0.01
Oil absorption capacity (g/g)	160^{a}±0.03	158^{b}±0.02	150^{c}±0.01	146^{a}±0.02	142^{e}±0.04	139^{f}±0.03

Value are means of three replicates: means in the same row with different superscript are significantly different ($p<0.05$).
Maize: pigeon pea protein concentrate ratio DFB (100% maize), BDE-(97.5:2.5), MNO-(95:5), XYZ-(90:10), PQR-(85:15), DEF-(80:20).

Table 2: Pasting Characteristics of maize-pigeon pea protein concentrate flour blends viscosity (RVU) Parameters

Samples	peak viscosity	Trough At 95°C	Breakdown	Final viscosity	Setback	peak time (min)	pasting temp. (°c)
DFB	**758.00^{a}**	**653.00^{a}**	**105.00^{a}**	**1895.00^{a}**	**1222.00^{a}**	**6.25^{a}**	**80.20a**
BDE	**658.34^{b}**	**574.**	**83.97^{b}**	**1645.85^{b}**	**1077.85^{b}**	**6.25^{a}**	**80.45^{a}**
MNO	**608.54^{c}**	**532.32^{c}**	**76.22^{c}**	**1521.35c**	**988.35^{c}**	**6.65^{a}**	**81.25^{b}**
XYZ	**563.00^{d}**	**505.32^{d}**	**57.68^{d}**	**1407.50^{d}**	**965.76^{d}**	**6.25^{a}**	**81.75^{b}**
PQR	**555.67^{e}**	**500.65^{d}**	**55.02^{e}**	**1405.32^{d}**	**824.65^{e}**	**6.20^{a}**	**82.25^{c}**
DEF	**535.34^{f}**	**485.32^{e}**	**50.02^{f}**	**1384.82^{e}**	**801.82^{f}**	**6.15^{b}**	**82.15^{c}**

Values are means of triplicates. Means in the same row with different superscript are significantly different ($p<0.05$)
Maize: Pigeon pea protein concentrate ratio
DFB (100; 00), BDE (97.5; 2.5), MNO (95:5), XYZ (90:10), PQR (85:15), DEF (80:20)

Table 3: Proximate Composition of 'Kokoro' Produced with Maize-Protein Concentrate Flour Blends

Samples	DFB	BDE	MNO	XYZ	PQR	DEF
Parameters						
Moisture (%)	6.88^{a}±0.05	6.62^{b}±0.01	5.57^{c}±0.01	5.20^{d}±0.01	4.48^{e}±0.01	4.42^{f}±0.01
Crude protein %	5.38^{f}±0.01	5.67^{e}±0.01	7.10^{d}±0.01	9.31^{c}±0.01	11.63^{b}±0.02	13.38^{a}±0.02
Crude fat%	10.37^{f}±0.01	11.33^{e}±0.020	12.71^{d}±0.02	14.21^{c}±0.02	15.47^{b}±0.02	18.01^{a}±0.01
Ash (%)	1.33^{c}±0.01	1.36^{c}±0.01	1.38^{c}±0.02	1.41^{b}±0.02	1.46^{a}±0.01	1.49^{a}±0.01
Crude fibre (%)	1.90^{a}±0.01	1.86^{a}±0.02	1.80^{b}±0.02	1.77^{c}±0.01	1.70^{d}±0.02	1.67^{e}±0.01
Carbohydrate (%)	74.34^{a}±0.01	73.16^{a}±0.02	71.44^{c}±0.01	68.10^{d}±0.03	65.26^{e}±0.03	61.04^{a}±0.03
Energy value (kcal/100g)	416.78^{f}	421.09^{d}	422.41^{b}	421.89^{c}	418.19^{e}	423.84^{a}
PH	7.25^{a}±0.01	7.01^{a}±0.01	6.76^{b}±0.01	6.70^{b}±0.01	6.41^{c}±0.01	6.02^{d}±0.01
Peroxide value (meqkg oil)	6.31^{a}±0.01	5.63^{b}±0.01	5.12^{c}±0.02	4.95^{d}±0.01	4.46^{e}±0.01	4.19^{f}±0.01

Values are means of triplicates. Means in the same row with different superscript are significantly different ($p<0.05$)

Maize: Pigeon pea protein concentrate ratio
DFB(100.0) BDE(97.5:2.5), MNO (95.5), XYZ (90:10) PQR(85.15), DEF(80:20).

Table 4: Mean Scores of Sensory Evaluation of 'Kokoro'from Maize-Protein Concentrate Flour Blends.
Parameters

Samples	Taste	Color	Flavor	Crispiness	Overall acceptability
DFB	7.40^{a}	6.90^{a}	6.40^{b}	7.50^{a}	7.20^{a}
BDE	7.00^{a}	7.00^{a}	6.70^{a}	7.40^{a}	7.10^{a}
MNO	6.50^{ab}	6.90^{a}	7.00^{a}	6.50^{c}	6.60^{ab}
XYZ	6.40^{b}	6.80^{a}	6.60^{ab}	6.70^{ab}	6.60^{ab}
PQR	4.50^{c}	5.30^{b}	5.70^{c}	4.40^{d}	4.40^{c}
DEF	3.40^{d}	3.90^{c}	4.60^{d}	2.30^{e}	2.30^{d}

Values are means of triplicates. Means in the same now with different superscripts are significantly different ($p<0.05$).
Maize: Pigeon pea protein concentrate ratio DFB (100.0), BDE (975:2.5), MNO (95.5), XYZ (90.10), PQR (85.15), DEF (80.20)

IV. Discussion

The results of the functional properties obtained are shown in table 1. There were significant differences ($P<0.05$) in the functional properties of the maize and protein concentrate flour blends. The swelling capacity is a function of the product to rise when having interaction with water. [19] reported that the swelling capacity affects the temperature at which a product forms gel in maize flour, a similar observation was obtained. The values of swelling capacity decreased with increase in the proportion of protein concentrate, with sample DEF (80:20) having the lowest value of 3.95% and sample DFB (100.0) having the highest (4.64%). According to [20] the value of solubility and swelling power of starch may be due to the protein-amylose complex formation in isolated starches and may cause decrease in swelling power.

The emulsion capacity ranged from 39.85% to 48.39%, this showed that there was significant difference ($p<0.05$) between all the entire samples in the emulsion capacity. Sample DFB (100% maize) had the highest value of 48.39% which is an indication that the samples has the capacity or tendency to form emulsion more than other samples with increased in protein concentrate proportion which may be due to the presence of amylase and amylopectin content in the maize flour [21]. At low protein concentrate absorption at the oil water interface is diffusion controlled, since it will spread over the surface before it can be absorbed. At high protein concentration, the activation energy barrier does not allow protein migration to take place in a diffusion dependent manners [22], this may be partly explained why the emulsion capacity decrease with increased protein concentration.

The results of the foaming capacity and stability showed that there were significant difference ($p<0.05$) between all the samples. The values were in the range 3.85-8.43% and (2.43-2.45%) respectively for foaming capacity and foaming stability. Formability is related to the rate of decrease in the surface tension of the air-water interface caused by absorption of protein molecules [21]. To exhibit good foaming, protein must be capable of migrating at the air-water interface, unfolding and rearranging at the interface [23]. According to [24], the foam capacity and stability were enhanced by greater protein concentration, because this increases the viscosity and facilitates the formation of a multilayer, cohesive protein film at the interface. Foam capacity increased as the level of inclusion of protein concentrate are increasing.

Dispersibility is an index of the ease of reconstitution of the flour samples in water. The percentage dispersibility showed that there was a significant difference ($p<0.05$) between all the samples. Sample DFB (100:0) had the highest value of 71.88%, while sample DEF (80:20) had the least value of 57.77%. This shows that sample DFB (100%maize) has the ability to disperse more and faster in aqueous solution or during food processing than other samples, this may be due to the level of protein concentrate proportion intothe products [21].

Packed and bulk density properties decreased with increase in protein concentrate flour inclusion. Sample DFB (100%) had the highest value of 0.50g/m/ and 0.71g/m/ for bulk and packed density respectively. Bulk density is an index of the heaviness of flour materials and expresses the relative volume of packaging material needed. The bulk density is generally affected by the particle size. It has relevant application in packaging, transportation and raw material handling [12].It also showed that the packed bulk density values are low and can occupy more space if packed in a container. The low packed density result in less packaging. However, [25] reported that higher bulk density is desirable, since it helps to reduce the paste thickness which is an important factor in convalescent and child feeding. The loose bulk density values are lower than the values obtained for packed density values. It is significant for the preparation of weaning food.

The results of both the water absorption and oil absorption capacity decreased with increase addition of protein concentrate in blends ranging from 198±0.04 to 150±0.01g/g and 160±0.03 to 139±0.03g/g respectively. These findings were in agreement with some previous reports [26]; [27]. The water absorption values recorded were significantly higher than the values (144-166 9 g/g) for maize benised flour blends [27] but lower than values (240-170 g/g) reported for maize-pigeon pea protein hydrolysate [26] . The water absorption behavior can be linked to the nature of starch in maize. The nature of the starch has been found to have effect on water absorption capacity [28]. Similarly, high water absorption capacity may also be attributed to the loose structure of starch polymers while a low value indicates compactness of the starch structure. Hence, the high WAC of the flour blends obtained in this study has the potential to bind water. [28] suggested that a higher WAC may be useful in products where hydration is required to enhance handling characteristic such as dough and pastes. Oil absorption capacity is the ability of a food or food ingredient to absorb oil or fat. The ability of proteins to bind fat is important, since fats act as flavor retainers and increase the mouth feel of foods, improve palatability, and extend the shelf life of bakery on meat product, meat extender, doughnuts, pancake, baked goods and soup mixes. It is an indicator for flavor retention. The functional properties revealed that the flour blended of corn flour and pigeon pea protein concentrate may find application in snacks formulation.

3.2. The pasting characteristic of the maize-pigeon pea-protein concentrate is as shown in Table 2.

The peak viscosity, which is the maximum viscosity developed during or soon after the heating portion ranged between 535.34 to 758.00 RVU, where DFB (100:0) had the highest value while sample DEF (80:20) had the lowest value. This is in agreement with the findings of [29],[12] and [26]. Peak viscosity usually indicates the water binding capacity of a mixture in a product. It decreased with the increasing level of protein concentrate inclusion. This might be due to a higher content of protein, which has been reported to lower paste viscosity [15] Peak viscosity is often correlated with final product quality and also an indication of the viscous load likely to be encountered by a mixing cooker. The trough or holding strength showed that there was significant difference ($P<0.05$) in all the samples. Sample DFB (100:0) had the highest value of 653.0 RVU. The addition of protein concentrate lowers the trough of maize flour; which implies that the blends may not find good applications in the food system, where high paste stability during looking is required [12]. The breakdown, which is the difference in the peak viscosity and trough is an indication of the rate of swelling stability, which is dependent on the nature of the product [12]. The breakdown viscosity of DFB (100:0) is 150.00(RVU). The maize-pigeon pea protein concentrate flour had lower value in range of 50.02-83.97 (RVU). [15] reported that the higher the breakdown in viscosity, the lower the ability of the sample to withstand heating and shear stress during cooking. Hence sample DEF (80:20) might be able to withstand heating and shear stress compared to other samples because of its low breakdown value. The final viscosity ranged from 1384.82-1895.00(RVU), the control sample DFB (100:0) had the highest (1895.00) (RVU), while sample DEF (80:20) had the lowest. [30] reported that final viscosity is used to indicate the ability of starch to form various paste or gel after cooling and that less stability of starch paste is commonly accompanied with high value of breakdown. This implies that sample DFB (100:00) will be less stable after cooling compared to Maize – Pigeon Pea Protein concentrate flours blends. The variation in the final viscosity might be due to the simple kinetic – effect of cooling on viscosity and the re-association of starch molecules in the samples. The phase of the pasting curve after cooling of the samples to 50^0C is referred to as the setback region, a point where the retro-gradation of starch molecules takes place, as high setback value is an indication of a non-cohesive paste with less tendency to retrograde or sythenesis upon cooling. The setback value decreases with an increase in the protein inclusion, with DFB (100:0) maize flour having the highest value of 1222.0(RVU) . The peak time ranged between 6.15min and 6.25min. There was no significant difference ($p<0.05$) between the samples. The peak time gives on indication of ease of cooling. The shorter the peak time, the higher the ease of cooling. [12]. The pasting temperature ranged from 80.20 to 82.75^{o}C. Sample DEF (80:20) had the highest pasting temperature of 82.75^{o}C while DFB (100:0) maize flour sample had the lowest value of 80.20^0C. The pasting temperature gives an indication of the minimum temperature required to cook a sample, which also has implication on the energy cost of preparing a food product. The result indicated an increase in the pasting temperature with increase in pigeon pea protein concentrate flour inclusion. The pasting temperature of all the samples were low when compared to pasting temperature obtained for kokoro of maize-beniseed blends [27] and Maize chips (kokoro) fortified with cowpea flour [29].

3.3. The results of proximate composition of 'kokoro' produced from maize flour and pigeon pea protein concentrate blends are shown in table 3.

There was significant difference ($p<0.05$) in the proximate composition of the samples. The crude protein (5.38-13.38%), ash (1.33-1.49%), fat (10.34-18.00%) and energy value (416.78-423.04 kcal/100g) contents increased while moisture (6.68-4.42%), crude fiber (1.90-1.67%), carbohydrate (74.34-61.04%) content and peroxide value (6.31-4.19meql kg oil) decreased with increasing proportion of protein concentrate in the product. The crude protein increase could be attributed to higher protein content of pigeon pea as reported by [12]. Protein content is of the most important qualities of any food. The value recommended for any food is 20% (FAO) 1996. Sample DEF (80:20) had the highest protein content of 18:00% while 100% maize kokoro had the lowest value of 10.34%. This work is in agreement with the previous studies by [26]; [12] and [31] on kokoro produced from pigeon pea and African yam bean respectively.

The moisture content of the snacks sample ranged from (4.42-6.68%) and sample DFB (100:0) having the highest 6.68%, the low moisture content (4.42-6.68%) was indicative of their high dry matter content which confers that they would have a good keeping quality. According to [32] low moisture foods have less tendency of spoilage. The values obtained for fat contents were similar to fat content obtained by [33], [12] and [26] in whole maize 'kokoro'.

The percentage ash content falls within the range reported by [26] for maize based snack supplemented with pigeon pea protein hydrolysate. The value obtained for the ash content indicated that sample DEF (80:20) had the highest value of 1.49% while (100% maize) had the least ash content of 1.33%. This indicates that supplementation of pigeon pea protein concentrate may enhance the amount of minerals in food product made from maize –protein concentrate flour blends [6], [26].

The carbohydrate content decreased from 74.34% to 61.04% as the percentage of protein concentrate is increased from 0 to 20%, this was due to the relatively low carbohydrate content of pigeon pea [34]; [12]; [26], from where the concentrate was produced. Similar findings have been reported with inclusion of soybean, beniseed flour, defatted groundnut and pigeon pea protein hydrolysate in maize flour respectively.[35], [28],[3] and [26].

3.4. The results of sensory evaluation is shown in table 4.

Differences in the score attribute, in terms of taste, colour, flavor, crispiness and overall acceptability may be due to the proportion of pigeon pea protein concentrate added to the product [28].

It is however expected that the sensory score for sample DFB (100% maize) in terms of overall acceptability was the highest. 'Kokoro' snacks food containing 80% maize and 20% protein concentrate was the least preferred in terms of all the sensory attributes under investigation.

However, substitution up to 10% with protein concentrate into the maize flour were still acceptable by the panelists. The result indicated that the increase in the pigeon pea protein concentrate cause a decrease in the score attribute in terms of taste, color flavor and crispiness of the kokoro pigeon pea protein concentrate fortified. This is attributed to the fact that the pigeon pea protein concentrate inclusion was actually new to the consumers of 'kokoro'.

V. Conclusion

The study showed that low nutritional quality of 'kokoro' can be improved through supplementation with pigeon pea protein concentrate. This is reflected in the improved protein (5.38-13.38%) which increased with increase in protein concentrate. Kokoro from maize-protein concentrate blend can serve as a nutritious food or snacks and help redress the problem of protein-energy malnutrition. The maximum levels of replacement which were acceptable are from 2.5% to 10%.

In addition to the aforementioned, there would be an increase in demand and utilization for pigeon pea by the processor of kokoro snacks; hence this would eventually encourage the cultivation of more hectares by the farmers for the crop and more income on returns.

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