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Original Research Article

Reintegrating rice bran into the diet: community readiness and anthropometric assessments in combating malnutrition in rice growing regions in Kenya

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ABSTRACT

Background: Malnutrition remains a critical public health issue in many low- and middle-income countries, particularly in sub-Saharan Africa, where it contributes significantly to childhood morbidity and mortality. Rice bran, a nutrient-rich byproduct of rice milling, holds potential as a cost-effective dietary supplement. However, in rice-growing regions like Kirinyaga, Kisumu, and Kwale in Kenya, rice bran is predominantly used as animal feed, with little recognition of its potential for human consumption. The aim of this study was to assess community knowledge, perceptions, and readiness to incorporate rice bran into the diet as a strategy to combat malnutrition, while also evaluating the nutritional status of children aged 6-59 months.
Methods: A cross-sectional study was conducted using cluster sampling in Kirinyaga, Kisumu, and Kwale. Nutritional status was assessed through stunting, wasting, and mid-upper arm circumference (MUAC) measurements. A sample of approximately 400 households per region was selected to gauge community perceptions regarding rice bran consumption.
Results: Awareness of rice bran was high in Kirinyaga (77.6%) and Kisumu (70.8%), yet it was largely perceived as animal feed, with 93.4% in Kisumu and 91.8% in Kwale associating rice bran with livestock. Malnutrition rates were notably high in Kwale, with 17.1% of children severely stunted, 5.3% severely wasted, and 12.9% experiencing edema.
Conclusions: Despite significant barriers to reintroducing rice bran into human diets, the study identified opportunities for intervention. Rice bran could be a crucial tool in combating malnutrition if effectively integrated into local food systems.

Keywords: Anthropometric assessment, Community readiness, Malnutrition, Rice Bran, Stunting

INTRODUCTION

Malnutrition remains a pervasive challenge in many low- and middle-income countries, contributing significantly to morbidity and mortality, especially among children under five years of age. In sub-Saharan Africa, despite various interventions, the burden of undernutrition- manifested through stunting, wasting, and micronutrient deficiencies- continues to compromise the growth and development of millions of young children.[1,2] Among the underlying causes of this malnutrition crisis are poverty, food insecurity, and poor dietary diversity, all of which

are exacerbated by socio-economic disparities.[3,4] One potential, yet underutilized, nutritional resource that could address these challenges is rice bran, a byproduct of rice milling. Rice bran is rich in essential nutrients, including vitamins, minerals, and dietary fiber, and has been shown to have significant health benefits.[5,6] However, in many rice-growing regions, such as Kirinyaga (Mwea), Kisumu (Ahero), and Kwale (Vanga) in Kenya, rice bran is primarily used as animal feed, with little recognition of its potential for human consumption.[7-9] This limited utilization reflects broader issues of awareness and cultural perceptions, which can hinder the adoption of nutritionally beneficial practices.[10] This study aimed to evaluate community knowledge, perceptions, and readiness to incorporate rice bran into the human diet as a potential strategy to address malnutrition. Additionally, it assessed the nutritional status of children aged 6-59 months, focusing on undernutrition.

The problem addressed in this study is the persistent high prevalence of malnutrition among children in these rice-growing regions, despite the availability of nutrient-rich byproducts like rice bran.[5,11,12] The study explores the community's knowledge, perceptions, and readiness to integrate rice bran into the local food system as a means to improve nutritional outcomes, particularly for children under five years old. Given the alarming rates of stunting, wasting, and other forms of malnutrition observed in these areas, there is a critical need to assess how rice bran can be effectively reintroduced into human diets.[13,14] The justification for this study lies in the potential of rice bran to serve as a cost-effective and locally available nutritional supplement that could significantly reduce the incidence of malnutrition. The findings provide valuable insights into the barriers and opportunities for promoting rice bran consumption, thereby contributing to broader efforts to enhance food security and nutritional health in vulnerable populations.[15,16] Moreover, this research is timely, as it aligns with global and national priorities to combat malnutrition through sustainable food systems, and food-based interventions.[17] The implications of the study are far-reaching, potentially informing public health strategies, nutritional policies, and community-based programs aimed at improving maternal and child nutrition health outcomes in Kenya and other similar contexts.[18] By understanding the factors that influence the acceptance and use of rice bran, this study could pave the way for innovative approaches to tackling childhood malnutrition.[4,17,18]

METHODS

Study design

A cross-sectional study design was employed to assess rice bran utilization and the nutritional status of children aged 6 to 59 months in Kirinyaga, Kisumu, and Kwale counties in Kenya between January 2023 and March 2023.

Study setting and population

The study population included 1,218 children aged 6-59 months from selected rice-growing regions in Nyando Sub-County (Ahero) in Kisumu, Mwea Sub-County in Kirinyaga, and Lunga Lunga Sub-County in Kwale. Household heads provided information on socio-economic characteristics, child care, dietary practices, and agricultural activities.

Sampling technique

A combination of cluster random sampling and purposive sampling was used to select participants from Kirinyaga, Kisumu, and Kwale due to their established irrigation schemes. Villages in each county were listed, and random balloting was conducted to select the first ten villages. The sample size was determined using Cochran's formula, resulting in a total of 1,218 children. To account for a 10% non-response rate, the final sample size was 1,250, with each county contributing 447 children aged 6 to 59 months. The study included households with children aged 6-59 months who resided in Kirinyaga, Kisumu, or Kwale counties, where caregivers were available and willing to participate. Households that did not have children in this age range, those with children suffering from chronic conditions unrelated to malnutrition, recent migrants, households participating in other nutrition programs, and those unable or unwilling to provide the necessary data or allow anthropometric measurements were excluded from the study.

Data collection tools and procedure

Research assistants were recruited and trained to assist with data collection. Introductory and consent letters were presented to caregivers, and only children with caregiver consent were included in the study. Anthropometric measurements, including length, weight, age, and mid-upper arm circumference (MUAC), were taken for children aged 6-59 months. Weight was measured using a portable scale, and for children unable to stand, a Salter scale was used. Data were recorded to the nearest 0.1 kg, and the WHO Anthro software (version 3.2.2, 2011) was used to calculate Z-scores for stunting, underweight, and wasting. Structured interviews were conducted with caregivers.

Statistical analysis

Data were coded and entered into a Microsoft Excel database, then exported to IBM SPSS version 26 for analysis. Descriptive statistics were used to generate frequencies. Anthropometric data were analyzed using the SMART for ENA program (2008) and interpreted using WHO (2006) cutoffs. Z-scores of ±2 SD were used to classify nutritional status. Children with MUAC values between 12.5 and 13.5 cm were considered mildly malnourished, while those with values below 11.5 cm were classified as severely malnourished.

RESULTS

Socio-demographic and economic characteristics

Table 1 reveals the socio-demographic and economic characteristics of respondents from Kirinyaga, Kisumu, and Kwale, highlighting a diverse profile. The majority (56.1%) are aged 31-50 years, likely more open to adopting new food practices, such as using rice bran. Most household heads are male (73.2%), suggesting potential male dominance in decision-making, which could affect rice bran integration, particularly since women, often primary caregivers, are underrepresented. A large majority (79.2%) are married, indicating stable households that might support new dietary practices. Religious diversity is notable, with Kirinyaga and Kisumu predominantly Christian, while Kwale has a significant Muslim population (66.6%), potentially influencing dietary practices linked to religious beliefs. Education levels vary, with most respondents having completed primary education (60.2%) and some secondary education (24.6%), suggesting that awareness campaigns should be tailored to different literacy levels. Occupationally, most respondents are engaged in farming (33.8%), casual labor (24%), and business (19.1%), reflecting the rural, agrarian nature of the study areas, which could aid rice bran reintegration due to direct agricultural involvement. Income data shows that most respondents earn less than 10,000 KES per month (61.7%), presenting economic challenges for purchasing rice bran as a supplement. A minority (5.1%) earn more than 20,000 KES monthly, reflecting limited economic diversity.

Table 1: Socio-demographic and economic characteristics of respondents.

Characteristics		Kirinyaga	Kisumu	Kwale	Total
		N (%)	N (%)	N (%)	N (%)
Age (years)	13-30	164 (43.7)	103 (27.5)	108 (27.5)	375 (31.6)
	31-50	213 (31.9)	216 (32.4)	238 (35.7)	667 (56.1)
	51-87	35 (24.0)	64 (43.8)	47 (32.2)	146 (12.3)
Gender	Male	250 (28.1)	340 (38.2)	301 (33.8)	891 (73.2)
	Female	173 (40.9)	54 (16.5)	100 (30.6)	327 (26.8)
Marital status	Single	63 (50.8)	30 (24.2)	31 (25.0)	124(10.5)
	Married	305 (32.7)	325 (34.8)	303 (32.5)	933(79.2)
	Divorced	31 (42.5)	5 (6.8)	37 (50.7)	73(6.2)
	Widowed	12 (25.0)	24 (50.0)	12 (25.0)	48(4.1)
Religion	Christianity	412(97.4)	392(99.5)	115(28.7)	919 (76.5)
	Islam	0 (0)	0 (0)	267 (66.6)	267 (22.2)
	Others	8 (1.9)	1 (0.2)	6 (1.5)	15 (1.3)
Education level	No formal schooling	10 (2.4)	12 (3)	64 (16)	86 (8.5)
	Primary	164 (38.8)	182 (46.2)	266 (66.3)	612 (60.2)
	Secondary	116 (27.4)	89 (22.6)	45 (11.2)	250 (24.6)
	Tertiary	28 (6.6)	29 (7.3)	12 (2.9)	69 (6.8)
Occupation	Formal employment	27 (27.0)	28 (28.0)	45 (45.0)	100 (8.2)
	Business	76 (31.4)	59 (24.4)	107 (44.2)	242 (19.1)
	Farming	159 (38.7)	145 (35.3)	107 (26.1)	411 (33.8)
	Casual Labor	113 (38.8)	102 (35.1)	76 (26.1)	291 (24.0)
	Unemployed	28 (31.8)	38 (42.2)	24 (26.7)	90 (7.4)
	Others	20 (24.7)	22 (27.2)	39 (48.1)	81 (6.7)
Monthly Income (KES) ($1=KES 78)	>20,000	30 (49.2)	18 (29.5)	13 (21.3)	61(5.1)
	10,000-20,000	106 (32.5)	126 (38.7)	94 (28.8)	326 (27.1)
	<10,000	255 (34.3)	231 (31.1)	257 (34.6)	743 (61.7)
	None	32 (42.7)	16 (21.3)	27 (36.0)	75 (6.2)

Anthropometric measurements and nutritional status

Table 2 highlights the prevalence of malnutrition among children aged 6-59 months in rice-growing regions, showing significant regional differences. Kisumu has the highest proportion of children with normal weight (88.9%), followed by Kirinyaga (85.1%) and Kwale (76.8%). Overweight prevalence is low across all regions, with slightly higher rates in Kisumu (4.3%) and Kirinyaga (4.1%) than Kwale (2.9%). However, Kwale has the highest rate of underweight children (9.6%), reflecting severe nutritional deficiencies. Severe stunting, an indicator of chronic malnutrition, is most prevalent in Kwale (17.1%), as is severe wasting (5.3%). Moderate

wasting is more common in Kirinyaga (8.5%). Edema, a sign of severe malnutrition, is alarmingly high in Kwale (12.9%), indicating a critical malnutrition crisis that demands urgent intervention. Table 3 shows the prevalence of stunting among children aged 6-59 months across age groups. In the youngest group (6-17 months), most children fall within the normal height range, with Kirinyaga at 75.9%, Kwale at 71.5%, and Kisumu at 70.2%. Severe stunting starts early, with Kwale having the highest prevalence (13.1%). In the 30-41 months group, severe stunting peaks at 20% in both Kwale and Kirinyaga, and 15.5% in Kisumu. As children age, severe stunting decreases, but Kwale consistently has the highest total severe stunting prevalence (17.1%), compared to Kirinyaga (12.1%) and Kisumu (11.1%).

Table 2: Prevalence of malnutrition based on age in wasting, stunting, underweight and overweight for children aged 6- 59 months.

Characteristics	Kirinyaga (%)	Kisumu (%)	Kwale (%)
Normal	85.1	88.9	76.8
Overweight	4.1	4.3	2.9
Underweight	4.7	1.5	9.6
Severe stunting	12.1	11.1	17.1
Severe wasting	3.5	2.2	5.3
Moderate wasting	8.5	3.6	5.1
Oedema	2.8	5.3	12.9

Normal (>-2 z score); severe wasting (<-3 z-score); moderate wasting (>-3 and <-2 z-score).

Table 3: Prevalence of stunting by age based on height-for-age z-scores for children aged 6-59 months.

County	Kirinyaga (%)				Kisumu (%)				Kwale (%)			
Age (months)	**N**	**Severe stunting**	**Moderate stunting**	**Normal**	**N**	**Severe stunting**	**Moderate stunting**	**Normal**	**N**	**Severe stunting**	**Moderate stunting**	**Normal**
6-17	89	4.6	19.5	75.9	104	7.7	22.1	70.2	139	13.1	15.3	71.5
18-29	98	16	22.1	61.1	95	17.6	16.5	65.9	124	24.4	22.7	52.9
30-41	90	20	13.6	65.9	87	15.5	13.1	71.4	83	20.3	19.0	60.8
42-53	75	8.3	15.3	76.4	65	3.3	26.2	70.5	35	12.5	18.8	68.8
54-59	27	7.4	11.1	81.5	9	9.1	18.2	72.7	12	0.0	28.6	71.4
Total	379	12.1	17.3	70.6	360	11.1	19.1	69.5	393	17.1	19.0	63.1

Table 4: GAM and SAM for children under five years.

County	Kirinyanga n=379		Kisumu n=360		Kwale n=393	
Indicator	**GAM (%)**	**SAM (%)**	**GAM (%)**	**SAM (%)**	**GAM (%)**	**SAM (%)**
MUAC	11 (2.9)	2 (0.5)	7 (1.9)	6 (1.7)	5 (1.3)	3 (0.8)
WHZ	33 (8.7)	13 (3.4)	19 (5.3)	7 (1.9)	33 (8.4)	16 (4.1)
Oedema		11 (2.9)		19 (5.3)		47 (12.0)
Total	44 (11.6)	26 (6.7)	26 (7.2)	32 (8.9)	38 (9.7)	66 (16.8)

Table 5: Participants knowledge on rice bran.

Characteristics	Kirinyaga % (N)	Kisumu % (N)	Kwale % (N)
Have you ever heard about rice bran?	77.6 (328)	70.8 (279)	51.5 (207)
Rice bran is used as a food for domestic animals	88.6 (375)	93.4 (367)	91.8 (367)
Rice bran is used for complementary feeding	8.7 (37)	5.5 (22)	5.7 (23)
Rice bran is used for household consumption	2.6 (11)	1.0 (4)	2.5 (12)

Table 4 presents the prevalence of global acute malnutrition (GAM) and severe acute malnutrition (SAM) among children under five. Indicators include mid-upper arm circumference (MUAC), weight-for-height z-scores (WHZ), and the presence of edema, a clinical sign of severe malnutrition. GAM and SAM based on MUAC are relatively low across all regions, with severe cases seen mainly in Kisumu. However, GAM prevalence is notably higher when measured by WHZ, with Kirinyaga and Kwale reporting rates of 8.7% and 8.4%, respectively. SAM prevalence was highest in Kwale at 4.1%, suggesting that acute malnutrition is more severe when assessed by WHZ. Edema prevalence, a sign of severe malnutrition, was significantly higher in Kwale (12.0%), indicating a critical malnutrition crisis in the region. Kwale exhibits the highest overall burden, with a total GAM rate of 9.7% and SAM at 16.8%, compared to Kisumu's GAM of 7.2% and SAM of 8.9%, and Kirinyaga's GAM of 11.6% and SAM of 6.7%.

Knowledge and perceptions of rice bran utilization

Table 5 highlights participants' knowledge and perceptions of rice bran across the regions. Awareness is high in Kirinyaga (77.6%) and Kisumu (70.8%), but lower in Kwale (51.5%). Across all regions, rice bran is overwhelmingly perceived as animal feed, with 93.4% in

Kisumu, 91.8% in Kwale, and 88.6% in Kirinyaga associating it with livestock use. Despite this awareness, its use in complementary feeding for children remains minimal, revealing a gap in recognizing its nutritional benefits. Rice bran's use for general household consumption is also extremely limited, further reinforcing its perception as animal feed rather than human food.

Perceptions of rice bran's nutritional value and appropriate use

Figure 1 illustrates the participants' perceptions of rice bran's nutritional value and appropriate use. Only 19.6% of respondents believe rice bran is nutritious, while 46.7% disagree, with Kwale showing the highest agreement (27.4%). Most respondents (55.3%) view rice bran as suitable for animal feed, reflecting its limited acceptance as human food. Only 17.5% support its use in children's diets, with resistance highest in Kirinyaga (62.2% disagreement). Similarly, only 16.8% agree with using rice bran for people with chronic conditions. Overall, 57% reject the idea of rice bran being consumed by everyone, indicating reluctance to adopt it into regular diets.

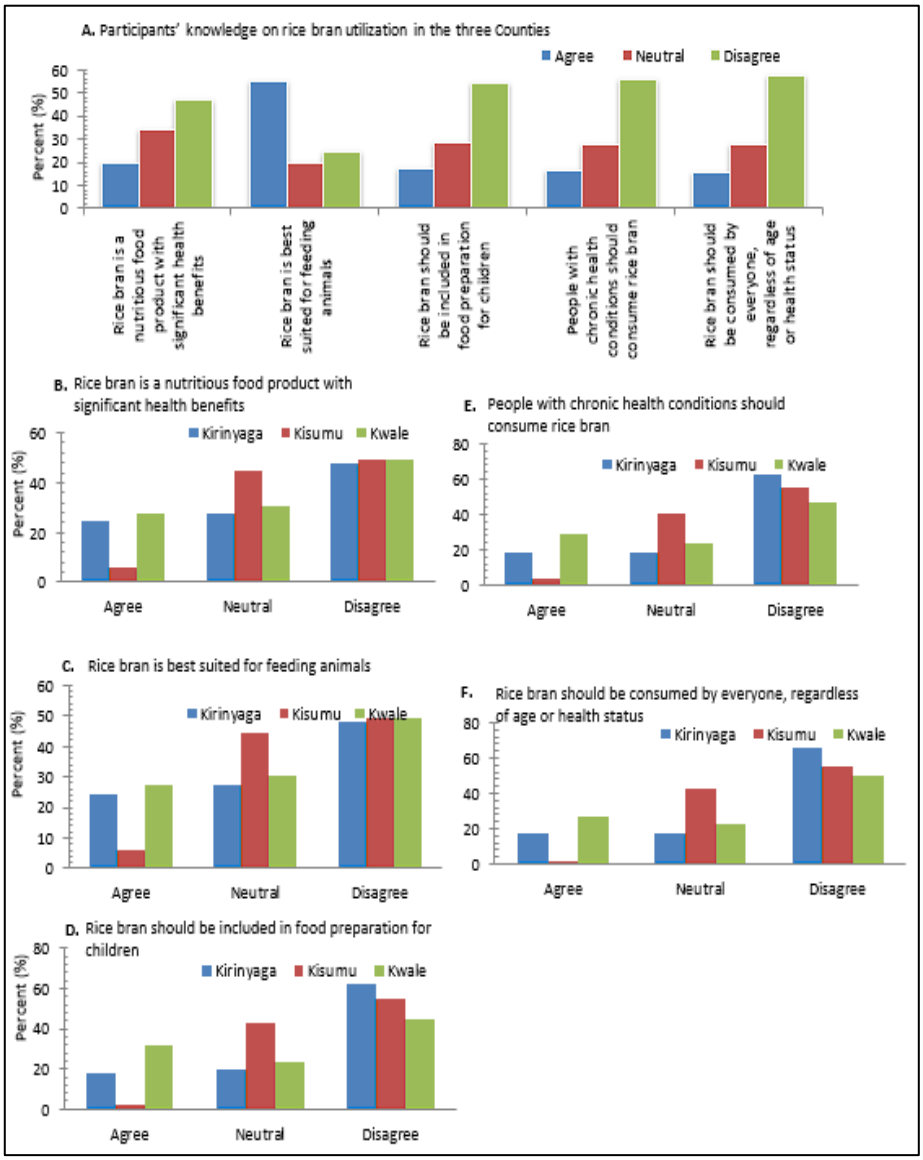

Figure 1: Knowledge on rice bran utilization.

DISCUSSION

Socio-demographic and economic characteristics

The socio-demographic and economic characteristics of the study population suggest that there is potential for integrating rice bran into the local food system, particularly due to the agrarian nature of the communities and the existing engagement in farming.[19] However, the low income and education levels pose significant challenges, as these factors may limit both the purchasing power and the awareness of the nutritional benefits of rice

bran. The gender imbalance and varied marital statuses also imply that household dynamics can play a crucial role in the acceptance and implementation of new dietary practices. Additionally, religious and cultural factors must be carefully considered to ensure that the promotion of rice bran is culturally sensitive and widely accepted.[20] The findings indicate that community readiness for utilizing rice bran as a food supplement will require comprehensive educational campaigns and possibly economic incentives to overcome the existing barriers related to income and education.[21,22] Integrating rice bran into the diet could significantly improve nutritional outcomes for young children, potentially reducing the incidence of malnutrition in these regions.

Nutritional status and prevalence of malnutrition

Kwale experiences the highest rates of underweight, severe stunting, severe wasting, and edema, putting children at greater risk of chronic and acute malnutrition, with serious consequences for their health and development.[13,23] Although Kisumu and Kirinyaga show better overall nutritional status, they still face significant levels of stunting, wasting, and underweight, indicating that malnutrition remains a challenge. Reintroducing rice bran into the local food system as a nutritional supplement could be especially beneficial in these regions.[9,11,14,24] Given the malnutrition severity in Kwale, promoting rice bran, a byproduct known for its nutritional value, could improve dietary intake and reduce malnutrition rates. The situation in Kwale highlights the urgency for targeted nutritional interventions. Programs that increase access to nutrient-rich supplements like rice bran, along with broader initiatives to enhance food security and dietary diversity, could lead to significant improvements in children's nutritional outcomes across these areas.[25,26]

Stunting remains a significant concern across all three regions, with severe stunting becoming more prevalent as children age, particularly in Kwale. This points to the impact of chronic malnutrition on children's growth, especially between 18-41 months, a crucial period for meeting increased nutritional needs.[27] Kwale is especially affected, indicating that prolonged periods of inadequate nutrition are common, likely due to factors such as food insecurity, limited dietary diversity, or poor feeding practices.[22,28-30] The combination of high stunting rates, along with previous reports of underweight and wasting, highlights a severe and ongoing malnutrition crisis in the region. Early childhood stunting has long-term consequences, including hindered cognitive development, poor academic performance, and reduced productivity in adulthood, underscoring the urgency for intervention.[31,32]

There is a significant burden of acute malnutrition among children under five in these rice-growing regions, with Kwale being the most affected, particularly with a high prevalence of severe cases, as shown by SAM rates and edema. This points to a severe nutritional crisis in Kwale, likely driven by food insecurity, poor dietary habits, or limited healthcare access. Kirinyaga also presents notable levels of GAM and SAM, especially when assessed using WHZ, indicating that while the situation is less critical than in Kwale, serious concerns about children's nutritional health remain.[33-35] Promoting the inclusion of rice bran in the diet could be a key step in tackling this malnutrition crisis. Additionally, addressing root causes like food security and access to healthcare is essential for sustainable improvements in child nutrition in these areas.[33]

Knowledge and perceptions of rice bran utilization

The findings show that although awareness of rice bran is relatively high, especially in Kirinyaga and Kisumu, its primary use remains as animal feed. The limited use of rice bran for complementary feeding or household consumption suggests that the community has yet to recognize its potential as a nutritious supplement for human diets. This underutilization indicates a need for education and awareness campaigns to shift perceptions and encourage its adoption as a food supplement. Given our aim to re-integrate rice bran into the local food system to improve child nutrition, there is a clear need for targeted interventions that promote rice bran health benefits and potential to reduce malnutrition.[13,14] The variation in awareness levels suggests the importance of region-specific outreach to increase knowledge about rice bran's nutritional value and safe use, which could significantly improve children's nutritional status and reduce malnutrition.[36]

There is a notable challenge in changing community perceptions and practices around using rice bran as a food supplement. Most respondents across the three regions still consider rice bran primarily as animal feed, with significant resistance to its inclusion in the diets of children, adults, or those with chronic health conditions. This resistance highlights the need for health campaigns and awareness programs to shift these attitudes.[37,38] The low percentage of participants acknowledging rice bran's nutritional benefits underscores the importance of targeted interventions that demonstrate its role in improving nutrition, particularly in reducing malnutrition among children. The strong opposition to incorporating rice bran into human diets, especially in Kisumu and Kirinyaga- where stunting and wasting are prevalent- reflects a gap between available nutritional resources and current practices.[39] To reintegrate rice bran into the local food system, tailored outreach efforts must address cultural and practical concerns, proving its safety and health benefits. Without such efforts, the potential of rice bran to improve nutrition, particularly in areas like Kwale, may remain unrealized. Future comparisons with anthropometric measures like stunting and wasting will provide further insight into how rice bran can be effectively utilized to combat malnutrition.

The study had limitations, including the cross-sectional design, which limited causality assessment, and potential sampling bias due to the selection of villages with irrigation schemes. Reliance on self-reported data risked bias, and the exclusion of children with unrelated chronic conditions overlooked vulnerable groups. The short study period and unexamined cultural beliefs may have influenced results.

CONCLUSION

In conclusion, rice bran has significant potential as a nutritional supplement in Kirinyaga, Kisumu, and Kwale, but community perceptions and resistance pose challenges to its adoption. Targeted nutrition education is essential to promote its benefits and overcome cultural barriers. Given the high rates of malnutrition, particularly stunting and wasting, efforts to improve children's nutritional status are crucial. Future research should focus on the effectiveness of educational interventions and the impact of rice bran consumption on malnutrition indicators like stunting, wasting, and MUAC.

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