Original Article

Sago worms as a nutritious traditional and alternative food for rural children in Southeast Sulawesi, Indonesia

Intan R Nirmala MSc[1], Trees MPH[1], Suwarni MPH[1], Mochammad S Pramono PhD[2]

[1]*Nutrition Department, Health Polytechnic, Ministry of Health, Kendari, Southeast Sulawesi, Indonesia*
[2]*National Institute of Health, Research and Development (NIHRD), Center of Research and Development of Humanity and Health Management, Ministry of Health, Republic of Indonesia*

Background and Objectives: The sago worm *Rhynchophorus ferrugineus* is a nutritious food source found in the remaining parts of a sago palm trunk after the removal of sago starch by farmers. The effort to increase sago worm consumption is investigated in an intervention study among children aged <5 years. **Methods and Study Design:** Children aged 1–5 years were allocated to a sago worm inclusive diet (n=10) and to a control group eating a usual diet, but without sago worms (n=13). Snacks were served once per day (100 g) for 45 days and designed to contain similar amounts of vegetables (carrots and long beans) and other ingredients including rice, sticky rice, cassava, sweet potato, banana, or tofu with or without sago worms. Food preference was ascertained by interview. Anthropometric measurements were taken at baseline and the endpoint. **Results:** After mixing all food stuffs into one product for instance nasi gurih, protein and fat content in the intervention group was higher compared to control group (8.8 g and 7.3 g vs 4.7 g and 0.5 g respectively). In the intervention group receiving complementary feeding with sago worms, children's height changed minimally as did the control group (0.3 vs 0.2 cm); no difference was observed between the groups regarding weight or height. **Conclusions:** Sago worm consumption can diversify the diet through usage in various dishes, so improving its overall nutritional quality. Worm addition in an intervention program does not compromise, but maintains nutritional value. Local use adds affordability and sustainability to the food and health systems in a sago-consuming culture, so contributing to food security.

Key Words: Sago worm, nutritious, food security, children under five, Indonesia

INTRODUCTION

Lack of nutritious food can impair children's physical and mental development. Childhood stunting is one of the most significant impediments to human development, globally affecting approximately 162 million children aged younger than 5 years.[1] Infant and young child feeding is a key area to improve child survival and promote healthy growth and development.[2] In Indonesia, the prevalence rates of stunting and underweight among children aged <5 years were reported to be 37.2% and 19.6%, respectively.[3] According to the Nutritional Assessment Survey conducted in 2015 in South Konawe District, the prevalence of underweight was 24.3%. Because the prevalence of underweight is higher in South Konawe District than in the national prevalence rate, nutritional problems are becoming a serious concern. Compared with the national data (18.4%), the average number of children aged 24–59 months whose protein intake was below the minimum requirement (<80% of RDA) was reported to be higher (27.8%) in Southeast Sulawesi Province.[4] The high number of children not receiving adequate protein intake indicates a family food security problem.

There is growing interest in how insects might fill nutrition gaps and contribute to present and future food security.[5-7] These creatures are nutritious in several respects, albeit variably, notably their protein, essential fatty acid, and micronutrient such as riboflavin, panto thenic acid, biotin and, in some cases, folic acid, copper, iron, magnesium, manganese, phosphorous, selenium and zinc composition.[8]

The sago worm *Rhynchophorus ferrugineus*, which is used in the eastern part of Indonesia, is a nutritious animal food sources in this regions (Figure 1). Southeast Sulawesi Province is a sago-worm-producing region, especially South Konawe District. The sago worm is a common nutritious animal food (Figure 2) consumed by Tolakinese families (Figure 3). Sago worms breed in the remaining parts of a sago trunk after the removal of sago starch by farmers (Figure 4). Sago worms are often consumed by sago farmers and their families; they prepare various sago-worm-based dishes such as stir-fried sago worms, sago worm satay, and fried sago worms (Figure 5). The crispy taste encourages their consumption among local people; the local people also believe that sago worms have many beneficial effects on their health and

Corresponding Author: Intan Ria Nirmala, Nutrition Department, Health Polytechnic, Ministry of Health, Kota Kendari, Southeast Sulawesi Province, Indonesia 93114.
Tel: +62 401 3129321; Fax: +62 401 3123173
Email: irnirmala@yahoo.com; irnirmala123@gmail.com
Manuscript received 10 March 2017. Initial review completed 23 March 2017. Revision accepted 13 May 2017.
doi: 10.6133/ apjcn.062017.s4

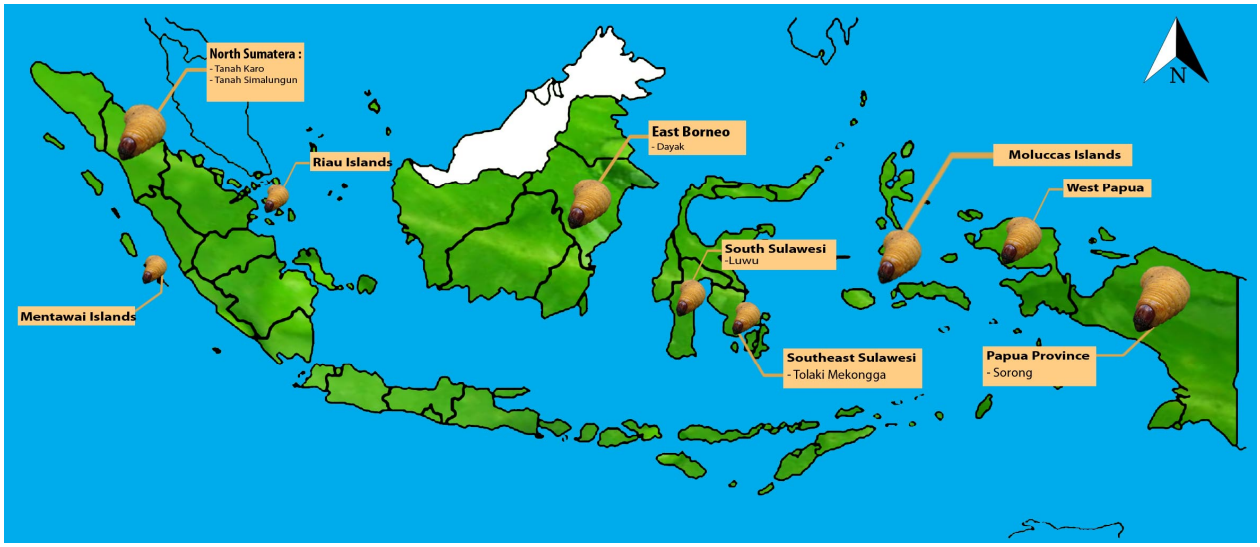

Figure 1. Map of sago worm areas in Indonesia.

Figure 2. Whole, fresh, and stir-fried sago worms in Kolono Subdistrict.

stamina. However, a technique for processing sago worms with the addition of other essential nutrients has not yet been developed.

Sago worms contain a high amount of protein and fat [approximately 25.5 g/100 g and 53.7 g/100 g, respectively (whole sago worm)]; however, their carbohydrate content is high if they are consumed in a homogenized form (60.2 g/100 g). Sago worms are considered a food source of energy based on the traditional understanding that they constitute a source of protein and carbohydrates. Sago worms consumed in any form still retain their protein content, and they contain fatty acids such as palmitic acid (32.4%), whose content is saturated as in coconut milk and; oleic acid (40.1%); and linoleic (n-6) (13.0%) along with linolenic acid (n-3), similar to that of soybean. The triolein of sago worms is high.[9] The nutrient composition of sago worms varies in both fresh and stir-fried cooking methods. Comparison of Table 1 shows that stir fried sago worms have protein, fat, fatty acids, and amino acids higher than fresh sago worms.

Figure 3. Children eating sago worm food.

Considering interventions such as supplementation, fortification, and dietary improvement, that target nutritional problems, a strategy that emphasizes food diversification based on local food systems is the more attractive and contributory to food security.[10] Although sago worms constitute a local sustainable food system and serve as a rich nutritional food source along with various animal food sources, they have yet to be comprehensively explored.[11] Therefore, the objective of the current study was to investigate the effect of sago worm consumption as a component of complementary feeding in children aged <5 years.

Many vulnerable groups cannot afford to buy fish and fish products; thus, sago worms can serve as a cheaper and easily available alternative. Increasing sago worm consumption maybe an accessible and affordable option in areas of food shortage, easily stored and transported as products for complementary feeding. To these ends, they need to be easily introduced into local diets and acceptable by the indigenous population, particularly children aged <5 years.

Figure 4. Harvesting sago worms in Awunio village.

MATERIALS AND METHODS

Study design and participants

This study was conducted in two villages in the Kolono subdistrict of South Konawe District, Southeast Sulawesi Province, Indonesia, between April and November 2016. A community-based, nonrandomized, controlled intervention design was applied in this study. This design was used because different types of intervention products were used that shown in Figure 5, such as complementary feeding using additional sago worm *serundeng*, sago worm *abon*, and sago worms stir fried as the filling of complementary food products (with chopped carrots and long beans in the filling).

Potentially age-eligible children were identified using data, provided by midwives, of a cohort of children aged <5 years. We included children aged 1–5 years who were stunted, wasted, and underweight; whose weight did not increase twice consecutively (called *2T* in the Indonesian language) and whose weight was below the red line based on the health card (called *Kartu Menuju Sehat* in the Indonesian language); who resided in the study area; and who provided signed informed consent from a legal guardian. Children who were allergic to sago worms and those with a history of malnutrition atrophy were excluded.

The study site was purposefully selected as a major producer of sago palms. Tolakinese children who eat sago worms traditionally were selected purposively as the sample.

Intervention

Children were divided into two groups: intervention and control. To minimize the discomfort of children and thereby ensure the acceptability of the study, the children (n=13) of one posyandu were included in the control group and those (n=10) of the other posyandu in the intervention group. There were less children in the intervention group due to more availability and accessibility to sago palm trees. Traditionally, children eat sago worms cooked with various dishes based on different basic commodities , such as grains, beans, vegetables and bananas, whereas adults generally eat the whole worm as a snack ,in a meal , either cooked or raw. Various types of sago worm snacks were used (Table 2, Figure 6) based on a baseline survey of children's snacks in stalls and traditional markets.

This study was conducted over 45 days. The control group was provided two pieces (50 g each) of complementary food without sago worms per day (containing 270.5±60.4 kcal of energy and 3.9±1.7 g of protein). In the intervention group, children were provided two pieces (50 g each) of complementary food with sago worms per day (containing 293.3±60.4 kcal of energy and 5.9±1.7 g of protein). The energy and nutrient contents of a daily ration are listed in Table 3. Community leaders and cadres of community health posts (called *Posyandu* in the Indonesian language) provided knowledge and practice-based information about processing sago worms as complementary feeding components. All mothers were encouraged to prepare their own children's snacks based on the material delivered through teaching and during training. Complementary feeding was delivered daily by a field team to homes around 09.00–10.00 or 14.00–16.00. In the following intervention period, children in the intervention and control who suffer from acute respiratory infection (ARI) were still considered to finish their foods. Unfortunately, the number of children who were sick during intervention were higher than children in the control group. Thus, children's compliance seems to effect the nutrient intake of the children. Both groups were

Figure 5. Sago worm serundeng, sago worm abon, stir-fried sago worms.

Table 1. Proximate, fatty acid, amino acid composition of fresh sago worms and stir-fried sago worms

	Fresh sago worms	Stir- fried sago worms
Proximate composition (100g)		
Carbohydrate, %	4.3	6.2
Protein, %	9.7	20.2
Fat, %	21.5	34.0
Fatty acids		
Palmitic acid, %	9.2	14.6
Oleat acid, %	9.7	15.2
Omega 3, %	0.2	0.3
Omega 6, %	0.3	0.5
Omega 9, %	9.7	15.2
Unsaturated fat, %	11.2	17.7
Saturated fat, %	10.3	16.2
Mono-unsaturated fatty acid (MUFA), %	10.7	16.9
Poly-unsaturated fatty acid (PUFA), %	0.49	0.82
Amino acids		
L-Leucine, ppm	4766	13505
L-Aspartic acid, ppm	6089	14327
L-Histidine, ppm	1410	4459
L-Threonine, ppm	3349	9891
L-Proline, ppm	3613	10889
L-Tyrosine, ppm	1988	8295
L-Lysine HCL, ppm	6925	16199
Glycine, ppm	3310	9737
L-Arginine, ppm	3422	9731
L-Valine, ppm	3062	10175
L-Isoleucine, ppm	2729	7665
L-Phenylalanine, ppm	2201	6303
L-Alanine, ppm	4187	13496
L-Glutamate acid, ppm	9925	25145
L-Serine, ppm	3180	10828
L-Methionine, ppm	984	2797
L-Cysteine, ppm	206	680

Table 2. Traditional sago worm – based food item preferences among children aged 1–5 years

Type of foods	Frequency (times)	n (%)			
		Liked		Disliked	
		Intervention (n=10)	Control (n=13)	Intervention (n=10)	Control (n=13)
Nasi Gurih (delicious rice)	7	90	100	10	-
Skotel (mixed rice and sticky rice)	10	100	100	-	-
Dadar Gulung (mixed wheat flour and grated coconut, brown sugar)	6	50	92.3	50	7.7
Roti Bakar (toasted wheat bread)	2	60	80	40	38.5
Tahu isi (tofu and vegetables)	3	100	100	-	-
Bola-bola ubi (sweet potato)	6	50	100	50	-
Kroket (cassava)	7	50	100	50	-
Panada (Fried wheat bread)	2	80	100	20	-
Bolu Pisang (banana)	1	80	100	20	-
Lemper (sticky rice, vegetables, and coconut milk)	1	60	69.2	40	30.8

observed and monitored every week for 45 consecutive days by using a questionnaire. The monitoring sheet was filled by coinvestigators every day. Every 2 weeks (14 days), researchers performed a retest, as in the initial test, to examine allergy complaints and atrophy, compliance with complementary feeding recommendations, and anthropometric and food intake measurements. Results were obtained through the answers provided by respondents in the questionnaire that had been prepared.

Outcome variables

Anthropometric measurements of children, including weight and height, were obtained at the baseline and final study point by trained field staff. Height was measured to the nearest 0.1 cm by using a microtoise type SH-2A (Guangdong, China) and weight was measured using digital Camry Scales type EB9003 ISO 9001 Registered (Guangdong, China). Anthropometric indices (height/age z-score, weight/age z-score, and weight/height z-score) were calculated using the SPSS macro for the WHO child growth standards.[12]

Data management and analysis

For quality assurance of the study data, the completeness, accuracy, and consistency of the data in the questionnaire were evaluated through multilevel checks performed by

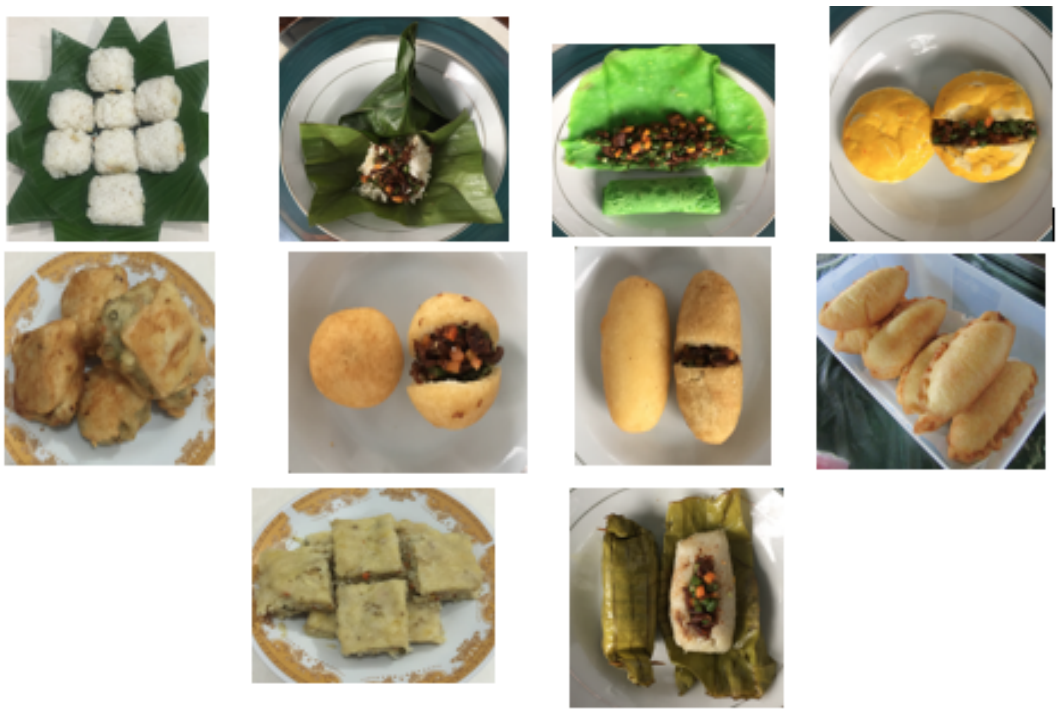

Figure 6. Children's sago worm snacks (from left to the right: nasi gurih, skotel, dadar gulung, roti bakar, tahu isi, bola-bola ubi, kroket, panada, bolu pisang, lemper).

Table 3. Nutritional composition of different kinds of food (100 g) for comparison to intervention and control group

Food	Energy (kcal)	Carbohydrate (g)	Protein (g)	Fat (g)	Vitamin A (µg)	Vitamin C (mg)	Calcium (mg)	Iron (mg)	Zinc (mg)
Intervention									
Nasi gurih (delicious rice)	268	56.1	8.8	7.2	98.4	1	10.6	0.6	0.7
Skotel (mixed rice and sticky rice)	268	56.1	8.8	7.2	98.4	1	10.6	0.6	0.7
Dadar gulung (mixed wheat flour and grated coconut, brown sugar)	270.1	53.9	11.2	7.5	98.4	1	15.4	1	0.5
Roti bakar (toasted wheat bread)	270.1	53.9	11.2	7.5	98.4	1	15.4	1	0.5
Tahu isi (tofu and vegetables)	77.1	4.1	9.7	10	98.4	1	75.6	3.8	0.5
Bola-bola ubi (sweet potatos)	101.3	20.4	5.9	6.9	98.4	10.4	11.3	0.8	0.4
Kroket (cassava)	114	24.2	5	7	102.4	21.1	18	0.7	0.2
Panada (Fried wheat bread)	270.1	53.9	11.2	7.5	98.4	1	15.4	1	0.5
Bolu pisang (banana)	103.9	23.7	4.8	6.9	159.4	8.4	6.6	0.6	0.1
Lemper (sticky rice, vegetables, and coconut milk)	268	56.1	8.8	7.2	98.4	1	10.7	0.6	0.7
Control									
Nasi gurih (delicious rice)	335.6	68.3	5.8	3.5	135.9	1	12.04	0.7	0.9
Skotel (mixed rice and sticky rice)	335.6	68.3	5.8	3.5	135.9	1	12.04	0.7	0.9
Dadar gulung (mixed wheat flour and grated coconut, brown sugar)	338.2	65.6	8.9	3.8	1.5	135.9	13.6	6.3	0.8
Roti bakar (toasted wheat bread)	338.2	65.6	8.9	3.8	1.5	135.9	13.6	6.3	0.8
Tahu isi (tofu and vegetables)	96.2	3.1	7	7	1.5	135.9	89.2	9.8	0.9
Bola-bola ubi (sweet potatos)	126.6	23.6	2.2	3.1	1.5	147.7	8.6	6.1	0.7
Kroket (cassava)	142.4	28.3	1.1	3.3	6.5	161.1	17	6.0	0.5
Panada (Fried wheat bread)	338.2	65.6	8.9	3.8	1.5	135.9	13.6	6.3	0.8
Bolu pisang (banana)	129.8	27.7	0.9	3.2	77.9	145.1	2.7	5.8	0.3
Lemper (sticky rice, vegetables, and coconut milk)	335.6	68.3	5.8	3.5	1.5	135.9	7.7	5.8	1.1

self-enumerators, other field workers, and field supervisors.

All statistical analyses were performed using the SPSS program for Windows, version 20.0. Continuous variables were examined for normal distribution and are presented as the mean (SD) and median (minimum–maximum), as appropriate. Furthermore, percentage (number of observations) is used for categorical variables. The Mann–Whitney U test was used to evaluate differences between screening and endpoint intervention. A p value of <0.05

Table 4. Baseline characteristics of participants in the intervention and control groups

Variable	%	
	Intervention (n=10)	Control (n=13)
Children sex		
Boys	50.0	46.2
Girls	50.0	53.8
Children's age (months)†	35.6±11.7	33.7±10.2
Children's age group		
12–<24 months	10.0	23.1
24–<60 months	90.0	76.9
Mothers's age (year)†	29.7±5.7	33.7±6.4
Mother's age group (years)		
<35	80.0	46.2
≥35	20.0	53.8
Number of children in the nuclear family‡	3 (1-5)	2 (1-7)
≤2	40.0	53.9
>2	60.0	46.1
Tribe of mother		
Tolakinese	50.0	76.9
Bugis	20.0	7.7
Others	30.0	15.4
Tribe of father		
Tolakinese	40.0	76.9
Bugis	40.0	7.7
Others	20.0	15.4
Mother's education		
Elementary school	40.0	30.8
Junior high school	30.0	38.5
Senior high school	0	23.1
University	30.0	7.7
Family income/month (Rp)		
<1,000,000.00	70.0	61.5
1,000,000.00–3,000,000.00	30.0	38.5

†Mean±SD.
‡Median (min-max).

was considered significant for all tests.

Ethical approval and consent

This study was approved by the Ethical Committee of the National Institute of Health, Research and Development (NIHRD), Ministry of Health, Republic of Indonesia (Certificate No. LB.02.01/5.2/KE.302/2016). The mothers of all children participating in the study provided written informed consent prior to enrollment.

RESULTS

Participants' characteristics

We observed no significant differences in the children's characteristics between the intervention and control groups. The average ages of the children in the intervention and control groups were 35.6±11.7 and 33.6±10.2 months, respectively. The majority of the mothers in the intervention group were aged <35 years, whereas more than half of the mothers in the control group were aged ≥35 years. Fifty percent of mothers in the intervention group and more than half of mothers in control group belonged to Tolakinese tribe. More Tolakinese mothers in the control not in the intervention groups, it was belong to the selection criteria of the study area which was depend on the availability and accessibility to sago palm trees. Furthermore, no significant differences were observed between the groups in terms of the number of children in the family or the highest educational qualification of parents. Most respondents reported having a household income of <Rp 1,000,000.00 per month (Table 4).

Compliance with complementary feeding recommendations

Compliance with complementary feeding recommendations differed significantly between the intervention and control groups in the first and third weeks. In the first week, the average complementary feeding consumption rate was 79.2% in the intervention group and 96.1% in the control group. In the third week, the average complementary feeding consumption rate increased in the intervention group (85.8%), and all children in the control group ate all the food without any leftover (100%). In the

Table 5. Compliance with complementary feeding recommendations per week per 100 g of material

Compliance	(Mean±SD)		*p*-value†
	Intervention	Control	
1st week	79.2±17.1	96.1±4.3	0.008
2nd week	79.1±31.4	99.0±2.9	0.088
3rd week	85.8±11.4	100±0.0	0.003
4th week	92.6±8.4	100±0.0	0.150
5th week	76.2±18.7	86.7±11.8	0.284
6th week	82.2±22.8	90.8±10.9	1.000
7th week	95.0±15.8	92.3±19.9	0.832

†*p* value; Mann–Whitney U test.

Table 6. Children's Nutrient intake before and after intervention and control groups

Nutrient	Baseline		*p*-value†	End point		*p*-value†
	Median (minimal–maximal)			Median (minimal–maximal)		
	Intervention (n=10)	Control (n=13)		Intervention (n=10)	Control (n=13)	
Energy, KJ/d	999 (459–1511)	635 (308–1389)	0.041	890 (247–1618)	927 (510–1532)	0.852
Protein, g/d	39.3 (24.1–122)	29.80 (5.1–50.3)	0.072	40.5 (8.3–82.3)	33.10 (9.5–56.3)	0.251
Fat, g/d	24.4 (3.6–36.1)	16.0 (1.3–39.0)	0.556	21.9 (2.7–31.3)	16.6 (0.8–49.2)	0.321
Vitamin A, µg/d	317.3 (96.3–1135)	86.4 (1.9–1228)	0.215	415 (48.6–1704)	649.4 (31.5–1485)	0.239
Vitamin C, mg/d	2.20 (0–58.7)	2.9 (0.1–16.4)	0.975	5.0 (0.4–31.3)	12.9 (0.8–44.7)	0.038
Calcium, mg/d	144.9 (39.4–536)	145 (16.2–344)	0.420	156 (12.4–477)	141.8 (16–318)	0.852
Iron, mg/d	3.6 (2.4–8.0)	2.4 (0.5–11.1)	0.054	2.85 (0.8–9.1)	4 (1–5.3)	0.291
Zinc, mg/d	3.8 (2.3–7.6)	2.2 (0.9–6.4)	0.023	3.35 (0.8–6.4)	3.1 (1.6–5.1)	0.780

†*p*-value Mann Whitney U test.

following weeks, no significant difference was observed between the two groups. However, according to the trend of compliance, the control group consumed more food than did the intervention group (Table 5).

Complementary feeding with/without sago worms at the baseline

The energy and zinc intakes differed significantly between the intervention and control groups ($p<0.05$). This was a likely outcome of low family income, adversely affecting family expenses, and of limited maternal education, with ignorance about amounts of appropriate food intake for children aged <5 years. Nutrient intakes in both the intervention and control groups were observed to be less than recommended for children aged 1–5 years. For example, the energy requirement of children aged 1–3 years is 1000 kcal and that for children aged 4–5 years is 1550 kcal;[13] this thus indicates the nutrient intake of the children in both the intervention and control groups to be inadequate (Table 6).

Complementary feeding with/without sago worms at the end of the study

After the intervention, the intake amount of vitamin C significantly differed between the intervention and control groups ($p<0.05$). Long beans and carrots are considered a potential source of vitamin C. After the intervention, the children's intake of protein, vitamin A, and vitamin C increased. The protein intake in the control and intervention groups increased by approximately 40.5 and 39.1 g, respectively; this intake amount is higher than the Indonesian recommended dietary allowance for children aged <5 years. The protein intake significantly increased in the intervention group compared with the control group because of the extra protein content obtained from sago worms (approximately 20 g). The vitamin A intake was higher in the control group (649 µg) than in the intervention group, because the complementary feeding in the control group contained mainly carrots and long beans (Table 6).

Effect of complementary feeding program on anthropometry after 45 days of intervention

After 45 days of intervention, no significant difference was observed in the weight and height of the children between the intervention and control groups [12.3 (9.1–14.5) kg vs 10.9 (7.5–14.1) kg, $p=0.110$; 92.5 (76.0–99.0) cm vs 86.6 (72.5–95.5) cm, $p=0.230$]. However, a trend of weight gain was observed in the control group compared with the intervention group (0.3 vs 0.2 kg). By contrast, height tended to increase in the intervention group compared with the control group (0.3 vs 0.2 cm). This finding indicates that the intervention period should be at minimum 3 months, which is the standard intervention period, and a high number of respondents should be included to obtain reliable data (Table 7).

DISCUSSION

This study was conducted to provide information on the use of sago worms as a potential protein source in complementary feeding for children aged <5 years in Kolono subdistrict, South Konawe District, Southeast Sulawesi Province, Indonesia. Sago worms, constituting an ingredient of the complementary feed, improved children's height. In the intervention program, nutrition education was also provided to mothers. The training was conducted to enhance the mothers' and cadres' skills regarding how to cook sago worms and to promote the consumption of sago worms as a potential protein source for child growth and development in order to reduce malnutrition among children aged <5 years. The training program was developed according to the first intervention study in which mothers had skillfully started making sago-worm-based snack foods such as siomay, otak-otak, ice cream, and nuggets. Through this information, the training program was designed considering a healthy food that can be processed using simple household technology and adjusted according to the families' economic capacity.

This study revealed that socioeconomic and demographic factors can affect the nutritional status of children aged <5 years. Because of economic factors, families have limited access to food sources. They cannot provide nutritionally balanced meals to their children, which increases the risk of malnutrition in children. Kamal reported that the relationship between poverty and malnutrition status is a manifestation of a pattern of somatic development of children living under poor conditions with inadequate food intake, greater exposure to infections, and lack of access to health care services.[14] The finding that the percentage of family income (<Rp 1,000,000.00) was higher in both the intervention and control groups is in line with that of the study of Eunice, Cheah, and Lee, who reported that low family income increases the risk of malnutrition in children. Families with low income contribute to child malnutrition.[15]

According to a situational analysis conducted by the

Table 7. Anthropometric outcomes in the intervention and control groups

Variable	Intervention (n=10)	Mean	Control (n=13)	Mean	*p*-value
Body weight, kg					
Baseline	12.5 (8.0-14.0)	11.6	10.5 (7.5-14.0)	10.4	0.149
Endline	12.3 (9.1-14.5)	11.8	10.9 (7.50-14.10)	10.7	0.306
Differences baseline and endline	0.3 (-1.0-1.1)	0.2	0.4 (-2.0-1.5)	0.3	0.576
Height, cm					
Baseline	92.2 (75.0-99.0)	88.7	86.5 (72.0-95.0)	85.2	0.264
Endline	92.5 (76.0-99.0)	89.1	86.6 (72.5-95.5)	85.4	0.254
Differences baseline and endline	0.2 (0.0-1.0)	0.3	0.1 (0.0-0.7)	0.2	0.252
WAZ					
Baseline	-1.7 (-3.3-0.7)	-1.4	-2.7 (-3.6-0.2)	-2.2	0.154
Endline	-1.4 (-2.5-0.9)	-1.2	-2.3 (-3.7-0.4)	-1.9	0.193
HAZ					
Baseline	-0.9 (-2.4-2.7)	-1.7	-0.8 (-2.6-0.6)	-2.5	0.321
Endline	-0.9 (-1.7-3.1)	-1.6	-0.5 (-3.9-0.9)	-2.4	0.193
WHZ					
Baseline	-2.1 (-4.1-1.7)	-0.6	-3.0 (-4.1-0.4)	-1.1	0.136
Endline	-1.9 (-4.0-1.8)	-0.4	-2.5 (-3.9-0.4)	-0.8	0.756

WAZ: weight/age z-score; HAZ: height/age z-score; WHZ: weight/height z-score; BW: body weight; BH: body height.

Health Intervention Research Team, NIHRD, and Nutrition Department, Health Polytechnic of Kendari, in 2014, most children from low-income families prefer to eat snacks over meals. Snacks, such as fast foods (gorengan, and siomay), energy drinks, and sugar-sweetened drinks, are considered to have a low nutrient content. However, the quality of the snacks consumed by such children is unknown. The current study attempted to modify nonnutritious snacks to nutritious snacks for children's growth and development. Accordingly, sago worms were used as a traditional food for Tolakinese because they are easily available at a low cost. However, the protein content of stir-fried sago worms was higher (20.2%) than that of fresh sago worms (9.7%). Moreover, zero-calorie snack intake decreased in both boys and girls in the two groups because approximately two-thirds of them consumed sago worms as an ingredient of complementary feeding on a daily basis. Encouraging the intake of complementary feeding made from sago worms as well as nutritious meals is more appropriate to promote healthy eating among children aged <5 years. In this study, the children's compliance with complementary feeding made from sago worms did not significantly differ between the two treatment groups. Moreover, the frequency of complementary feeding intake was higher in the control group than in the intervention group. Additional sago worms may play an important role in increasing the amount of food consumed by children. Evidence indicates that an appropriate additional quantity of sago worms can influence the flavor of foods, especially for those who consumed sago worms for the first time. This finding is in line with that reported in the study of Talavera, Narciso, and Felix; they reported that the foreign flavor of foods is one of the factors resulting in nonadherence to complementary feeding intake.[16] The intervention group underwent an adaptation process because the food provided to this group contained the protein-rich sago worms, whereas the control group did not encounter problems with compliance because the provided food did not contain sago worms. An examination of human taste perception regarding consumed food revealed that nutrient absorption is influenced by the constituents of the consumed food.[17] People's selection of food is driven by taste and exposure to the environment; hence, an effective strategy should be used to make products from insects more pleasant in terms of taste, texture, and smell. This will result in the insect-based products not being used as a substitute for beef or chicken but as a food itself.[18] In this study, only Tolakinese children who could recognize sago worms, preferred its distinctive taste, and were aware about its nutritional and health benefits were enrolled.

Of the 23 mothers, two in both the intervention and control groups had already adopted a sago worm recipe to increase the protein sources of food. When sago worms were not available in the household, they substituted them with chicken and shrimp as one ingredient of snacks for their children. This is in accordance with the result reported by Talavera, Narciso, and Felix; they demonstrated that mothers easily adopted the recipe from local ingredients, which are easily available at the household level, and used simple tools for cooking along with affordable ingredients such as chicken eggs.[16]

Various factors can explain why this study might be different from other studies. Olaya, Lawson, and Fewtrell demonstrated that when extra food was provided in the form of 100% red meat, mothers reported that children could receive the food very well without any cases of vomiting.[19] By contrast, in our study, children in both groups developed fever, flu, and cough in the middle of the intervention period because of the weakening of their immunity due to changes in weather. However, children who were sick did not drop out of the intervention period. This may be because sago worms and vegetables (carrots and long beans) can boost the immune system of children aged <5 years when sick; therefore, the extra food was consumed every day, despite the declining response, because it was not expected to cause drastic weight loss.

In our study, the protein intake was higher in the intervention group than in the control group because the intervention group received extra 20 g of sago worm in the

complementary feed. The vitamin A and C intake was higher in the control group than in the intervention group (649.4 μg vs 415 μg and 12.9 mg vs 5.0 mg). This was presumably due to the consumption of vegetables (carrots and long beans) in the intervention group and control groups; however, the level of compliance with the recommended complementary feed intake was lower in the intervention group. An overall improved nutritional status of children in both groups is not unexpected when both are the subject of attention. Prior to the energy and protein intake at screening and during the intervention, the children consumed rice, instant noodles, and fish as usual. All children received the nutritious meal or snack once per day for 6 days per week.[20]

Rettore, Burke, and Barry-Ryan reported that insects have a high protein content that is of high quality and contains all essential amino acids. They also contain unsaturated fatty acids, minerals, vitamins, and fiber. Insects have the potential to be nutritious food in the future.[5,7,21] However, additional studies are still required in terms of product development, but the greatest challenge is related to consumer perception. Although researchers have many challenges to overcome, entomophagy is necessary to change eating habits in order to overcome food insecurity. In line with the findings that changing eating habits is not easy, a very long process is required in which sago worms could be continuously introduced. Not only Tolakinese children but also children in other sago consuming population should be aware of the nutritional, economic and sustainability benefits of sago worms.

Our findings are relevant to the traditional use of insects in food cultures across Indonesia and elsewhere. For example, flying insects like flying termites (in Bahasa Indonesia is 'laron') are caught and fried in Java, as are grasshoppers, worms from the turi flower (East Java), nyale worms (Lombok), crickets, moths, butterfly larvae (West Java), teak tree cocoon (East Java), wasps (East Java). The Asia Pacific region has numerous further examples.[22]

Limitations

The duration of the intervention program was limited to 45 days. Ideally, this type of study should be conducted for a minimum of 3 months. Another limitation of this study is that allocation of participants to the study groups was not randomized, but rather according to village commitment and convenience to sago palm availability. Finally, the use of a food stuff as an intervention is inherently biased. To mitigate this bias, participants were not informed whether they had been assigned to the intervention or control group.

Conclusion and recommendations

Consumption of sago worms by young children is an option, especially where sago is the staple and the worm has a traditional culinary place. It can improve nutritional eating with or without snacking. Local food guides can take into account the overall food culture and the role that insect consumption can play. The more important findings of this study are, however, that children who live in sago consuming communities can achieve nutrition security through the consumption of sago worms and the dietary diversity that their usage encourages.

ACKNOWLEDGMENTS

We thank the children and their mothers for their participation and interest, as well as the entire field team for their dedication and hard work in successfully conducting the study.

AUTHOR DISCLOSURES

The authors declare that there are no conflicts of interest in conducting and reporting this study. This study was fully funded by the NIHRD, Center of Research and Development of humanity and Health Management, Ministry of Health, Republic of Indonesia. The funding bodies had no role in the study design, data collection, data analysis, data interpretation, or decision to publish the findings. The abstract was accepted as an oral and a poster presentation at the 1st South East Asia-Public Health and Nutrition (SEA-PHN) Conference in Kuala Lumpur on 14-17 May 2017.

REFERENCES

1. World Health Organization. Micronutrient deficiencies - iron deficiency aneamia. WHO; 2014 [cited 2017/03]; Available from: http://www.who.int/nutrition/topics/ida/en/index.html.
2. World Health Organization. Infant and Young Child Feeding. WHO; 2016 [cited 2017/03]; Available from: http://www.who.int/mediacentre/factsheets/fs342/en/index.html.
3. Ministry of Health, Republic of Indonesia. National Report of Research on Basic Health 2013. Jakarta: Board of Health Research and Development, Ministry of Health; 2013.
4. Ministry of Health, Republic of Indonesia. National Report of Research on Basic Health 2007. Jakarta: Board of Health Research and Development, Ministry of Health; 2007.
5. van Huis A, Itterbeeck JV, Klunder H, Martens E, Halloran A, Muir G, Vantomme P. Edible insects: future prospects for food and feed security. FAO Forestry Paper, Rome; 2013.
6. Liu ZY. Insects as food in China. J Ecol Food Nutr. 1997;36: 201-7. 10.1080/03670244.1997.9991515
7. Yi C, He Q, Wang L, Kuang R. The utilization of insect-resources in Chinese rural area. J Agric Sci. 2010;2:146-54.
8. Rumpold BA, Schluter OK. Potential and challenge of insects as an innovative source for food and feed production. IFSET. 2013;17:1-11.
9. Ali OM, Chu KL, Wang CW. Neutral lipid profile of sago worm, the larva of weevil Rynchophorus ferrugineusthe. Proceeding of the 1st International Conference on Natural Resources Engineering & Technology, Malaysia; 2006. pp. 233-6.
10. Wahlqvist ML. Connected community and household food based strategy (CCH-FBS): Its importance for health, food safety, sustainability and security in diverse localities. J Ecol Food Nutr. 2009;48:457-81 . doi: 10.1080/03670240903308596.
11. Kuhnlein VH, Receveurs O. Local cultural animal food contributes high level of nutrients for Arctic Canadian Indegenous adults and children. J Nutr. 2007;137:1110-4.
12. WHO. WHO Child Growth Standards: Methods and Development: Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index- for-age. Geneva: WHO; 2006.
13. Ministry of Health Republic of Indonesia. Angka Kecukupan Gizi 2004 bagi orang Indonesia. Indonesian nutrition network, Departemen Kesehatan RI. Jakarta: Ministry of Health, Republic of Indonesia; 2004.
14. Kamal M. Socio-economic determinants of severe and moderate Stunting among under-five children of rural Bangladesh. Mal J Nutr. 2011;17:105-18.

15. Eunice MJ, Cheah WL, Lee PY. Factors influencing malnutrition among young children in a rural community of Sarawak. Mal J Nutr. 2014;20:145-64.
16. Talavera MTM, Narciso MH, Felix ADR. Recipe trials to improve complementary feeding: the Philippine experience. Mal J Nutr. 2014;20:183-95.
17. Tontisirin, K, Nantel G, Bhattacharjeef L. Food-based strategies to meet the challenges of micronutrient malnutrition in the developing world. Proc Nutr Soc. 2002;61:243-50.
18. Deroy O, Reade B, Spence C. The insectivore's dilemma, and how to take the West out of it. Food Qual Prefer. 2015;44:44-55.
19. Olaya GA, Lawson M, Fewtrell MS. Efficacy and safety of new complement feeding guidelines with an emphasis an red meat consumption: a randomized trial in Bogota, Colombia. Am J Clin Nutr. 2013;98:983-93.
20. Scherbaum V, Purwestri RC, Stuetz W, Inayati DA, Suryantan J, Bloem MA, Biesalski HK. Locally produced cereal/nut/legume-based biscuits versus peanut/milk-based spread for treatment of moderately to mildly wasted children in daily programmes on Nias Island, Indonesia: an issue of acceptance and compliance? Asia Pac J Clin Nutr 2015;24: 152-61. doi: 10.6133/apjcn.2015.24.1.15.
21. Rettore A, Burke R, Barry-Ryan C. Insect: a protein revolution for the western human diet. Dublin Gastronomy Symposium; 2016.
22. Bukkens SGF. The nutritional value of edible insects. J Ecol Food Nutr. 1996;36:287-319.