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ACCEPTABILITY OF GERMINATED PORRIDGES WITH MICRONUTRIENT POWDER AMONG CHILDREN (6-23 MONTHS) IN KENYA: A PARALLEL SITE-RANDOMIZED FEEDING TRIAL

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ABSTRACT: *Introduction: Foods prepared from germinated ingredients have lower antinutrients and thus suitable vehicles for Micronutrient powder (MNP). Unfortunately, home consumption of these food products is declining in Kenya. Methods: Three phase acceptability study: a seven-day phase one using a cross-over design, a two-week parallel site-randomized feeding trial, and a focus group discussion with caregivers. Results: Caregivers reported significant differences in color and texture between germinated flour porridge and control porridge, but these differences did not impact overall acceptance. Significantly more non-germinated flour porridges were consumed during the sensory testing. Conversely, germinated flour sorghum porridge ($p=0.003$), maize ($p=0.127$), and millet ($p=0.073$) were consumed over a 2-week feeding phase. Significantly more germinated flour porridges compared to non-germinated flour porridges were consumed in the latter days compared to the initial days ($p<0.001$). Caregivers gave positive feedback on the germinated porridges. Conclusion: The three germinated porridges were accepted and could serve as vehicles for MNP in Homa-bay County.*

KEYWORDS: Germination, sensory evaluation, young children, micronutrient powders, Homa-bay county, Kenya.

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INTRODUCTION

Cereals and legume-based foods are typical complementary foods in Kenya. Specifically, porridge and *ugali* (stiff porridge) made from milled cereal grains (maize, millet, and sorghum) are the commonest complementary foods for infants across the country (Walingo, 2009). The nutritional value of these foods is constrained by anti-nutrients such as phytates, oxalates, and lectins that reduce the digestibility and bioavailability of micronutrients among them iron and zinc. Low rates of consumption of animal based foods, coupled with the predominant use of cereal-based complementary foods, are therefore thought to contribute to the high levels of iron and zinc deficiency in low-income countries including Kenya (White et al., 2021).

Soaking and germination are known processes that break down the anti-nutrients, increasing the amounts of bioavailable essential micronutrients (Mahanta et al., 2020). Germination of grains has been used for a long time, probably because it is practical in any setting, relatively simple and cheap (Singh, Rehal, Kaur & Jyot, 2013). Unfortunately, the use of germination and other traditional food processing practices that were previously practiced in Kenya are quickly disappearing due to changing lifestyles, food preparation methods, and food taste preferences (Casari et al., 2022; Reardon et al., 2021; Walingo, 2009). The use of germinated or fermented soft porridges as complementary foods is about 10% in our study population (Momanyi-Nyasimi et al., 2024). The neighboring communities with comparable cultural orientations also reported low utilization of fermented complementary foods (Ahoya et al., 2019).

The use of commercial micronutrient powders (MNP), which consists of multiple micronutrients in powder form for point-of-use fortification of foods consumed by children 6-23 months, is one of many strategies to address micronutrient deficiencies in settings with high prevalence of micronutrient deficiencies (World Health Organization, 2016). MNPs contain essential micronutrients that are ready to use with solid and semi-solid complementary foods. It is widely known that MNPs have no or negligible effects on the sensory properties of carrier foods and high acceptability (Home Fortification Technical Advisory Group (HFTAG), 2015; World Health Organization, 2016). However, some studies have reported sourness, medicinal taste, and bitterness which they have attributed to improper preparation or choice of the carrier food or poor quality of the MNP (Creed-Kanashiro et al., 2016; Gittelsohn & Cristello, 2014; Kounnavong et al., 2011).

MNPs require a suitable vehicle that does not hinder the bioavailability of the nutrients. In Kenya, cereal-based foods are the most likely vehicles of choice for the addition of the MNPs. To reduce the anti-nutrients and maximize the bioavailability of the intrinsic and supplemental iron and zinc in the cereals and the MNP, the use of flours from germinated grains is recommended. Yet, evidence of the acceptability of complementary foods prepared from germinated ingredients is lacking. This study determined the consumer acceptability of germinated flour porridges with added MNP in Homa-bay County, a rural county in Kenya.

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METHODOLOGY

Study Setting

We conducted this study in four sub-locations within West Kwabwai location in Homa-bay County, Kenya. The area is predominantly inhabited by the Luo community, whose main livelihood is fishing and sugarcane farming. Sugarcane farming has expanded in the area, with more land acreage devoted to it at the expense of nutritious and staple food crops such as maize and sorghum. The location has a malnutrition rate of 27.5% and poverty level of 44% (Kenya National Bureau of Statistics, 2018).

Eligibility Criteria

This study included caregivers who were the primary caregivers of children aged 6-23 months, lived in the study area, and could understand the study's purpose to provide informed consent. Eligible children had to have been consuming semi-solid or solid complementary foods at least once daily for two weeks before the study. Exclusion criteria included children with illnesses affecting appetite, severe malnutrition (height-for-age (HAZ), weight-for-age (WAZ) or weight-for-height (WHZ) Z-scores < -3 with respect to World Health Organization growth standards (World Health Organization 2006), or known allergies to the cereal used in the study.

Study Design

The study was conducted in three phases: a seven-day phase one using a cross-over design followed by a two-week parallel site-randomized feeding trial, and then a focus group discussion. The study personnel and caregivers did not know the identity of the flour and the porridges.

Sample Size

Phase One: Pairs of 50 healthy children, 6-23 months old, and their caregivers.

Phase Two: A sample size of 200 children for the randomized controlled trial was calculated using the formula $m = [c /\delta^2]2$ (Chan, 2003), where, m = total sample size for control and intervention, c = 7.9 for 80% power, δ = 30% standardized effect size. Estimates of the standard deviation, design effect, and attrition rate were based on previous studies in Kenya (Macharia-Mutie et al., 2012; Suchdev et al., 2012). Fifty children were assigned to each group because a minimum of 50 judgments was required to provide sufficient statistical power (De Kock et al., 2016).

As shown on Figure 1, 50 mother-child pairs were assigned to each of three experimental groups—germinated maize, millet, and sorghum flour porridge—along with a control group. Each group participated in a two-week feeding period, with the control group having a one-week rest between tests to minimize carryover effects. Children from the first phase were excluded from this phase.

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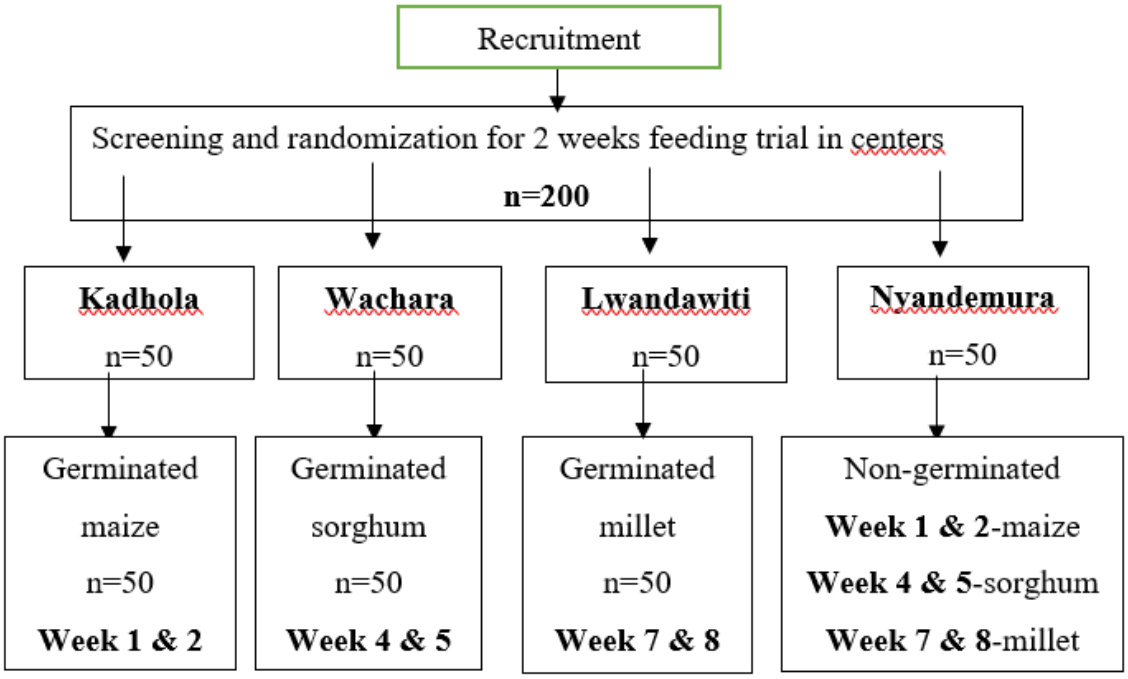

Figure 1: Representation of the research approach for acceptability trial

Phase 3: Thirty-six caregivers (12 per intervention arm) participated in the focus group discussion

Sampling Method

i. **Phase One:** The fifty pairs of children and caregivers were selected by simple random sampling from the listed households.

ii. **Phase Two:** The study participants were recruited at the sub-locations. All children aged 6-23 months were first screened at the community level by community health workers. A listing of all households with children aged 6-23 months in each sub-location was compiled of those found eligible for the study. Simple random sampling was done to select and enroll the study participants based on the sample size required.

iii. **Phase Three:** Convenience sampling was used to identify 12 participants from among the phase two's 50 participants in each intervention arm.

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Data Collection

1. Phase One

Sixty minutes before feeding the children study porridge, caregivers were instructed not to provide any foods (including breast milk) to their children and complete a brief questionnaire on child illness symptoms and a description of the child's appetite over the past 24 hours. To evaluate the taste, texture, color, and flavor of the porridge, the caregiver tasted a spoonful and reported her assessment using a 5-unit hedonic scale with smiley faces (with 1 as 'strongly like' and 5 as 'strongly dislike').

After that, the caregiver fed the child for 15 minutes until the child either finished or refused more porridge. For those who refused more before the 15-minute mark, the researcher instructed the mother to wait for 30 seconds before offering it a second and final time. For all children, feeding was stopped at 15 minutes, and the amount consumed was assessed. The amount of spilled or regurgitated porridge was measured by soaking up the spillage with pre-weighed towels and factored into the calculations. The investigator recorded the duration of the feeding. Immediately after feeding, we asked the mother to indicate the child's reaction to the product using a 5-unit hedonic scale with smiley faces.

2. Phase Two

Upon arrival at the study site, caregivers were instructed not to feed the children (including breast milk) for 60 minutes prior to offering the study porridge. Caregivers then completed a brief morbidity questionnaire regarding their children's illness symptoms over the past 24 hours. After the 60 minutes elapsed, the caregiver was asked to feed her child until either the child finished or refused more porridge. In cases where the child did not finish the porridge, the researcher instructed the mother to wait 30 seconds before presenting it a second and final time. The amount of porridge consumed by the child was then recorded after weighing. The amount of spilled or regurgitated porridge was measured by mopping the spillage with pre-weighed towels and factored into the calculation.

3. Phase Three

A semi-structured focus group discussion (FGD) guide was used to explore caregivers' perceptions of the porridge and their willingness to continue using it if provided with the flour. Local community health workers recruited participants, and discussions were conducted in Dholuo, the local language. A trained moderator facilitated the FGDs, adapting the discussion based on participants' responses. All sessions were tape-recorded, transcribed, and analyzed to understand caregivers' attitudes toward the porridges.

Product Development

The grains (dry white maize, finger millet, and red sorghum) were purchased from the open-air market that serves the residents in the study area. We conducted the germination of the grains, modifying the methods outlined by Hotz and Gibson (2001). White maize, finger millet, and sorghum grains were prepared by soaking them in excess tap water at 22°C for 12 hours, after which the excess water was drained, as illustrated in Figure x. The grains were placed on perforated trays and covered with a cotton cloth at a temperature of 28-35°C for 48 hours, with occasional turning during the first 24 hours to facilitate sprouting and germination. The

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germinated grains, along with the vegetative portion, were sun-dried to achieve a final moisture content of 12% at a temperature of 25-28°C over 2 days. The grains underwent extrusion at temperatures ranging from 105 to 110°C to reach a moisture content of 8%, followed by electric disc milling using a sieve size of 0.8 mm. The flour (500 g) was packaged in airtight polythene bags and transported to the study area.

We prepared porridge in a large aluminium pot using a local recipe—2 kg of flour in 40 litres of community-sourced borehole water. Cooking involved bringing the water to a boil, then adding the flour while stirring with a wooden spoon for 15–20 minutes until the porridge boiled. The porridge was served in identical, pre-weighed plastic cups at the feeding centre. At a temperature of 60°C, we added a 1 g sachet of MNP to the porridge in a cup and stirred until it completely dissolved. The cup with porridge was weighed before it was passed over to the caregiver to feed the child. Before the children consumed the porridge, the caregiver cooled it to the temperature that the porridge was served to the child at home. Children who needed more were served additional porridge following the same procedure. We weighed the remnant after the child stopped eating the porridge to determine how much the child had consumed.

Statistical Analyses

These were conducted using IBM SPSS Statistics Version 25.0 [IBM Corp., Armonk, NY, USA]. Median caregiver ratings of key sensory properties were assessed by non-parametric bivariate Chi-square correlations using Kendall's tau-b for associations in organoleptic properties of porridges. Friedman's two-way non-parametric analysis of variance by ranks was used to compare differences between germinated and non-germinated porridges based on the amount of porridge eaten and the amount of time it was eaten. We conducted Wilcoxon signed rank tests to identify the individual differences between each type of germinated and non-germinated porridge. We used ANOVA to analyse the information from the acceptability trial. The analysis was performed using the General Linear Model Univariate procedure to compare the amount of porridge consumed per day to the control for each centre, using repeated measures for interactions between the 6 porridge types and the day. We used Bonferroni adjustment to adjust all p-values for multiple comparisons. Significant differences were considered at $p \leq 0.05$. Thematic analysis was employed to identify, analyse, and report themes related to caregivers' shared experiences and perspectives, as well as the underlying dynamics associated with the porridge consumed by their children.

Ethical Considerations

The Kenyatta University Ethical Review Committees (ERC) and the Institutional Review Board of the National Commission for Science, Technology and Innovation (NACOSTI) approved this study protocol. Additionally, the study received approval from the Homabay County Health and Education Departments. The study's objectives were communicated to local administrators, opinion leaders, village elders, and community members. Informed consent was obtained from the study caregivers, who were assured of data confidentiality, with personal identifiers removed prior to analysis.

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RESULTS

A. Phase One

Fifty children and their corresponding caregivers from Got Kojowi sub-location participated in the sensory testing. The children were almost evenly distributed into the three age groups (6-11, 12-17, 18-23 months). The median and mean ages of the children who enrolled in the study were both 15 months. More male children (54%) participated in the study. About 42% of the caregivers were young mothers aged between 15 and 24 years. More than 50% of the caregivers attained an incomplete primary level of education. Approximately 70% of the caregivers reported earnings of less than KES 4,000 (USD40) per month.

Caregiver's Liking and Ratings of Key Organoleptic Properties of Different Porridges

Germinated versus Non-germinated Porridges

Caregivers observed a notable difference in colour between germinated and non-germinated maize ($p=0.01$). However, when considering all key attributes, they believed that germinated maize porridge was significantly better than the non-germinated variety ($p=0.009$). Caregivers did not report any significant differences in the children's preference between the two porridges.

For sorghum, the colour and texture of non-germinated porridge were significantly superior to those of the germinated sorghum porridge ($p=0.039$; $p=<0.00$). Overall, caregivers significantly preferred the non-germinated porridge ($p=0.025$), while the children showed no preference for either porridge.

Although caregivers noted a significant difference in the texture of non-germinated millet porridge compared to the germinated version ($p=0.02$), the overall evaluation did not reveal a significant difference between the two. Similarly, the children's reactions to both porridges were not significantly different.

Between Germinated Porridges

Caregivers detected significant differences in color and taste between the germinated porridges ($p=0.046$; $p=0.012$). Germinated millet porridge tasted significantly better than sorghum porridge. The color of germinated millet porridge was better than maize and sorghum porridges. Overall, caregivers liked germinated maize porridge ($p=0.006$) while the children exhibited no significant preference among the three different porridges.

Between Non-germinated Porridges

Caregivers assessed the texture of maize porridge significantly better than sorghum and millet porridges ($p=0.02$). Overall, caregivers appraised the sorghum porridge significantly better compared to the other two porridges ($p=0.028$). Children exhibited no significant preference for a particular porridge.

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	MAIZE					SORGHUM					MILLET					Within subject comparison [1](p value)	
	Germinated (X)		Non-germinated (K)			Germinated (Z)		Non-germinated (L)			Germinated (Y)		Non germinated (M)			Germinated porridges	non-germinated porridges
	Median	IQR	Median	IQR	P value	Median	IQR	Median	IQR	P value	Median	IQR	Median	IQR	P value		
Taste	2^{ab}	1.75 - 2	2	2-2	0.439	2^{b}	2 - 2	2	2-2	0.109	2^{a}	1-2	2	2-2	0.655	**0.046**	0.513
Flavor/Aroma	2	2-2	2	2-2	0.527	2	2-2	2	2-2	0.317	2	2-2	2	2-2	0.317	0.223	0.607
Color	2^{b}	2-3	2	2-2	**0.01**	2^{b}	2-3.25	2	2-2	**0.039**	2^{a}	2-2	2	2-2	0.480	**0.012**	0.174
Texture	2	2-3	2^{a}	2-2	0.371	2	2-4	2^{ab}	2-2	**<0.00**	2	2-3.25	2^{b}	2-2	**0.02**	0.086	**0.02**
General liking	1^{a}	1-2	2^{b}	1-2	**0.009**	2^{b}	1-2	1^{a}	1-2	**0.025**	2^{b}	1-2	2^{ab}	1-2	0.178	**0.006**	**0.028**
Child liking	2	2-2	2	1-2	0.166	2	2-2	2	2-2	0.108	2	1-2	2	2-2	0.297	0.129	0.157

Table 1: Mother ratings of key organoleptic properties of germinated porridges and non-germinated porridges

[1]p-value for differences between three germinated or three non-germinated porridges using non-parametric Friedman test for repeated measures (p-value < 0.05). Within a row, values with different superscript letters are significantly different using the Wilcoxon signed-rank test for pairwise comparisons (Bonferroni adjusted) (p-value < 0.05).

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Germinated versus Non-germinated Porridges Consumption Rates

Children consumed more non-germinated porridge than germinated porridge. Significant differences were found between germinated and non-germinated maize, sorghum, and millet porridges. Similarly, the velocity of consumption of the maize and sorghum porridges differed significantly between the germinated and the non-germinated porridge.

There was a difference between the germinated porridges ($p<0.001$), unlike the non-germinated porridges ($p=0.316$). The pairwise comparison revealed significant differences between the germinated sorghum and maize and the germinated sorghum and millet. However, we observed no difference between germinated millet and germinated maize. Germinated and non-germinated porridges recorded significant differences ($p=0.001$ and $p=0.002$, respectively) in the velocity of porridge consumption. Among the germinated porridges, children consumed less sorghum porridge per minute than maize and millet porridges.

Table 2: Comparison between germinated porridges [3] and/or between non-germinated porridges [3] on the amount and velocity of consumed porridges

	Maize			Sorghum			Millet			Within subject comparison [1](p value)	
	germinated	Non - germinated	P value	germinated	Non-germinated	P value	germinated	Non-germinated	P value	Germinate porridges	Non-germinated porridges
Amount consumed	161.82[a]	188.48	**0.041**	119.92[b]	205.46	**<0.001**	154.06[a]	201.46	**0.001**	**<0.001**	0.316
Velocity of consumption	19.7[a]	21.7[b]	0.396	13.65[b]	31.1[a]	**<0.001**	24.5[a]	22.8[b]	0.886	**0.001**	**0.002**

1p-value for differences between three germinated or three non-germinated porridges using non-parametric Friedman test for repeated measures (p-value < 0.05). Within a row, values with different superscript letters are significantly different using Wilcoxon signed-rank test for pairwise comparisons (Bonferroni adjusted) (p-value < 0.05)

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B. Phase 2

Sociodemographic Characteristics and Different Centers

Demographic characteristics were nearly evenly distributed in the control and intervention groups. More male children than females participated in both the control and the intervention groups. All the caregivers were the mothers of the index children. Approximately 50% of the caregivers in the intervention and control groups had attained an incomplete primary level of education, with less than 10% attaining a secondary school level of education. In both the control and intervention, over 40% of the caregivers were young mothers aged between 15 and 24 years, and 60% of the caregivers reported monthly earnings of less than Kenya shillings 4,000 (USD 40).

Table 3: Sociodemographic characteristics of study participants for the acceptability trial

	Germinated porridge			**Non-germinated porridge**		
Sub-location	Maize Kadhola [n=50]	Millet Lwanda Witi [n=50]	Sorghum Wachara [n=50]	Maize Nyandemura [n=50]	Millet	Sorghum
Children characteristics						
Age of children						
06-11 months	[15] 30%	[17] 34%	[13] 26%	[20] 40%	[20] 40%	[20] 40%
12-17 months	[21] 42%	[15] 30%	[22] 44%	[12] 24%	[12] 24%	[12] 24%
18-23 months	[13] 26%	[18] 36%	[15] 30%	[18] 36%	[18] 36%	[18] 36%
Sex of children						
Male	[27] 54%	[26] 52%	[24] 48%	[26] 52%	[26] 52%	[26] 52%
Female	[23] 46%	[24] 48%	[26] 52%	[24] 48%	[24] 48%	[24] 48%
Caregiver characteristics						
Age of caregiver						
15-19	[9] 18%	[10] 20%	[9] 18%	[13] 26%	[13] 26%	[13] 26%
20-24	[11] 22%	[13] 26%	[13] 26%	[12] 24%	[12] 24%	[12] 24%
25-29	[11] 22%	[10] 20%	[11] 22%	[10] 20%	[10] 20%	[10] 20%
30-34	[7] 14%	[4] 8%	[5] 10%	[4] 8%	[4] 8%	[4] 8%
35-39	[6] 12%	[7] 14%	[6] 12%	[4] 8%	[4] 8%	[4] 8%
40-44	[5] 10%	[4] 8%	[5] 10%	[5] 10%	[5] 10%	[5] 10%
45+	[1] 2%	[2] 4%	[3] 6%	[2] 4%	[2] 4%	[2] 4%
Education status of caregiver						
None	[3] 6%	[1] 2%	[4] 8%	[0] 0%	[0] 0%	[0] 0%
Primary incomplete	[24] 48%	[27] 54%	[24] 48%	[28] 56%	[28] 56%	[28] 56%
Primary complete	[10] 20%	[13] 26%	[12] 24%	[10] 20%	[10] 20%	[10] 20%
Secondary incomplete	[6] 12%	[5] 10%	[4] 8%	[6] 12%	[6] 12%	[6] 12%
Secondary complete	[5] 10%	[3] 6%	[5] 10%	[4] 8%	[4] 8%	[4] 8%
Tertiary	[2] 4%	[1] 2%	[1] 2%	[2] 4%	[2] 4%	[2] 4%
Monthly income status of caregiver						
<2,000	[10] 20%	[12] 24%	[11] 22%	[11] 22%	[11] 22%	[11] 22%
2,001-4,000	[23] 46%	[19] 38%	[24] 48%	[21] 42%	[21] 42%	[21] 42%
4,001-6,000	[8] 16%	[11] 22%	[8] 16%	[9] 18%	[9] 18%	[9] 18%
6,001-8,000	[4] 8%	[3] 6%	[3] 6%	[5] 10%	[5] 10%	[5] 10%

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8,001-10,000	[4] 8%	[4] 8%	[3] 6%	[4] 8%	[4] 8%	[4] 8%
>10,000	[1] 2%	[1] 2%	[1] 2%	[0] 0%	[0] 0%	[0] 0%

Comparing the Consumption and Acceptability of Porridge Types at Different Centers

A significant [p=0.003] difference was observed between the amount of germinated and non-germinated sorghum porridge consumed over the 2 weeks, unlike maize [p=0.127] and millet [p=0.073], as shown in Figure 2 below. The day the germinated versus non-germinated porridges were consumed was also significant [p<0.001] for all the three porridge types in reference to the amount.

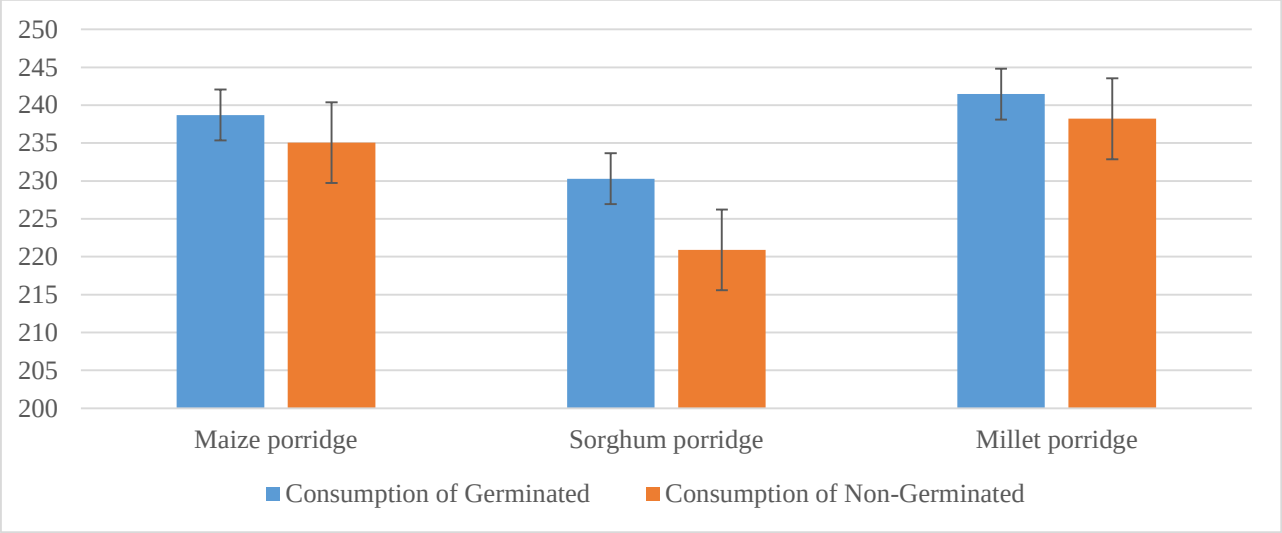

Figure 1: Comparison of amount of porridge consumed between control and intervention groups during the 2 weeks feeding period using ANOVA

There was also a statistically significant [p<0.001] interaction between the amount of maize and sorghum porridge consumed and the day of consumption. Furthermore, when the last day [14] was compared to all the other days, a significant difference was observed between the amount of germinated versus non-germinated porridge consumed on Days 2, 3, and 4 for sorghum and Days 2 and 3 for maize and millet.

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Table 4: Acceptability of different germinated versus non-germinated porridges during the 2-week trial period

Day	Maize	*p*-Value			Millet	*p*-Value			Sorghum	*p*-Value		
		Germinated Maize	Day	Germinated Maize X Day		Germinated Millet	Day	Germinated Millet X Day		Germinated Sorghum	Day	Germinated Sorghum X Day
1	194.42*	0.127	0.000	0.000	215.38*	0.073	0.000	0.201	198.39*	0.003	0.000	0.000
2	220.15*				223.76*				219.92*			
3	226.88				231.34				217.66*			
4	237.89				239.97				223.20			
5	241.88				241.74				227.20			
6	241.20				247.89				231.08			
7	248.25				245.18				238.76			
8	247.81				242.54				232.13			
9	243.33				243.13				220.63			
10	244.59				246.46				226.36			
11	248.40				246.37				227.72			
12	246.50				246.49				221.05			
13	229.60				243.61				235.79			
14	237.30*				243.81*				238.43*			

Asterisk shows pairwise comparison significance of Day 14 [last day] in relation to all the other days. Used a General Linear Model (Univariate) to compare daily porridge intake across centers, assessing interactions between the six porridge types and the day using repeated measures

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C. Focus Group Discussion

There was one focus group organized for each of the three intervention arms. The identified codes were organized along the following dimensions (defined at the beginning of the study): child liking of the porridge, observed side effects, caregiver satisfaction, and feasibility of continuing to use germinated porridges.

Child Liking of the Porridge

There was consensus among the caregivers in all three intervention arms that their children liked the porridge. Drinking relatively more porridge (compared to home-prepared porridge), a child sleeping after taking the porridge, and being playful were signals that caregivers attributed to liking the porridge by their children.

"*My child drinks a lot of this porridge and sleeps more than before; I see she has more energy now."*

Observed Side Effects

Caregivers did not report any side effects that they could attribute to the porridge. When asked if their children developed diarrhea after taking the porridge (a predominant concern in the community on the use of germinated and fermented porridge), caregivers did not report any diarrhea episodes after taking the porridge. Some caregivers instead thought that the health of their children improved during the study.

"…after taking this porridge, all the skin rashes my child had on the body are gone; his skin is very smooth." "This porridge is like medicine; during this time, my child has not gotten ill."

Caregiver Satisfaction

Overall, the caregivers thought the porridges were good for their children and therefore were satisfied with the feeding program. The low dropout rate (1-3%) among carers in the feeding centers further demonstrates their confidence in the porridges. However, an important concern raised by the caregivers during the focus group discussions was the discrimination of older children, especially those who accompanied them to the feeding centers.

One of the caregivers said, *"I almost stopped coming for the porridge after my 4-year-old girl cried a lot when she was denied porridge as the brother was drinking…it pained me."*

Feasibility of Using Germinated Porridges in the Community

Caregivers were concerned that the study was ending. They wished the program would have continued because their children had developed a taste for the study porridge.

A young caregiver whose child consumed germinated millet porridge for 2 weeks remarked, *"You have spoilt the mouths of our child; I doubt that he will go back to our usual porridges."* The caregivers were worried that children would reject the non-germinated porridges after getting used to the germinated porridges.

Caregivers demonstrated eagerness to continue providing the porridges if the process of developing the flour was explained to them or the flour was available for them. *'If you give us*

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the remaining flour, we can prepare the porridge in our homes, or you can explain to us how the flour is prepared.'

D. Morbidity Assessment

Assessment of morbidity during the two phases of the study did not reveal significant differences in the incidence of illnesses between the control and intervention groups. Illnesses such as fever, cough, malaria, loss of appetite were reported in all groups. Two children whose caregivers reported diarrhea after consuming germinated sorghum porridge continued taking the porridge after a break of three days without any problems.

DISCUSSION

Acceptability of foods, especially foods for children, are known to vary depending on the context and culture of the people. This study reports changes in the acceptability of three commonly consumed cereal-based porridges when germinated. Overall, germination has been shown to improve the sensory properties of cereal-based foods (Akinsola et al., 2017; Yenasew & Urga, 2023). Nonetheless, varietal differences in individual species about the production of enzyme activities during germination may affect the sensory properties of germinated cereals and pulses (Banigo & Muller, 1972). Moreover, the duration of germination has been shown to impact the functional and sensorial quality of the porridge from germinated cereals (Benincasa et al., 2019; Yenasew & Urga, 2023).

In this study, the color and texture of germinated porridges changed and differed depending on the type of cereal used. Germination was found to negatively impact the color of germinated maize and sorghum. Similarly, germination had a negative effect on the texture of germinated millet and sorghum porridges. The taste and aroma/flavor did not change with the germination of the three different cereal-based porridges. Our findings are inconsistent with those from a study in Nigeria that reported improved organoleptic properties of finger millet products after germination (Inyang & Zakari, 2008). Several researchers have established that germination of grains reduces the viscosity of their gruels, increases the simple sugars adding a pleasant sweet flavor to food products, and substantially augmenting the nutrient content of the cereals (Helland et al., 2002; Malleshi & Desikachar, 1982; Rodríguez-España et al., 2022). Our divergent findings could be attributed to the negative perceptions regarding the use of germinated food products on children in this community emphasizing the influence of context in the sensory evaluation of products.

The color and taste of germinated millet porridge were ranked significantly better than the other two porridges by caregivers. This finding is consistent with results from other studies that reported that finger millet had a highly pleasant flavor and acceptable taste as compared to maize and other cereals (Inyang & Idoko, 2006; Kaur et al., 2019; Malleshi & Desikachar, 1986). The favorable rating of germinated millet is related to the effect that germination has on the viscosity of the gruels, which could influence the sensory properties. Germinated millet gruel exhibits lower viscosity as compared to gruels from maize and sorghum (Mosha & Svanberg, 1983). In spite of the good rating of the qualities of the millet porridge, the overall rating of the different porridge by caregivers was in favor of non-germinated maize porridge. Similarly, among the germinated porridges, maize porridge received a favorable verdict among the caregivers. Although the panelist of caregivers thought maize porridges were the best, the

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children consumed more germinated millet porridge per minute compared to all other porridges. It is not surprising that maize porridges ranked better, considering that maize porridge is the everyday porridge in the study area among both adults and children. Besides, Malleshi and Desikachar (1986) reported that germinated maize retains its characteristic maize flavor.

Children consumed higher quantities of the three germinated porridges in comparison to the non-germinated porridges in the two-week trial period in contrast to the sensory testing. A steady increase in the consumption of germinated porridges as the day progressed was reported. The day the porridge was consumed during the 2-week feeding trial was significant for all porridges. This could be due to improved palatability as reported by reviewed studies, which have shown increased intake as palatability increased, for example, subjects either feel hungrier and less full after a palatable meal compared to a less palatable meal (Sørensen et al., 2003). Since germinated porridges were new foods among these children, the increased acceptance intake could be a result of the monotony of the non-germinated porridges, as demonstrated in another study where acceptance and intake of the meal declined with monotony (Meiselman et al., 2000). These children found their usual non-germinated porridge less pleasant than the new germinated porridge which they preferred. These results are similar to earlier findings from Ethiopian refugees, which indicated that monotony in the diet could develop a long-term form of sensory-specific satiety (Rolls & De Waal, 1985).

Overall, lower amounts of germinated sorghum compared to maize and millet porridges were consumed in both the sensory testing and the 2 weeks' acceptability study. However, while significantly lower amounts of germinated sorghum porridge were consumed during the sensory testing, significantly higher amounts of the same porridge were consumed during the acceptability trial. We attribute this finding to improved palatability of the germinated sorghum porridge over the 2 weeks. Similar to our findings, another study reported a lower acceptability of germinated sorghum (Matthew et al., 2018). A possible explanation of these findings is that soaking sorghum for 96 hours results in a small reduction in viscosity in high tannin sorghum variety and a bitter-tasting porridge (Malleshi & Desikachar, 1986). This could be attributed to the slow development of the activity of the amylolytic enzyme in the seed because of the inhibitory effect of the tannins (Mosha & Svanberg, 1983; Nefale & Mashau, 2018).

This study demonstrates the potential danger of assuming the acceptability of food during a one feeding stance, for example, when using a tasting panel, as compared to several time exposures like a 2-week feeding trial. Previous research has found that 10-15 exposures to a novel food can increase liking and consumption (Williams et al., 2008). In a study where infants were exposed to a diet for 8 days, it was reported that not only can infants discriminate flavors but repeated opportunities to taste a particular or a variety of foods may promote willingness to consume that food, resulting in its acceptability in the pediatric population (Mennella et al., 2008). Again, in another study where the rating of food was low when tasted once, it was observed that during the 5-day eating period, this changed and the investigators concluded that with repeated exposure, the desire to eat a less preferred food could increase over time (Zandstra et al., 2000).

Evaluating the acceptability of foods among infants and children is difficult as it is subject to caregiver and researcher interpretation (Sutrisna et al., 2017). We attribute the incongruity in our findings to the caregiver bias. Based on caregivers' assessment of their children's reaction to the porridges during feeding, there were no differences in acceptability of the germinated

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porridges compared to the non-germinated porridges. On the contrary, based on the comparison of the amount of porridges consumed and the velocity of consumption of the porridges, it was clear that children did not like the germinated sorghum porridge during the sensory testing.

LIMITATION OF THE STUDY

Our findings must be interpreted, taking into consideration the limitation of this study. Germinated and fermented porridges are regularly consumed by adults in this community, and therefore, blinding the caregiver on the identity of the porridge was not fully achieved. Most of the caregivers whom the study relied on to assess the organoleptic properties could easily identify the germinated porridges. We think that failure to fully blind the caregivers, coupled with the misinformation in the community regarding the use of processed porridges as complementary foods, could have made the evaluation of the organoleptic properties by the caregivers biased.

Because MNP was added to all the porridges, we reason that it did not influence the evaluation of the organoleptic properties of the non-germinated and germinated porridges. However, a study among Indonesian children revealed that addition of MNP on commonly consumed foods affected organoleptic properties of the carrier foods (Sutrisna et al., 2017).

Another weakness of the study was that both the sensory and the 2 weeks feeding trial were conducted at feeding centers. Feeding centers do not provide a relaxed and familiar environment for the children to feed. This could explain why the amounts of porridge consumed during the sensory testing were generally lower compared to the 2 weeks feeding period. It was not logistically possible to do direct observations of feeding at home in this community.

IMPLICATION TO RESEARCH AND PRACTICE

This research suggests that health workers and community leaders should promote the use of germinated porridges as potential complementary foods in this community, given their favorable reaction from caregivers and children.

CONCLUSION

Based on the evaluation of the sensory properties of germinated and non-germinated porridges, the consumption of porridges, and the feedback from caregivers during the focus group discussions, germinated porridges were accepted as complementary food in this community and could serve as carriers of the MNP.

FUTURE RESEARCH

Due to the possibility of contamination during food processing, which could induce diarrhea, there is a need for research into the availability of ready-to-use (commercialized) germinated

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flour in the community as a means of standardizing the germination process. Alternatively, an interventional investigation on home-preparation of germinated flour is required.

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