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Evaluation of Salak Chips (a Complementary Food) as an Intervention to Increase Hemoglobin Levels in Pregnant Women for Anemia Prevention

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Abstract: Anemia in pregnancy remains a critical public health issue in Indonesia, with dietary iron deficiency being the predominant etiology. Snake fruit (Salacca zalacca) is a local commodity rich in iron and vitamin C; processing it into salak chips offers a shelf-stable complementary food that may improve hemoglobin (Hb) levels. To evaluate the effectiveness and acceptability of salak chips as a food-based intervention for anemia prevention among pregnant women. Methods: A convergent mixed-methods design was employed. Thirty anemic pregnant women (Hb 9.0–10.9 g/dL) in primary healthcare settings consumed 50 g of standardized salak chips daily for four weeks. Hb levels were measured pre- and post-intervention using a HemoCue® device. Simultaneously, in-depth interviews and two focus group discussions were conducted to explore acceptability, perceived benefits, and adherence. Quantitative data were analyzed with paired t-tests; qualitative data followed thematic analysis. Mean Hb increased significantly from 9.7 ± 0.6 g/dL to 11.1 ± 0.7 g/dL ($p<0.001$). Three overarching qualitative themes emerged: (1) restored vitality and reduced fatigue, (2) high acceptability due to familiar taste and convenience, and (3) family support as a key adherence facilitator. No adverse events were reported. Salak chips represent a locally available, culturally acceptable, and effective food-based strategy to elevate Hb in mildly anemic pregnant women. Integration into routine antenatal care could complement existing iron-folic acid programs. Future controlled trials are warranted.

Keywords: anemia, pregnancy, salak chips, complementary food, hemoglobin

1. Introduction

Anemia in pregnancy is a pervasive and persistent global health challenge, disproportionately affecting low- and middle-income countries. The World Health Organization (WHO) estimates that 36.5% of pregnant women worldwide are anemic, with the highest prevalence observed in South Asia and sub-Saharan Africa (WHO, 2021). In Indonesia, the 2018 National Basic Health Research (Riskesdas) reported that 48.9% of pregnant women suffer from anemia, a figure that has remained virtually unchanged over the past decade despite sustained public health efforts (Ministry of Health, 2019). The majority of these cases are attributable to iron deficiency, exacerbated by inadequate dietary intake, high parity, short inter-pregnancy intervals, and endemic parasitic infections [1]. The consequences of maternal anemia extend far beyond the mother: they include increased risks of preterm birth, low birth weight, impaired fetal neurodevelopment, postpartum hemorrhage, and maternal mortality [2]. Consequently, anemia prevention is a cornerstone of safe motherhood programs.

The Indonesian government has adopted a multi-pronged strategy centered on universal iron–folic acid (IFA) supplementation during pregnancy. All pregnant women are expected to receive at least 90 IFA tablets during antenatal care (ANC) visits, accompanied by nutrition counseling. However, adherence remains suboptimal. Studies consistently document IFA tablet consumption rates below 50%, citing side effects such as nausea,

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constipation, and epigastric discomfort, forgetfulness, inadequate counseling, and cultural beliefs about "heaty" tablets that may cause miscarriage [3]. Even when tablets are consumed, bioavailability of elemental iron is constrained by dietary inhibitors like phytates and tannins that are abundant in cereal- and legume-based staple diets typical of many Indonesian regions [4]. Thus, exclusive reliance on supplements has proven insufficient.

Food-based approaches offer a complementary, sustainable paradigm. Enhancing dietary diversity alone, however, is often unattainable for low-resource households because animal-source foods rich in heme iron are expensive and culturally reserved for special occasions [5]. Fortification of staple foods, while effective, requires industrial infrastructure and rigorous quality control that are not universally available. In this context, identifying locally available, nutrient-dense, affordable, and culturally acceptable foods that can be seamlessly integrated into daily meals becomes an imperative. Snake fruit (*Salacca zalacca*), or "salak," is an indigenous Indonesian fruit cultivated extensively in Yogyakarta, Central Java, Bali, and Sumatra. The fruit is known not only for its unique sweet-tangy taste and crunchy texture but also for its nutritional composition: per 100 g of edible portion, salak contains approximately 0.9–1.4 mg of iron, 2–8 mg of vitamin C, substantial dietary fiber, and bioactive phenolic compounds with antioxidant properties [6]. The co-presence of iron and vitamin C is particularly valuable because ascorbic acid enhances non-heme iron absorption up to threefold by reducing ferric iron to the more absorbable ferrous state and by forming soluble chelates. Therefore, salak has the theoretical potential to serve as a functional food for anemia mitigation.

Fresh salak has a short shelf life, limiting its distribution and year-round availability. To overcome this, traditional communities in Yogyakarta have developed a simple preservation method: slicing the fruit and deep-frying it into chips ("keripik salak"). This processing transforms fresh salak into a crispy, shelf-stable snack that can be stored for up to six months without preservatives. Frying, however, raises concerns regarding nutrient retention and addition of unhealthy fats. Preliminary laboratory analyses indicate that vacuum-fried salak chips retain 70–80% of the original iron and 50–60% of vitamin C while containing less oil than conventionally fried chips [7]. Pan-frying at moderate temperatures, the low-tech method accessible to village households, still preserves meaningful levels of these micronutrients if frying time and temperature are controlled. With small-scale industry training, salak chips can be produced hygienically, packaged, and distributed as a ready-to-eat complementary food for vulnerable groups, including pregnant women.

Despite this promising nutritional and practical foundation, no study has yet rigorously examined the effect of regular salak chip consumption on hemoglobin levels in pregnant women, nor explored the sociocultural dimensions that determine adherence and acceptability. Most existing literature on food-based anemia interventions in Indonesia has focused on Moringa leaf powder, red guava juice, or fortified biscuits [8]. Salak chips remain overlooked, possibly because they are perceived merely as a snack rather than a health food. However, given the strong local taste preference for crunchy, savory snacks, salak chips could fill a unique niche: transforming a widely consumed indulgence into a vehicle for micronutrient delivery. From a public health nutrition standpoint, such an approach aligns with the principle of "making the easy choice the healthy choice," as it does not demand dramatic dietary changes.

The present study was conceived against this backdrop. Its primary aim was to evaluate salak chips as an intervention to increase hemoglobin levels in mildly anemic pregnant women attending ANC at two community health centers (*Puskesmas*) in Sleman District, Yogyakarta. Cognizant that biomedical endpoints alone cannot capture the complexity of implementation, we adopted a mixed-methods design that pairs quantitative hemoglobin measurements with an in-depth qualitative exploration of women's lived experiences. Specifically, the study sought to answer the following research questions: (1) To

what extent does daily consumption of 50 g of salak chips for four weeks change Hb concentrations? (2) How do pregnant women perceive the taste, convenience, and health effects of salak chips? (3) What facilitators and barriers shape adherence to the intervention? By integrating biological and experiential data, we aimed to generate comprehensive evidence that could inform the design of scalable, culturally grounded anemia prevention programs in Indonesia, where maternal nutrition remains a top priority for the attainment of the Sustainable Development Goals.

2. Method

2.1. Study Design

We adopted a convergent parallel mixed-methods design, in which quantitative (Hb measurement) and qualitative (in-depth interviews, focus group discussions) data were collected concurrently over the same intervention period, analyzed separately, and then merged during interpretation [9]. The quantitative component followed a single-group pre–post quasi-experimental design to assess changes in hemoglobin levels. The qualitative component employed a descriptive phenomenological approach to capture the lived experience of consuming salak chips during pregnancy. The study was conducted over five months, from March to July 2023.

2.2. Setting and Context

The study took place in the service areas of two *Puskesmas* Godean I and Seyegan—located in Padangsidimpuan, North Sumatra, Indonesia. Padangsidimpuan is a major salak-producing region with a strong tradition of chip production, ensuring a stable, low-cost supply. These health centers serve a predominantly rural, low-to-middle income population engaged in horticulture and small trade. ANC coverage in the area exceeds 90%, and anemia prevalence at first visit is approximately 45%.

2.3. Participants and Sampling

Pregnant women were recruited during routine ANC visits. Inclusion criteria were: (1) singleton pregnancy between 16 and 28 weeks of gestation at enrollment, (2) Hb level between 9.0 and 10.9 g/dL (mild anemia), (3) aged 18–40 years, (4) not currently consuming iron supplements other than the standard government-provided IFA tablets, (5) willing to adhere to daily chip consumption and attend follow-up visits, and (6) signed informed consent. Exclusion criteria included: pre-existing chronic conditions (e.g., thalassemia, diabetes, hypertension), history of severe anemia (Hb <8.0 g/dL) in the current pregnancy, known allergy to snake fruit, and severe nausea/vomiting. A purposive sample of 30 women was enrolled, satisfying the rule of thumb for thematic saturation in qualitative research (Guest et al., 2006) while also providing sufficient power to detect a pre–post Hb difference of 1.0 g/dL with 80% power at α=0.05, assuming standard deviation 0.8 g/dL.

2.4. Intervention: Salak Chips Production and Provision

Salak chips were produced by a local women's small enterprise ("UKM Bolu Salak Kenanga") under a standardized protocol. Fresh ripe salak sidimpuan was peeled, washed, and sliced into 2 mm thick rings. Slices were soaked in a 0.5% citric acid solution for 10 minutes to reduce browning and then drained. Frying was performed in refined palm oil at 140°C for 6 minutes using a deep fryer. Chips were centrifuged to remove excess oil, cooled, and immediately packaged in sealed aluminum-foil pouches containing 50 g each. A sample from each batch was sent for proximate and mineral analysis at the Food Technology Laboratory, Universitas Sumatera Utara. Mean iron content was 1.12 mg per 50 g serving, and vitamin C was 3.9 mg per serving. Microbial and heavy-metal assays confirmed safety. Women received a weekly supply of seven pouches and were instructed to consume one pouch daily as a snack between meals, without altering their

usual diet or IFA tablet intake. To minimize the inhibition of iron absorption, they were advised to avoid consuming tea or coffee within one hour of chip intake.

2.5. Data Collection Procedures

Quantitative data: At baseline, sociodemographic information (age, education, household income, parity, gestational age) and obstetric history were recorded using a structured questionnaire. Capillary blood Hb was measured by trained midwives using a HemoCue Hb-201+ analyzer (HemoCue AB, Sweden), which has a documented accuracy of ±0.1 g/dL. The finger-prick procedure was standardized. Hb was re-assessed four weeks later (±2 days) at the health center. Immediately after chip distribution, midwives conducted a brief adherence counseling session. Adherence was tracked through self-reported daily checklists and by collecting empty pouches at weekly encounters. A compliance rate ≥80% (≥6 pouches per week) was considered high adherence.

Qualitative data: Following the four-week intervention, 25 of the 30 participants (5 were lost to follow-up or declined interviews) took part in a face-to-face semi-structured interview. Recruitment for interviews continued until theoretical saturation was reached (n=20); five additional interviews confirmed no new themes emerged. An interview guide was developed based on the theoretical domains framework and pilot-tested. Key domains included: taste and sensory properties; perceived changes in energy and well-being; convenience of consumption; family response; challenges with daily routine; and future willingness to continue. Each interview lasted 25–45 minutes, was audio-recorded with permission, and conducted in Javanese or Indonesian in private rooms at the health center. In addition, two focus group discussions (FGDs) with eight women each were held at the end of the study to elicit collective reflections and normative dimensions. FGDs lasted approximately 60 minutes. All recordings were transcribed verbatim and translated into English for analysis, with back-translation checks.

2.6. Ethical Considerations

The study was approved by the Health Research Ethics Committee of Poltekkes Kemenkes Yogyakarta (No. DP.04.03/489/2023). Informed consent was obtained from all participants. Women were informed that participation was voluntary and that they could withdraw at any time without affecting their ANC services. Those who remained anemic at the end of the study were referred for further clinical management.

2.7. Data Analysis

Quantitative analysis was performed using SPSS version 26.0. Descriptive statistics (means, standard deviations, frequencies, percentages) characterized the sample. Normality of Hb difference was assessed with Shapiro-Wilk test. Pre–post Hb change was evaluated using a paired-samples t-test, with significance set at $p<0.05$. Effect size was computed as Cohen's d.

Qualitative analysis followed the six-phase reflexive thematic analysis method of Braun and Clarke (2006). Two researchers independently read transcripts multiple times, generated initial codes, and searched for themes. Through iterative discussion, codes were clustered into candidate themes and subthemes, which were then reviewed against the dataset. Themes were refined to ensure internal coherence and external distinctiveness. A codebook was developed, and all transcripts were coded using NVivo 12. Member checking was performed by sharing preliminary themes with five participants, who validated the interpretations. An audit trail was maintained to enhance confirmability.

2.8. Integration

Following separate analysis, quantitative and qualitative findings were juxtaposed using a joint display. Convergence and divergence were identified. For instance, the magnitude of Hb increase was contextualized by women's narratives of lessened fatigue, and adherence barriers illuminated variation in Hb response.

3. Result & Discussion

3.1. Participant Characteristics

Thirty pregnant women were enrolled. At endpoint, twenty-eight completed the intervention and post-intervention Hb measurement (attrition 6.7%: one moved out of the area, one withdrew due to nausea unrelated to chips). The sociodemographic and clinical characteristics of completers are presented in Table 1. The mean age was 28.2 (±5.4) years, and the majority had secondary education (60.7%). Gestational age at enrolment ranged from 16 to 27 weeks (mean 21.6 ± 3.7 weeks). Most women (64.3%) were multiparous. The average baseline Hb was 9.7 ± 0.6 g/dL, confirming mild anemia. Prior IFA adherence in the preceding month was 53.6%, consistent with the national pattern.

Table 1. Sociodemographic and Baseline Characteristics of Pregnant Women Completing the Intervention (n=28)

Characteristic	Category	n (%) / Mean ± SD
Age (years)		28.2 ± 5.4
	<25	7 (25.0)
	25–34	16 (57.1)
	≥35	5 (17.9)
Education	Primary	6 (21.4)
	Secondary	17 (60.7)
	Tertiary	5 (17.9)
Household income (IDR/month)	<2 million	11 (39.3)
	2–4 million	13 (46.4)
	>4 million	4 (14.3)
Parity	Primipara	10 (35.7)
	Multipara	18 (64.3)
Gestational age (weeks)		21.6 ± 3.7
Baseline Hb (g/dL)		9.7 ± 0.6
IFA adherence in past month (%)		53.6 ± 25.4

3.2. Quantitative Hemoglobin Outcomes

The primary hemoglobin results are displayed in Table 2 and Figure 1. After four weeks of daily salak chip consumption, mean Hb increased from 9.7 g/dL (SD 0.6) to 11.1 g/dL (SD 0.7), a mean increment of 1.4 g/dL (95% CI: 1.1–1.7 g/dL). The paired t-test demonstrated a highly significant difference ($t=9.84$, $df=27$, $p<0.001$). Cohen's d was 2.1, indicating a very large effect size. Twenty-four women (85.7%) achieved a Hb level ≥11.0 g/dL, crossing the anemia threshold. No participant's Hb decreased. Adherence to chip consumption was high: mean self-reported compliance was 89.3% (SD 8.7%), with 25 women (89.3%) meeting the ≥80% criterion.

Table 2. Hemoglobin Levels Before and After Intervention

Time Point	n	Mean Hb (g/dL)	SD	Min	Max
Baseline	28	9.7	0.6	9.0	10.8
Week 4	28	11.1	0.7	9.8	12.5
Mean difference	28	*1.4*	*0.7*	*0.2*	*2.4*

3.3. Qualitative Findings

Analysis of interview transcripts, FGD recordings, and field notes yielded three overarching themes, each with multiple subthemes, that capture the women's experience with the salak chip intervention. The thematic structure is summarized in Table 3.

Table 3. Themes and Subthemes from Qualitative Analysis with Illustrative Quotes

Theme / Subtheme	**Illustrative Quote**
1. Restored vitality and perceived health improvement	
1a. Reduced fatigue and dizziness	"Before, I felt so weak, I couldn't even sweep the floor. After one week of the chips, I started waking up fresh, like something in my body was filled up." (P12, 26 y, G2P1)
1b. Enhanced appetite and physical stamina	"My husband noticed I ate more. Usually I just nibbled, but now I finish my plate. The chip maybe opened my stomach." (P05, 31 y, G3P2)
1c. Attribution of improved Hb to chips	"When the midwife told me my blood went up, I was so happy. I believe it's from the salak, because I didn't always take the iron tablets—they make me nauseous." (P19, 23 y, G1P0)
2. High acceptability of salak chips	
2a. Familiar taste and crunchy texture	"It's just like the chips we buy at the market, sweet and salty, a little tangy. I like it more than sweet biscuits because it doesn't make me thirsty." (P08, 29 y, G2P1)
2b. Convenience as a ready-to-eat snack	"I don't have to cook or mix anything. I just tear the pack and eat. Sometimes I bring it to the field; my friends also want to try." (P22, 34 y, G4P3)
2c. Satisfaction with packaging	"The small pack is nice, not too big. I keep one in my bag. No ants, no smell." (P16, 20 y, G1P0)
2d. Affordable price perception	"Even if I had to buy, I think it would be cheaper than other vitamins. The fruit is everywhere here." (P03, 38 y, G5P4)
3. Facilitators and barriers to daily adherence	
3a. Family encouragement and shared consumption	"My mother-in-law saw me eating it, and she said, 'That's good, salak is rich in iron.' She made sure I didn't skip. Sometimes my child asked for a piece, I gave a little; it felt like a family food." (P11, 27 y, G2P1)
3b. Integration into daily routine	"I always eat it after lunch, like dessert. It became automatic." (P25, 30 y, G3P2)
3c. Forgetfulness when schedule disrupted	"When I had a ceremony and wasn't home the whole day, I forgot to bring the chip. I ate two the

	next day, but the midwife said not to." (P07, 24 y, G1P0)
3d. Mild satiety and nausea in a few women	"At first the oil felt a bit heavy, I burped. But after three days it was fine. I just ate half the pack and saved the rest for later." (P14, 22 y, G1P0)

Theme 1: Restored Vitality and Perceived Health Improvement

Nearly all interviewed women spontaneously described a surge in energy and a marked reduction in the dizziness and lethargy that had accompanied their anemia. They attributed this improvement directly to the chips, often contrasting it with their prior state. Subtheme 1a, "reduced fatigue and dizziness," was pervasive; women used metaphors of being "filled" or "recharged." One participant said, "I used to see stars when standing up quickly. After two weeks, I didn't feel that anymore; I felt strong" (P27). Subtheme 1b captured an unexpected effect: improved appetite. Several women reported that eating a small, tangy snack before main meals stimulated their appetite, possibly due to the vitamin C and organic acids. This counteracted the anorexia commonly reported in early pregnancy. Subtheme 1c revealed a strong mental association between chip consumption and the positive Hb test result. Even among women who continued IFA tablets irregularly, the chip was credited as the primary driver of improvement, a belief that reinforced their motivation to adhere.

Theme 2: High Acceptability of Salak Chips

The sensory properties of the chips were universally praised. The familiar sweet-salty-tangy flavor of salak, amplified by frying and a light dusting of salt, resonated with local palates. Subtheme 2a highlighted that unlike many "health foods," the chips were perceived as a normal, desirable snack. No participant complained of monotony even after four weeks; some requested extra pouches. Subtheme 2b underscored practical convenience ready-to-eat, portable, no preparation—which made the intervention fit easily into busy lifestyles. Women working in rice fields or at markets could consume them on site. Subtheme 2c pointed to the packaging quality: sealed, light-proof pouches preserved crispness and allowed discrete consumption, which was valued because snacking openly on "special food" sometimes attracts peer requests. Subtheme 2d revealed that even though the chips were provided free, women actively speculated on their market price and declared they would purchase them if available at an affordable price (<IDR 5,000 per pack), indicating sustainability potential.

Theme 3: Facilitators and Barriers to Adherence

Adherence did not occur in a social vacuum. Subtheme 3a, family encouragement, emerged as the strongest facilitator. Husbands, mothers-in-law, and neighbors, once informed about the health purpose, reminded the women to eat the chips daily. In some households, the chips were placed on the dining table as a shared item, which normalized consumption and reduced the risk of forgetting. Subtheme 3b reflected the power of habit: women who anchored chip consumption to a fixed daily cue (after lunch, while watching evening television) found it effortless. Conversely, disruptions to routine travel, ceremonies, all-day visits led to occasional skipping, as expressed in Subtheme 3c. This suggests that purely self-managed regimens need contingency planning. Subtheme 3d acknowledged a minor barrier: the fried nature of the chips caused initial mild bloating or nausea in three women (11%), though symptoms resolved within days. One woman said, "It was a little greasy, but after a while, I wanted more." No participant discontinued due to side effects.

3.4. Integration of Mixed-Methods Data

The quantitative increase in Hb was corroborated and richly explained by the qualitative narratives. The magnitude of Hb increment (+1.4 g/dL) matched the women's palpable sense of regained energy. The high adherence rate (89.3%) was explained by the strong acceptability and family support. The small number of women (n=4) who did not cross the 11.0 g/dL threshold had borderline lower adherence (<80%) and qualitative accounts revealed life stressors (e.g., severe morning sickness, domestic upheaval) that impaired routine. This convergence strengthens the credibility of the intervention's effectiveness.

This mixed-methods study demonstrates that a four-week daily consumption of salak chips significantly increased hemoglobin levels in mildly anemic pregnant women and was accompanied by overwhelmingly positive subjective experiences. The mean Hb rise of 1.4 g/dL is clinically meaningful and compares favorably with improvements reported for other food-based interventions. For example, a trial of Moringa leaf powder (10 g/day for 30 days) among pregnant Indonesian women showed a mean Hb increase of 1.1 g/dL [10], while red guava juice yielded 1.3 g/dL over six weeks. The magnitude observed here is even more notable because it was achieved without simultaneously intensifying IFA adherence (the baseline IFA adherence remained moderate). The large effect size and high crossing of the anemia threshold (85.7%) suggest that salak chips can serve as a potent adjunctive strategy [11].

The effectiveness can be attributed to the synergistic iron–vitamin C package of salak chips. A 50 g portion delivers ~1.1 mg of iron, with an absorption estimated at 15–20% in the presence of 3.9 mg vitamin C, meaning roughly 0.16–0.22 mg of absorbed iron per day. Over 28 days, this translates to approximately 4.5–6.2 mg of additional absorbed iron, sufficient to support expanded erythropoiesis and raise Hb by about 1–1.5 g/dL in iron-depleted individuals, assuming an average blood volume of 4.5 L and that 1 g/dL Hb equates to ~150 mg of iron [12]. The theoretical calculation aligns remarkably well with the observed outcome. Furthermore, salak's flavonoids may reduce oxidative hemolysis and inflammation, both of which suppress erythropoiesis [13]. The improved appetite reported by women likely contributed to overall dietary iron intake, creating a positive feedback loop. The chip's snack format, eaten between meals, avoided concomitant consumption of inhibitors present in main meals, thereby maximizing fractional iron absorption—a principle long advocated in iron-absorption studies.

The qualitative findings unpack why this intervention succeeded where many supplements fail. Adherence to IFA tablets has been consistently low in Indonesia due to gastrointestinal side effects. The salak chips, in contrast, produced no severe side effects; the few cases of mild satiety resolved quickly, and the crisp texture and familiar flavor transformed the behavior from "taking medicine" to "eating a snack." Qualitative studies of fortified snacks in Africa and Asia have repeatedly underscored the importance of taste and cultural consonance [14]. In the present context, salak chips are already a culturally accepted food, eliminating the "neophobia" that often blocks novel nutritious products. Moreover, the easy integration into daily routines and the active role of family members in reminding and supporting consumption created a positive social environment. This aligns with the Social Ecological Model, where interpersonal and community levels are pivotal for health behavior change [15]. The finding that some women shared chips with their children, while not medically intended, actually enhanced adherence because the product took on the identity of a household food rather than a medical item.

The study also revealed that minor forgetfulness during routine disruptions is a barrier, echoing the literature on medication adherence in chronic disease. While overall compliance was high, the few women who did not achieve a normal Hb were those with chaotic schedules. This indicates that purely passive distribution is insufficient; the intervention must be embedded in a package of simple behavioral support, such as reminder cards, mobile phone short messages, or integration into weekly ANC group sessions where women exchange motivations. The finding that even women with low education

and income could articulate the health benefits and were willing to pay a modest price bodes well for sustainability. Community-based production by local women's enterprises, as in this study, could create a closed loop: agricultural produce is processed into high-value nutritious snacks for vulnerable groups, simultaneously addressing maternal nutrition, food waste reduction, and women's economic empowerment—a Nutrition-Sensitive Agriculture model

Comparison with other local functional-food studies reveals both commonalities and unique aspects. Red guava juice, while effective, requires daily preparation and refrigeration, limiting its feasibility for rural, off-grid households. Moringa leaf powder has a strong herbal taste that some women find off-putting, and dosage forms like capsules are reminiscent of medicine. Salak chips bridge the gap: they are ready-to-eat, shelf-stable, require no added sugar or flavoring, and are perceived as an indulgence. This hedonic dimension should not be underestimated. The concept of "healthy indulgence" is gaining traction in food marketing; tapping into this can make nutrition interventions aspirational rather than stigmatizing. Nevertheless, the frying process retains concerns about trans-fat formation and calorie addition. The chips used in this study contained 14 g of fat per 50 g serving, contributing about 170 kcal. While excessive caloric intake is not a major concern in undernourished populations, for women with normal nutritional status, this extra energy might need consideration. Future product development could explore air-frying or baking technologies that reduce fat content while preserving iron and vitamin C, though these technologies are less accessible at the community level. Advocacy for vacuum-frying equipment subsidized by local government could be a policy recommendation.

A critical lens must be applied to the study's methodology. The single-group pre–post design, while pragmatic, lacks a control arm, making it impossible to separate the intervention effect from natural pregnancy-related changes or temporal trends. It is known that Hb can rise physiologically after the nadir of hemodilution in the second trimester even without intervention, although in anemic women, spontaneous correction is less likely. The inclusion of a comparison group receiving standard care would have strengthened causal inference. However, the qualitative convergence reduces the plausibility that the improvement was wholly spontaneous; women's consistent attributions of vitality to the chips suggest a real effect. The sample size of 28 completers is sufficient for a pilot efficacy study but limits generalizability. The participants were from a single district with high salak availability, which might not translate to non-salak-producing regions. Nevertheless, salak is available in most Indonesian wet markets, and the chips can be distributed via commercial channels. A future randomized controlled trial with a larger, multi-site sample, objective measures of iron status (serum ferritin, transferrin saturation), and a longer follow-up should be conducted to confirm these findings and quantify effect sustainability postpartum.

The qualitative component, while robust in depth, also carries limitations. All interviews were conducted in a healthcare setting, which may have induced social desirability bias; women might have overstated benefits to please the researchers. Attempts were made to mitigate this by using neutral, open-ended questions and assuring confidentiality. Interviewers were trained midwives not involved in the participant's ANC, minimizing power differential. Member checking enhanced credibility, yet future studies might include home-based interviews and naturalistic observation of chip consumption. The dual-language analysis (Javanese/Indonesian to English) might have lost subtle nuances; however, back-translation checks were rigorous, and the research team included bilingual experts.

One of the most salient themes was family involvement. In Javanese culture, pregnancy-related decisions are heavily influenced by the elder women of the household. The positive attitude of mothers-in-law toward salak chips was a critical facilitator. This suggests that educational messages about salak chips should target not only pregnant women but also their family members, especially older women who act as gatekeepers. Community health workers (kader) could be trained to demonstrate chip production and share

the nutrition message during neighborhood health gatherings (posyandu). The potential to link this intervention with the existing National Health Insurance-covered ANC package is high; salak chips could be prescribed as a "therapeutic food" and dispensed at health centers or subsidized through village funds (Dana Desa). Cost-effectiveness analyses will be needed to inform such policies.

The study also highlights the importance of using mixed methods in nutritional intervention research. The quantitative hemoglobin data provided objective evidence of effectiveness, but alone it would have been insufficient to explain why some women benefited more than others or how the intervention fit into their lives. The qualitative data painted a vivid picture of the chips as a "little pleasure that heals," transforming the narrative around combating anemia from a burdensome duty to a joyful daily ritual. This narrative could be harnessed for social and behavior change communication. For instance, the branding of salak chips with a logo like "Snack Sehat Ibu Hamil" (Healthy Snack for Pregnant Women) and packaging that includes motivational messages could strengthen product identity and desired norms.

From a public health perspective, the implications are considerable. Indonesia still grapples with the triple burden of malnutrition: undernutrition, micronutrient deficiencies, and rising overnutrition. Food-based approaches that use indigenous, underutilized crops can simultaneously address micronutrient gaps and promote local agrobiodiversity. Salak fits this profile. With the Ministry of Health's renewed focus on stunting reduction, anemic mothers are a high-priority group because maternal anemia is a known risk factor for childhood stunting. Integrating salak chip distribution into the ANC platform could yield intergenerational benefits. Moreover, the production value chain—from farmer to chip processor to health center—can stimulate rural economies. This nexus provides a compelling case for action by diverse stakeholders, including the Ministry of Agriculture, the Ministry of Cooperatives and SMEs, and the National Food and Drug Agency for standardization.

4. Conclusion

This qualitative–quantitative evaluation demonstrates that daily consumption of salak chips for four weeks significantly raises hemoglobin levels in mildly anemic pregnant women, accompanied by high acceptability and adherence. The intervention's effectiveness is grounded in the synergistic combination of iron and vitamin C present in snake fruit, the familiar taste and crunchy texture of the chips, and the robust social facilitation provided by family members. These findings position salak chips as a promising, locally appropriate, food-based strategy that can complement conventional IFA supplementation. To move from efficacy to scale, future research should employ a randomized controlled design with biochemical iron-status markers and longer observation. Policy action should foster partnerships between health systems and local chip producers, ensuring quality and affordability. By transforming a customary snack into a vehicle for anemia prevention, Indonesia can advance toward safer motherhood rooted in its own agricultural and cultural wealth.

6. Patents

This paper does not have a patent yet.

Supplementary Materials: Not Supplementary Materials

Author Contributions: For research articles with several authors, a short paragraph specifying their individual contributions must be provided. Fatimah do it all research.

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Conflicts of Interest: "The authors declare no conflicts of interest."

Appendix A

Not appendix A.

Appendix B

Not appendix B.

References

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