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PROXIMATE AND SENSORY QUALITIES OF BREAKFAST CEREALS FROM SPROUTED MILLET AND BAMBARANUT COMPOSITE FLOUR

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ABSTRACT
The proximate and sensory qualities of breakfast cereals produced from sprouted millet and bambaranut composite flour were investigated in this study. Sprouted millet and bambaranut flours were blended into various ratios of 90:10 (AOE), 60:40 (BOD), 70:30 (COC), 50:50 (DOB) and 100% yellow corn flour (EOA) which was used to produce the breakfast cereals. The breakfast cereals were analyzed for their proximate composition and evaluated for their sensory qualities. The proximate composition of the breakfast cereals varied from 8.26% -9.84% for moisture content, 8.44% -11.92% for crude protein, 10.85% - 14.84% for fat, 1.25% - 2.36% for crude fibre, 1.24% -2.16% for ash and 61.70% -67.46% for carbohydrate content. The sensory qualities of the breakfast cereals ranged from 4.60 -7.40 for colour, 3.70 – 7.30 for aroma, 4.60 – 7.90 for taste, 5.90 – 7.30 for texture, 6.80 – 7.70 for crunchiness, 5.80 – 7.70 for appearance and 5.70 – 8.40 for overall acceptability respectively. Breakfast Cereals from this composite flour had a significant difference ($p < 0.05$) across the parameters of moisture content, crude protein, fat, crude fibre, ash and carbohydrate content. Composite flour formulations were not significantly different ($p<0.05$) from the control in overall acceptability. This shows the possibility of producing nutritious breakfast cereals with desirable organoleptic qualities or properties from sprouted millet and bambaranut composite flour.
Keywords: breakfast cereals, bambaranut, sprouted millet

INTRODUCTION
Breakfast is the first meal of the day especially when taken in the morning (Merriam – Webster Dictionary). Breakfast is often considered one of the most important meals as it provides the body with essential nutrients and energy to start the day. Studies have shown that Individuals that do not eat breakfast are likely to have problem with metabolism, concentration and weight (Bahrami *et al*., 2017). It usually Includes a varieties of food Items such as grains, fruits, dairy products and proteins.

The mostly widely eaten breakfast food is cereals. Breakfast cereals are corn, wheat, oats, rice and other grains processed, cooked and shaped by flaking, puffing or shredding (2024, cereal breakfast food).They can be grouped as hot cereals (traditional cereals) and cold cereals (ready to eat cereals), where hot cereals requires heating or further cooking before it can be taken and ready to eat cereals, which can be consumed without heating and most times with milk (Fast, 2014). These ready-to-eat cereal food products are the dominant segment of the breakfast cereals industries. It is rapidly gaining acceptance in most countries thereby displacing some traditional

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diets or foods like pap (ogi) because of its convenience and also its nutritive value. Breakfast cereals can be consumed as dry snack food with or without water or milk added; this can be due to one's location, habits or how hungry or famished the individual might be. Previous Studies has related that 42% of 10 years old children and 35% young adults take cereals on non-breakfast occasions (Haines *et al.,*2016) . The common breakfast cereals produced In Nigeria are, Kellogg's, Quaker oats, Golden morn cereals, NASCO cornflakes and many others.

Millet is a group of small-seeded cereal grains belonging to the Poaceae family and is widely cultivated for food and fodder, especially in arid and semi-arid regions (FAO, 2018). There are different types of millet, including pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine coracana*), and foxtail millet (*Setaria italica*), each with unique characteristics suited to various growing conditions (Amadou *et al*., 2013).

Sprouting is the process by which seeds germinate and begin to grow into young plants. It is a critical stage in the life cycle of a plant, involving the transformation of a dormant seed into an actively growing organism. The process is widely recognized for its benefits in both agricultural and nutritional contexts. Sprouting is a fundamental biological process with wide-ranging benefits for plant growth, agriculture, and human nutrition. The enhanced nutrient content and digestibility make sprouted seeds an excellent addition to a balanced diet. Sprouting can help optimize conditions for seed growth, whether for agricultural production or personal consumption.

Bambara nut (*Vigna subterranea*) is a leguminous crop native to Africa and is widely grown in tropical regions for its edible seeds (Hillocks *et al.,* 2012). It is highly valued for its adaptability to poor soil conditions and resistance to drought, making it an important food security crop, particularly in arid and semi-arid areas (Murevanhema & Jideani, 2013).

Recently, legumes have been incorporated into breakfast cereals in other to increase its nutritional content or value and reduce malnutrition in masses. Most cereals do not possess some amino acids especially Threonine, Lysine, Methionine and Tryptophan (Onweluzo and Nnamuchi, 2019). Legumes have high contents, in range of 20 –40%, about twice that of cereals and root tubers (Kent, 2020). Therefore, the combination of legumes and cereals to produce breakfast cereal foods helps to supplement nutrients that either of the both might lack which the other contains.

MATERIALS AND METHODS

Source of Raw Materials

Wholesome millet and bambaranut seeds were purchased from a commercial store in Eke market Afikpo. Good and clean water was gotten from the Student Centre of the school, Akanu Ibaim Federal Polytechnic Unwana in Ebonyi state.

Preparation of Raw Materials

The millet and bambara nut seeds were sorted to remove dirt and other materials that may serve as contamination. Damaged seeds were also removed.

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Preparation of Sprouted Millet Flour

The flour was produced using the method described by Okafor, Jane, Ani and Gabriel (2014) to sprout the millet seeds with slight modifications. Millet seeds were sorted, washed, and soaked in clean water for 12 hrs at room temperature (28±2°C) with change in soaking water at 4hr. interval to prevent fermentation. Soaked seeds were separately spread on jute bag and covered with the same and was allowed to sprout for 48 hrs. with sprinkling of water at 3hrs intervals. After sprouting period, the seeds were evenly spread on oven trays and dried at 60ºC for 12 hrs. It was then dehulled, winnowed and hammer-milled into a flour of 0.6mm size, sieved and packaged differently in high-density polyethylene bag for further use or analysis.

Preparation of Sprouted Bambara Nut Flour

The flour was produced using the method described by Okafor, Jane, Ani and Gabriel (2014) to sprout bambara nut seeds with slight modifications. Bambara nut seeds were sorted, washed and soaked in clean water for 24 hours at room temperature (28 ± 2ºC) with change in soaking water at 4 hrs interval to prevent fermentation. Soaked seeds were separately spread on jute bag and covered with the same and was allowed to sprout for 48 hrs. with sprinkling of water at 3-hrs intervals. After sprouting period, the seeds were evenly spread on oven trays and dried at 60°C for 20 hrs. It was then dehulled, winnowed and hammer-milled into a flour of 0.6mm size, sieved and packaged differently in high-density polyethylene bag for further use or analysis.

Preparation of flour blends

Flour blends were formulated by mixing milled sprouted millet flour and sprouted bambaranut flour at different rations to generate composite flour Sample. 100% corn flour was used as a control.

Table 1: Blend formulation for composite flour from sprouted millet and bambaranut flours.

Sample code	Ratio of SMF (%)	Ratio of SBF (%)	Ratio of YCF (%)
AOE	90	10	___
BOD	60	40	___
COC	70	30	___
DOB	50	50	___
EOA	___	___	100

KEY:

SMF = Sprouted Millet Flour.

SBF = Sprouted Bambara nut Flour.

YCF = Yellow Corn Flour

Production of Breakfast Cereals

Breakfast cereals were produced from the flour blends formulated as shown in the above table according to the method described by Chima *et al.,*(2022). For each flour blend, 200g of composite flour was manually mixed with 24g of sugar, 3 drops of milk flavor and 0.4g of salt in stainless steel bowl for about 3 minutes to obtain a uniform mixture. Water (160ml) was added slowly, and the entire dough mixed thoroughly for about 2 minutes to obtain uniform dough. The dough was steamed for 10 minutes to gelatinize the flour. The dough was shaped into flakes of

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breakfast cereals using a manual cold extruder and transferred into baking pans. The flakes of breakfast cereals were toasted with oven at a temperature of 150°C for 35 minutes. The breakfast cereals flakes were allowed to cool under room temperature, de-panned, packaged in containers or polyethylene bags and stored at room temperature for the various determinations or evaluations.

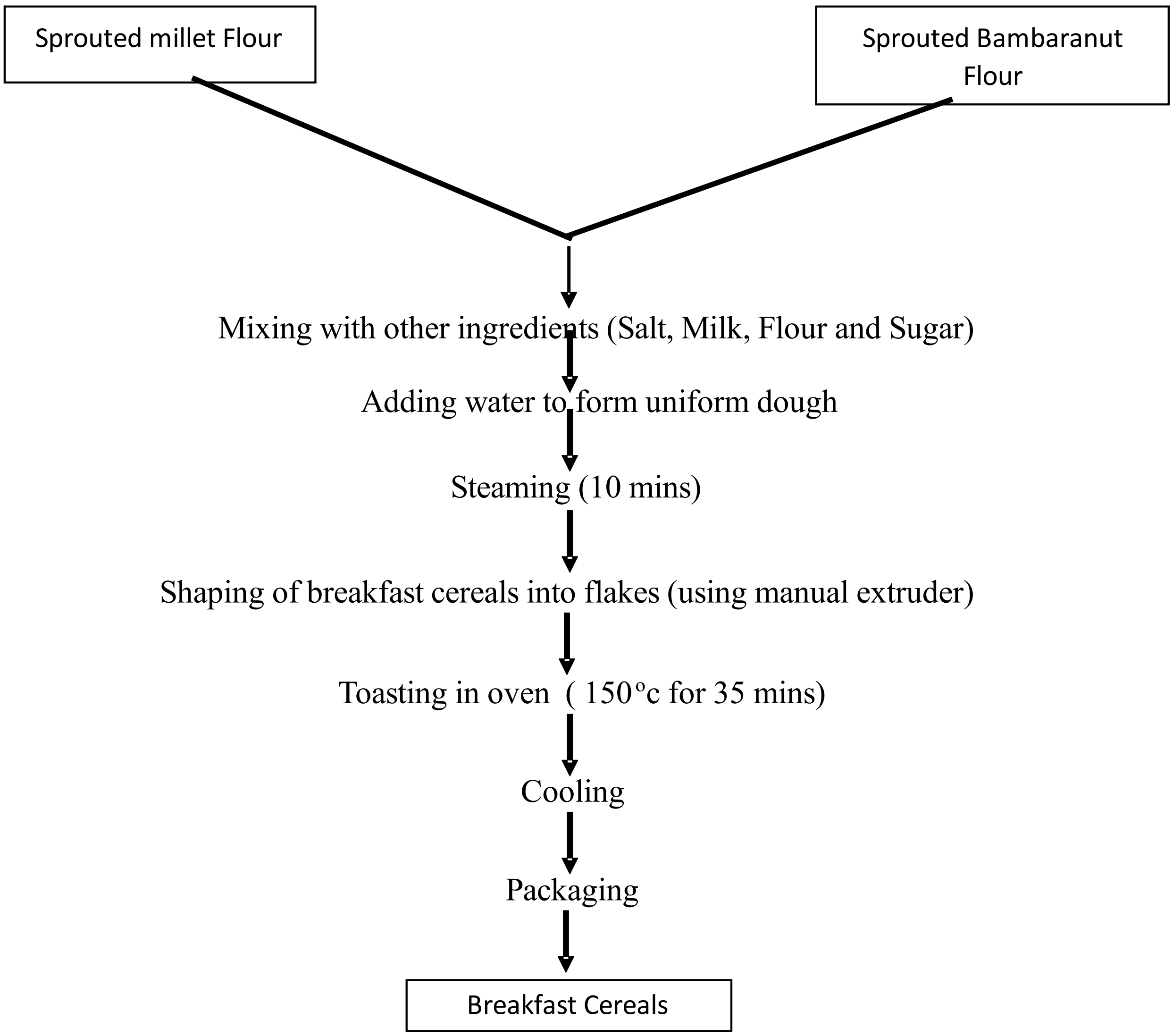

Fig. 1: Flow chart for production breakfast cereal

Proximate Composition

The proximate composition (Moisture, protein, fat, ash and fibre) of the cookies samples were deter-mined according to the standard methods described by AOAC, (2005) while carbohydrate content was determined by difference.

Sensory Evaluation

A ten-man panelist was selected from the department of Food Technology, Akanu Ibaim Federal Polytechnic Unwana, Ebonyi state. The panelists were screened with respect to their interest and ability as described by Ihekeronye and Ngoddy (2014). The study was carried out in a well illuminated sensory evaluation room. At mid-morning, each panelist was provided with clean water to rinse their mouths between the five evaluation sessions of 3 minutes interval. The 100% yellow corn flour sample was served as control.

Statistical Analysis

Data from proximate analysis and sensory evaluation were subjected to analysis of variance (ANOVA), and difference between means were assessed by least significant difference test at $p<0.05$, using SPSS Version 23

RESULTS AND DISCUSSION

Proximate Composition results of Breakfast Cereals samples

SAMPLE CODES	MOISTURE CONTENT (%)	CRUDE PROTIEN (%)	FAT (%)	CRUDE FIBER (%)	ASH (%)	CARBOHYDRATE
AOE	$9.84^{a}\pm0.04$	$8.44^{e}\pm0.02$	$14.56^{b}\pm0.02$	$1.66^{d}\pm0.04$	$1.24^{e}\pm0.02$	$64.28^{c}\pm0.01$
BOD	$8.26^{e}\pm0.03$	$9.83^{d}\pm0.01$	$10.85^{e}\pm0.02$	$1.86^{c}\pm0.01$	$1.76^{c}\pm0.02$	$67.46^{a}\pm0.01$
COC	$9.35^{b}\pm 0.04$	$11.92^{a}\pm0.02$	$12.52^{c}\pm0.01$	$2.36^{a}\pm0.03$	$2.16^{a}\pm0.01$	$61.70^{e}\pm0.01$
DOB	$8.97^{c}\pm0.03$	$10.85^{b}\pm0.01$	$11.54^{d}\pm0.01$	$2.05^{b}\pm0.01$	$1.92^{b}\pm0.02$	$64.68^{b}\pm0.01$
EOA	$8.66^{d}\pm0.04$	$10.46^{c}\pm0.01$	$14.84^{a}\pm0.02$	$1.25^{e}\pm0.03$	$1.36^{d}\pm0.03$	$63.44^{d}\pm0.01$

Values are $\pm$ standard deviation of triplicate determination. Difference within the same column are significantly different at ($P < 0.05$).

KEY:

AOE = 90%SMF (Sprouted Millet Flour) + 10% SBF (Sprouted Bambaranut Flour)
BOD = 60%SMF (Sprouted Millet Flour) + 40% SBF (Sprouted Bambaranut Flour)
COC = 70% SMF (Sprouted Millet Flour) + 30% SBF (Sprouted Bambaranut Flour)
DOB = 50% SMF (Sprouted Millet Flour) + 50% SBF(Sprouted Bambaranut Flour)
EOA = 100% YCF (Yellow Corn Flour)

The results prepared shows that there was significant difference ($p <0.05$) across the key parameters, namely:

Moisture Content: The range value for moisture content was (8.26 % - 9.84%) with sample AOE having the highest moisture context and Sample BOD having the least moisture content. The moisture content value recorded in this study (9.35%) for sample COC was the same as recorded (9.35%) for sample formulation (80% Sorghum + 15% Bambaranut flour + 5% date fruit flour), in sorghum-based breakfast meal flour reported by (Olurin *et al*., 2021). Kabuo *et al*., (2015) noted that different food materials have different capacity for absorbing or retaining moisture which may exist as absorbed water.

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Moisture content is important because it affects the shelf life of products. Lower moisture content generally indicates better storage stability and lower risk of microbial growth (Khalil *et al.,* 2020). However, high moisture could contribute to softer textures which might not be favorable in breakfast cereals.

Protein Content: The crude protein value observed for sample DOB (10.85%),was similar to the value (10.37%) reported for formulation (60% sorghum + 25% Bambara nut flour + 15%+ 15% Date fruit flour for sorghum based breakfast by Olurin et al., 2021.

Considering the crude protein content, sample COC had the highest protein content, while sample AOE had the lowest protein content, which suggests that the inclusion of more bambaranut in the flour sample, improves protein content. Bambaranut is known for its high protein content and complementary amino acid profile to that of millet (Adebowale *et al.*, 2021). The increased protein content in these breakfast cereals will improve their nutritional value, especially for protein-deficient diets.

Fat Content: Fat content is relatively high across all samples, with yellow corn flour (control) having the highest fat percentage (14.84%) and other formulations ranging from 10.85% to 14.56%, Fat content is important for the flavor and energy value of breakfast cereal. Higher fat contributes to better mouth feel and enhances the energy density of the cereal, making it a good source of energy.

Fibre Content: Crude fiber content ranges from 1.25% (sample EOA) to 2.36% (sample COC). The fiber content increases as the percentage of bambaranut increases, particularly in sample COC. The value obtained or the fiber in this study for sample DOB (2.05%) and sample COC (2.36%) is slightly lower than the value(4.58%) reported for bambaranut by (Anhwange and Atoo., 2015).

Fiber is crucial for digestive health and is often a desirable attribute in breakfast cereal (Oboh *et al*, 2022). The high fiber content in sample COC could improve satiety and digestive health, making it a good choice for individuals seeking fiber rich diets.

Ash Content: The range value for ash content is (1.24% - 2.16%) with sample COC scoring the highest and sample AOE having the least score (1.24%). The ash content value obtained in sample COC (2.16%) was slightly lower than the value (3.53%) obtained for bambara nuts by (Anhwange and Atoo., 2015).

The higher ash content in the millet-bambara nut blend suggests higher mineral content which are vital for bone health and metabolic functions (Yusuf *et al*., 2018). This makes the composite flours nutritionally superior to yellow corn flour in terms of mineral availability.

Carbohydrate Content: Carbohydrate content is highest sample BOD (67.46%) and lowest in sample COC (61.70%). Increased bambara nut ratios leads to a reduction in carbohydrate percentage due to the higher fat and protein contents of bambara nut (Ajayi *et al*., 2021). For individuals seeking low carbohydrate options, formulations with higher bambara nut percentage may be preferred. The Carbohydrate content value of bambara nuts reported by Anhwange and Atoo., (2015) was slightly lower than the values recorded for carbohydrate content in this findings.

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The proximate composition of millet-Bambara nut composite flour makes it a primary alternative to traditional yellow corn flour for breakfast cereal production. Higher protein, fat and fiber content as a result of this blend suggest that these formulations may be suitable for improving the dietary quality of consumers.

SAMPLE CODES	COLOUR	AROMA	TASTE	TEXTURE	CRUNCHINESS	APPREARANCE	OVERALL ACCEPTABILITY
AOE	$6.90^{ab}\pm0.88$	$6.00^{ab}\pm1.25$	$6.30^{b}\pm1.25$	$6.10^{a}\pm1.45$	$7.00^{a}\pm1.56$	$6.20^{b}\pm1.40$	$6.90^{b}\pm1.20$
BOD	$5.60^{bc}\pm1.35$	$5.10^{bc}\pm1.37$	$7.70^{ab}\pm1.25$	$6.40^{a}\pm1.84$	$7.20^{a}\pm1.23$	$6.30^{b}\pm1.16$	$7.10^{ab}\pm1.52$
COC	$6.10^{b}\pm1.10$	$5.50^{b}\pm1.58$	$7.20^{ab}\pm1.48$	$6.50^{a}\pm1.27$	$7.40^{a}\pm1.07$	$5.80^{b}\pm1.69$	$6.90^{b}\pm1.29$
DOB	$4.60^{c}\pm2.32$	$3.70^{c}\pm2.36$	$4.60^{c}\pm2.50$	$5.90^{a}\pm1.66$	$6.80^{a}\pm1.03$	$5.90^{b}\pm1.52$	$5.70^{b}\pm2.31$
EOA	$7.40^{a}\pm1.17$	$7.30^{a}\pm0.95$	$7.90^{a}\pm0.99$	$7.30^{a}\pm1.25$	$7.70^{a}\pm1.16$	$7.70^{a}\pm1.34$	$8.40^{a}\pm0.97$

Sensory Evaluation Results of Breakfast Cereal Samples

Values are mean and standard deviation of triplicate determination. Mean with different superscript within the same column are significantly different ($p<0.05$).

KEY :
AOE = 90% SMF (Sprouted Millet Flour) and 10% SBF (Sprouted Bambaranut Flour)
BOD = 60% SMF (Sprouted Millet Flour) and 40% SBF (Sprouted Bambaranut Flour)
COC = 70% SMF (Sprouted Millet Flour) and 30% SBF (Sprouted Bambaranut Flour)
DOB = 50% SMF (Sprouted Millet Flour) and 50% SBF (Sprouted Bambaranut Flour)
EOA = 100% YCF (Yellow Corn Flour)

Colour: In terms of color, the control (sample EOA) scored the highest with a mean score of 7.40, suggesting a visually appealing color that is likely familiar to consumers. The color scores decreased as the proportion of bambaranut increases. Sample DOB had the lowest score (4.60), which indicates a less favorable color as compared to the other samples. This may be due to the darker appearance of bambaranut in comparison to millet and corn.

Aroma: In terms of aroma, yellow corn scored highest indicating a strong pleasant aroma preferred by consumers. As the percentage of bambaranut increases the aroma score declines. This suggests that higher bambaranut content must have an aroma less appealing to consumers. The mean value for aroma (3.70 – 7.30) was lower than that recorded (5.57-7.70) by Helen & Ragina., (2013).

Taste: Yellow corn scored highest in taste indicating high preference among consumers. The taste of sample BOD and sample COC were comparable to the control (EOA) indicating that this

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formulation retains an acceptable taste for consumers. However sample DOB scored lowest showing that a high proportion of bambaranut significantly reduces taste acceptability. The taste scores range (4.60-7.90) were lower than the values reported (6.2-8.4) for sweet potato and soybean flour complementary food by Haque *et al*., 2013.

Texture and Crunchiness: Texture ranged from 5.90 – 7.30, this was similar to that reported by James *et al,*. 2018 (5.75-7.30) for millet – based infant formula. There was no significant difference (P<0.05) in texture and crunchiness. This suggests that the texture of the various formulations were largely acceptable. With regards to the crunchiness of the various formulations, the absence of significant differences suggest that the incorporation of bambaranut flour does not adversely affect the crunchiness of the cereal, which is a desirable attribute in breakfast cereals.

Appearance: The range for appearance (5.80 – 7-70) observed in this study was similar to that recorded (6.3-8.3) for sweet potato and soybean flour complementary food by Haque *et al.,* 2013.

Overall Acceptability: The general acceptability of sample EOA (control) had the highest acceptability while sample DOB had the lowest rating. The overall acceptability scores declined as the proportion of bambaranut increased. This indicates that consumers are less likely to prefer cereals with a higher proportion of bambaranut.

Conclusion

The study shows that millet and bambara nuts composite flours have potential in breakfast cereal production, particularly with lower proportions of bambara nuts. Formulations with up to 40% bambaranut flour retained good sensory properties and can serve as nutritious alternatives to conventional cereals. However, higher proportions of bambara nuts reduced sensory acceptability especially in terms of aroma, colour and taste. The millet-bambaranut samples had a higher proportion of protein and ash content which is advantageous to protein deficient individuals.

The use of sprouted millet and bambara nut composite flour can be utilized as the major raw materials for the production of breakfast cereal food. The use of this composite flour in breakfast cereals making and other baked food products would greatly enhance the utilization of these crops in developing countries like Nigeria and West Africa at large, where the crops has not been optimally utilized.

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