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The effect of providing multi nutrient functional biscuits on the nutritional status of malnourished toddlers

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Abstract

The main cause of malnutrition in Indonesia is the lack of nutrient intake, making it necessary to address this through the provision of supplementary foods. On the other hand, Indonesia has various local food resources that have not been optimally utilized, which need to be processed to enrich the nutritional content of snacks that can be used to prevent malnutrition. This study aims to determine the effect of Tumiz functional biscuits on the nutritional status of malnourished toddlers. The research was conducted as a clinical trial using a randomized control group pretest-posttest design, involving malnourished toddlers divided into two groups. Each group consisted of 35 children, with each group receiving the following treatment: K1 (Tumiz biscuits + nutrition education for their mothers), and K-2 (only nutrition education for their mothers). The intervention lasted for 4 weeks, nutrition status and albumin levels, before and after the intervention. The effect of the intervention within each group was analyzed using paired sample t-tests, while the effect between groups was analyzed using independent sample t-tests. The results showed a significant improvement in the z-score of BB/TB in the intervention group ($p=0.007$), but there was no significant difference in the z-scores of BB/U and TB/U between the two groups. Albumin levels decreased significantly in both groups, with no significant difference ($p=0.312$). In conclusion, the administration of Tumiz biscuits improved nutritional status based on BB/TB, but did not have a significant effect on BB/U and TB/U. Decreased albumin may be caused by a metabolic response due to prolonged malnutrition.

Introduction

The 2018 Basic Health Research (Riskesdas) reported a prevalence of underweight at 17.7%, stunting at 29.9%, and wasting at 10.2%. In addition to malnutrition issues among toddlers, nutritional deficiencies are also found in pregnant women, with a prevalence of anemia at

48.9%.[1] One of the main causes of malnutrition is the lack of adequate nutrient intake. Malnutrition during the toddler phase can lead to linear growth disorders, which may reduce physical abilities and productivity in the future.[2,3] Children who experience growth disorders during pregnancy and early childhood are at risk of developing various degenerative diseases.[4-6] Malnourished toddlers often show signs of increased metabolism, leading to oxidative stress.[7,8] This condition can affect a child's health and bodily functions, including cognitive function and brain development. Efforts to meet nutritional needs through balanced diets or supplementary feeding can help prevent malnutrition in toddlers and reduce oxidative stress.[9,10]

Efforts to meet nutritional needs can be achieved through the utilization of local food sources by developing snacks or foods that contain complete nutrients according to the target's needs or are considered multinutritional. Multinutritional snacks are local foods that contain energy-giving, body-building, and regulatory nutrients to meet the nutritional needs of the target population. These snacks are developed by utilizing various functional local food sources. In Eastern Indonesia, readily available local food sources include sago worms, legumes (such as soybeans and mung beans), and vegetables like carrots.

Sago worms are a local resource abundant in Eastern Indonesia, particularly in Sulawesi, Maluku, and Papua.[11] Fresh sago worms are highly nutritious, containing 13.80% protein and 18.09% fat. In addition, sago worms also contain antioxidants (78.6%)[12] and minerals (calcium, phosphorus, potassium, sodium, iodine, and zinc) in significant amounts.[13] The potential for essential amino acids, essential fatty acids, and minerals is also higher and more complete in sago worms. Sago worms share similarities with silkworms in structure and physical properties, making them suitable for processing into multinutritional flour as a base ingredient for complementary foods for infants (MP-ASI),[14] shredded meat products, and various other snacks and food products.[15-17] Sani Silwanah (2014) has developed sago worm flour into complementary infant food (MP-ASI) as an alternative to improving nutrient intake in toddlers.[13]

Previously (in the first year), five types of functional snacks enriched with Multinutritional Flour (Tumiz) were developed. One of these is Tumiz Biscuits. Based on nutrient analysis, Tumiz functional biscuits contain several essential nutrients, such as energy, protein, fat, vitamin A, iron, zinc, calcium, and antioxidants. The composition and amount of these nutrients can be utilized as supplementary food or complementary feeding (MP-ASI) to meet the nutritional needs of vulnerable groups, such as infants aged 6-11 months, toddlers, and pregnant women.

In the second year, we conducted trials of Tumiz functional snacks, specifically Tumiz biscuits, on test animals (preclinical trials). The results of the preclinical trials showed that Tumiz functional biscuits could improve the growth and nutritional status of test animals (Wistar rats). The administration of Tumiz biscuits affected the increase in body weight, albumin levels, body length, and IGF-1 levels in malnourished rats.

As a follow-up to the second-year research, clinical trials are needed to assess the use of Tumiz Biscuits as an intervention for malnourished toddlers. The clinical trial results are expected to answer the question: "What is the effect of Tumiz Biscuits on the nutritional status of malnourished toddlers?" This study aims to determine the effect of Tumiz Functional Biscuits on the nutritional status of malnourished toddlers.

Materials and Methods

Study design

The clinical trial was conducted using a randomized pretest-posttest controlled trial design. The clinical trial was carried out by testing Tumiz biscuits on a sample of children under five who were malnourished, to assess the impact on the nutritional status of children. It began with screening families with malnourished toddlers—those experiencing stunting, wasting, and underweight—using anthropometric methods, including height-for-age (H/A), weight-for-height (W/H), and weight-for-age (W/A) indices. Toddlers who met the criteria were subjected to an initial measurement (pretest) of height, and weight. The sample was then divided into two groups using a simple random method. The first group received Tumiz biscuits and nutrition education, while the second group received only nutrition education for the mother without providing Tumiz biscuits to their children. The intervention of providing local snacks to the toddlers and nutrition education to the mothers was conducted daily for two months (60 feeding days).

Location and time

The clinical trial/intervention was carried out in several posyandu areas under the jurisdiction of Paccerakkang, Daya, and Sudiang Raya public health centers in Makassar from April to July 2024.

Population and sample

The study population consisted of all families with toddlers living in Makassar. The sample consisted of mothers with malnourished toddlers suffering from stunting, wasting, or underweight (z-score < -2 SD) in the Paccerakkang health center area of Makassar. A total of 35 samples per group were selected through random sampling.

Data collection

The data collected included information on nutritional knowledge, attitudes, child-feeding practices, nutrient intake, Tumiz biscuit consumption, child growth, and toddler nutritional status. Nutritional knowledge, attitudes, and feeding practices were collected through interviews using questionnaires. Nutrient intake was measured using a 24-hour recall method. Information on Tumiz biscuit consumption was assessed using daily consumption control sheets with a checklist.

Nutritional status is assessed based on H/A, W/A, and W/H indexes, as well as albumin levels. Weight was measured using a digital scale with a precision of 0.1 kg, and height was measured using a microtoise. The child's age was determined based on the birthdate provided by the parents or recorded from the child's health card (KMS). The anthropometric data were then calculated into z-scores for the W/A, H/A, and W/H indices using the WHO Anthro software application. Anthropometric measurements were performed by trained personnel, such as nutrition staff from the health centers or enumerators with D4 nutrition education qualifications.

Data analysis

The collected data were entered into a data processing software for statistical analysis. Univariate and bivariate analyses were conducted. The univariate analysis involved calculating the mean and Standard Deviation (SD) of variables such as weight, height/length, W/A, H/A, W/H z-scores. Bivariate analysis was used to assess changes in nutritional status of toddlers before and after the intervention within each treatment group. These changes were evaluated by comparing the mean difference of each variable before and after the intervention using the "Paired T-test." To assess the difference in changes between the intervention groups, the "Independent T-test" was used. Conclusions were drawn with a 95% confidence level.

Ethical considerations

This study was conducted after obtaining ethical approval from the Health Research Ethics Committee (KEPK) of Poltekkes Kemenkes Makassar, No. 1133/M/KEPK-PTKMS/VII/2024. Before the interviews and blood sampling, informed consent was obtained from all participants.

Results

Characteristics of parents

Table 1 shows that the majority of mothers in the control and intervention groups had a high school education, with proportions of 47.1% and 51.4%, respectively. In the intervention group, more mothers did not finish primary school (25.8%) compared to the control group (10.9%). Statistical analysis showed no significant difference between the two groups (p=0.488). Most fathers in both groups had a high school education. However, in the intervention group, more fathers did not finish primary school (31.5%) compared to the control group (11.4%), with a statistically significant difference (p=0.037). The majority of mothers in both groups were housewives, with no significant difference between the groups (p=0.560). Most fathers in both groups worked as laborers or drivers, with no significant difference between the control and intervention groups (p=0.169). There were no significant differences in the number of family members or the number of toddlers between the two groups.

Child's health condition

Table 2 shows that 77.1% of children in the intervention group were reported to have been sick in the last month, compared to 54.3% in the control group, with a statistically significant difference (p=0.036). There was no significant difference in illness frequency (p=0.155), but the duration of illness was longer in the intervention group than in the control (p=0.061). There was variation in the types of illnesses suffered by the children, but no significant difference between the groups.

Child's dietary pattern

Table 3 shows that the majority of children in both groups were not given prelacteal foods and started receiving complementary feeding at the age of 6 months, with no significant differences (p=0.673 and p=1.000). Most children ate three times a day in both groups, with no significant difference (p=0.263). There were no significant differences in the balance of food portions and consumption of colorful foods between the two groups. Maternal knowledge about nutrition in both study groups showed no significant difference (p=0.353).

Nutritional status of children

Table 4 shows that in the control group (n=35), the weight-for-age z-score increased from -2.22 ± 0.96 to -1.84 ± 0.81 after the intervention with a significant p-value (p=0.026). In contrast, the intervention group (n=35) receiving Tumiz biscuits changed from -1.72 ± 0.95 to -1.60 ± 0.85, but this change was not significant (p=0.600). The difference in weight-for-age z-score changes between the control and intervention groups was also not significant (p=0.371), indicating that the Tumiz biscuits did not significantly differ from the control.
The height-for-age z-score in the control group (n=35) decreased from -2.90 ± 1.40 to -3.06 ± 1.46 with a p-value of 0.642, which is not significant. The intervention group (n=35) also showed a decrease from -2.63 ± 1.04 to -3.06 ± 1.59, with a p-value of 0.154. The difference in changes between the two groups for height-for-age z-score was not significant (p=0.644), suggesting that Tumiz biscuits did not have a significant impact on height changes in this period.
According to the weight-for-height index, the control group (n=31) showed an increase in z-score from -1.04 ± 1.76 to -0.10 ± 1.18 with a p-value of 0.202, which is not significant. However, the intervention group (n=28) had a larger increase from -0.52 ± 1.33 to 0.24 ± 1.56 with a significant p-value of 0.007. Despite this, the difference in weight-for-height z-score changes between the control and intervention groups was not significant (p=0.715).
Table 4 indicates a significant decrease in serum albumin levels in both the control (p=0.000) and intervention groups (p=0.000). No significant difference in the decrease of albumin levels between the control and intervention groups (p=0.312).

Discussion

Our study found that the control group experienced a significant increase in Z-scores for weight-for-age (WAZ) (p=0.026), while the intervention group showed no significant change (p=0.600). These results indicate that Tumiz functional biscuits had a better impact on the control group than the intervention group. Research by Wang *et al.* (2020) stated that significant changes in nutritional status are often more visible in children undergoing long-term interventions that involve not only energy supplementation but also overall dietary improvements.[18] Additionally, a study by Green *et al.* (2021) found that the effectiveness of nutritional interventions is more evident in groups experiencing mild malnutrition than in those with more severe malnutrition.[19]

In the change in height-for-age Z-scores (HAZ), neither group showed significant improvement after the intervention (p=0.642 for control and p=0.154 for intervention). This indicates that Tumiz Biscuit intervention did not affect height improvement. According to a study by Liu *et al.* (2019), short-term interventions rarely show a significant impact on linear growth in stunted children, as the recovery process for linear growth takes longer.[20] A study by Gupta et al. (2021) also emphasized the importance of micronutrient supplementation, such as zinc and vitamin A, to support linear growth.[21]

The change in weight-for-height Z-scores (WHZ) showed a significant improvement in the intervention group (p=0.007), while the control group showed no significant improvement (p=0.202). This indicates that Tumiz Biscuits played a role in improving the weight-to-height ratio in children experiencing wasting. According to research by Kim *et al.* (2022), nutritional interventions focused on increasing protein and fat intake can contribute to improving WHZ in malnourished children.[22] This finding is also supported by research by Brown *et al.* (2020), which showed that improvements in WHZ often occur more quickly in children receiving high-protein supplementary food interventions.[23]

The difference in changes in WAZ between the control and intervention groups was not significant (p=0.371), although the control group experienced a greater increase. Research by Lopez *et al.* (2023) stated that improvements in WAZ are not always directly related to supplementary food interventions but also to factors such as environmental hygiene and access to clean water.[24] Another study by Zhang *et al.* (2021) also showed that family factors and parenting practices play important roles in determining the outcomes of nutritional interventions.[25]

The difference in changes in HAZ between the two groups was also not significant (p=0.644), indicating no meaningful differences in linear growth. A study by Smith *et al.* (2021) emphasized that to observe significant changes in HAZ, interventions need to be conducted over a longer period, at least 12 months, and involve the provision of essential micronutrients.[26] Research by Yamamoto *et al.* (2020) also showed that nutritional interventions need to be combined with other health programs, such as deworming, to improve linear growth in stunted children.[27]

The difference in changes in WHZ was also not significant (p=0.715) between the two groups, although both groups showed improvements in weight-to-height ratio. This may reflect that improvements in WHZ occur faster than in HAZ. A study by Fernandes *et al.* (2022) found that weight gain is easier to achieve than height improvement, which takes longer to show the effects of an intervention on linear growth.[28] Another study by Johnson *et al.* (2023) supports this finding, stating that improvements in WHZ can be an early indicator of the effectiveness of nutritional interventions.[29]

The study results showed a significant decrease in serum albumin levels in both the control and intervention groups. This decrease can be interpreted as the body's response to prolonged malnutrition or as a result of metabolic processes occurring during the intervention period. The decrease in albumin levels in both groups may be associated with the metabolic stress condition often observed in malnourished children, leading to increased protein breakdown, including albumin. This decrease is consistent with a study by Kumari *et al.* (2021), which found that serum albumin levels tend to decrease in children experiencing acute malnutrition due to metabolic processes that utilize body proteins for energy.[30] Research by Carvalho *et al.* (2023) also supports this, showing that in conditions of malnutrition, serum albumin levels can decrease even during nutritional supplementation interventions, as the body prioritizes other metabolic needs.[31] Further studies are needed to understand the mechanism of albumin decline during nutritional supplementation interventions and how it relates to improving children's nutritional status.

Second, the metabolic response to malnutrition may also cause the protein from food to be directed more towards maintaining and restoring critical body functions rather than for albumin synthesis. This process is known as the prioritization of vital function recovery, where the body allocates nutritional resources to support essential organ functions before restoring protein reserves such as albumin. A study by Smith *et al.* (2021) showed that in children with chronic malnutrition, additional protein and energy intake is often first used to restore muscle mass and immune function before there is an increase in blood albumin levels. This might explain why, despite being given nutrient-rich Tumiz biscuits, there was no significant increase in serum albumin levels in the short term.[32,33]

Conclusions

There is no difference in the nutritional status of children who received Tumiz functional biscuits compared to the control group. The provision of Tumiz biscuits only significantly improved the nutritional status (WHZ index) based on the WHZ index.

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Table 1. Education level and occupation of parents.

Variable	Control		Intervention		p-value
	n	%	n	%	
Mother's Education:					
Did not finish primary	4	10.9	11	25.8	
Primary School	14	26.5	4	11.4	
Junior High School	1	2.9	1	2.9	0.488
Senior High School	15	47.1	14	51.4	
Higher Education	1	11.8	5	8.6	
Father's Education					
Did not finish primary	4	11.4	11	31.5	
Primary School	14	40.0	4	11.4	
Junior High School	1	2.9	1	2.9	0.037
Senior High School	15	42.9	14	40.0	
Higher Education	1	2.9	5	14.3	
Mother's Occupation					
Housewife	34	97.1	33	94.2	

Employee	1	2.9	1	2.9	0.560
Civil Servant	0	0	1	2.9	
Father's Occupation					
Employee	11	31.4	4	11.4	
Trader	0	0	2	5.7	
Civil Servant/Retired	2	5.7	2	5.8	0.169
Laborer/Driver	23	63.9	26	74.2	
Unemployed	0	0	1	2.9	
Family Members (people)	5.23 ± 1.21		4.80 ± 1.49		0.192
Number of toddlers (people)	1.71 ± 0.79		1.46 ± 0.61		0.180

Table 2. Child's health condition before intervention.

Variable	Control		Intervention		p-value
	n	%	n	%	
Child sick in the last month					
Yes	19	54.3	27	77.1	0.036
No	16	45.7	8	22.9	
Frequency of illness					
1 time	14	73.7	14	50.0	
2 times	4	21.1	13	46.4	0.155
3 times	0	0	1	3.6	
>3 times	1	5.3	0	0	
Duration of illness					
1 day	0	0	1	3.6	
2 days	8	42.1	5	17.9	
3 days	8	42.1	8	28.6	0.061
>3 days	3	15.8	14	50.0	
Type of illness					
Cough	1	5.3	0	0	
Cold	1	5.3	3	10.7	
Fever	5	26.3	8	29.6	0.699

Diarrhea	1	5.3	8	28.6	
Cough, cold, fever	9	47.4	1	3.6	
Cough, cold, fever, diarrhea	2	10.3	13	46.4	
Birth weight (kg)	2.98 ± 0.33		2.93 ± 0.49		0.608
Birth length (cm)	48.51 ± 1.04		48.00 ± 2.81		0.313

Table 3. Child's dietary pattern before the intervention.

Variable	Control		Intervention		p-value
	n	%	n	%	
Prelacteal feeding					
Yes	4	11.4	2	5.7	0.673
No	31	88.6	33	94.3	
Age of starting solid food					
0 months	34	97.1	35	100	1.000
4 months	1	2.9	0	0	
Frequency of eating daily					
1 time	0	0	1	2.9	
2 times	5	14.3	6	17.1	0.263
3 times	28	80.0	23	65.7	
>3 times	1	2.9	5	14.3	
Meal balance					
Imbalanced	12	34.3	14	40.0	0.554
Balanced	23	65.7	21	60.0	
Prelacteal feeding					
Yes	4	11.4	7	20	
No	26	74.3	26	74.3	0.349
Age of starting solid food	5	14.3	2	5.7	

Table 4. Changes in the nutritional status of young children before and after intervention.

Nutritional Status Indicator	Group	Pretest	Post-test	Sig*	changes	Sig**
Weight-for-age z-score	Control (n=35)	-2.22 ± 0.96	-1.84 ± 0.81	0.026	0.38 ± 0.97	0.371
	Intervention (n=35)	-1.72 ± 0.95	-1.60 ± 0.85	0.600	0.12 ± 1.39	
Height-for-age z-score	Control (n=35)	-2.90 ± 1.40	-3.06 ± 1.46	0.642	-0.21 ± 2.07	0.644
	Intervention (n=35)	-2.63 ± 1.04	-3.06 ± 1.59	0.154	-0.43 ± 1.75	
Weight-for-height z-score	Control (n=35)	-1.04 ± 1.76	-0.10 ± 1.18	0.202	0.94 ± 1.91	0.715
	Intervention (n=35)	-0.52 ± 1.33	0.24 ± 1.56	0.007	0.76 ± 2.00	
Albumin level	Control (n=29)	4.86 ± 0.27	4.17 ± 0.36	0.000	-0.57 ± 0.44	0.312
	Intervention (n=32)	4.75 ± 0.33	4.33 ± 0.31	0.000	-0.47 ± 0.43	

*Paired t-test; **Independent t-test