RESEARCH ARTICLE

Protein-Energy Nutritional Status of Moderately Low Protein Intake-Sago Diets Compared to Sufficiently Protein Intake-Rice Diets in Well-Nourished Lowlanders in Papua, Indonesia

[version 1; peer review: 1 approved with reservations]

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V1 First published: 02 Feb 2022, 11:138
<https://doi.org/10.12688/f1000research.76099.1>
Latest published: 02 Feb 2022, 11:138
<https://doi.org/10.12688/f1000research.76099.1>

Abstract

Background: Protein inadequacy is prevalent in developing countries because of the high consumption of starchy staple foods. Sago, as a staple food in Papua Province, was eaten with less protein. This study aimed to analyze the nutritional status of protein-energy in well-nourished adults of the moderately low protein in-take (MLP)-sago group compared to the sufficient protein intake (SP)-rice group, in lowland Mimika, Papua.

Methods: This cross-sectional-analytic study was conducted on 50 participants. Twenty-four-hour food recall, body composition, albumin, and complete blood count were used to assess the nutritional status.

Results: There were no differences in the body compositions and albumin levels between the MLP-sago and SP-rice groups. Multivariate linear regression showed that the mean corpuscular volume (MCV) ($\beta = -0.524$, $P = 0.007$) was a predictive factor for albumin in the sago group, while in the rice group, hemoglobin ($\beta = 0.354$, $P = 0.089$) and white blood cell counts ($\beta = 0.396$, $P = 0.059$) were predictive factors.

Conclusions: The MLP-sago and SP-rice groups exhibited no differences in the body and visceral protein; however different

Open Peer Review

Approval Status ?

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version 1	?
02 Feb 2022	view
1. Dina Keumala Sari , Universitas Sumatera Utara, Medan, Indonesia	

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predictors of albumin were found between the groups, suggesting an adaptive mechanism in the MLP-sago group to maintain normal albumin levels.

Keywords

moderately low protein intake; sago; albumin; MCV; visceral fat; basal metabolic rate; well-nourished, Papua.

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Author roles: **Syauki AY:** Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Project Administration, Resources, Software, Supervision, Validation, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; **Ogawa A:** Funding Acquisition, Project Administration, Resources, Writing – Original Draft Preparation, Writing – Review & Editing; **Simanjuntak URP:** Investigation, Project Administration, Resources; **Mangiwa IG:** Investigation, Project Administration, Resources; **Doi M:** Data Curation, Resources; **Kageyama S:** Data Curation, Resources; **Inoue R:** Conceptualization, Formal Analysis, Methodology, Project Administration, Resources, Software, Validation, Writing – Original Draft Preparation, Writing – Review & Editing; **Taslim NA:** Conceptualization, Supervision, Writing – Original Draft Preparation, Writing – Review & Editing; **Irie Y:** Conceptualization, Formal Analysis, Funding Acquisition, Methodology, Project Administration, Supervision, Validation, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing

Competing interests: No competing interests were disclosed.

Grant information: The author(s) declared that no grants were involved in supporting this work.

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How to cite this article: Syauki AY, Ogawa A, Simanjuntak URP *et al.* **Protein-Energy Nutritional Status of Moderately Low Protein Intake-Sago Diets Compared to Sufficiently Protein Intake-Rice Diets in Well-Nourished Lowlanders in Papua, Indonesia [version 1; peer review: 1 approved with reservations]** F1000Research 2022, 11:138 <https://doi.org/10.12688/f1000research.76099.1>

First published: 02 Feb 2022, 11:138 <https://doi.org/10.12688/f1000research.76099.1>

Introduction

Protein is an essential element of the diet. It is required for the growth and maintenance of the 25,000 proteins that have been encoded by the human genome. The latest recommendation for protein requirements was released in 2007.¹ Access to quality nutrients, especially proteins, is a problem among poor populations in low-income countries. Countries in sub-Saharan Africa and South Asia have a prevalence of protein inadequacy of more than 5%. Proteins from animal-source foods in the food supplies of sub-Saharan Africa and Asia have been shown to be lower than the global average (20% and 32% vs. 40%, respectively). Most of the proteins (70%) consumed in sub-Saharan Africa are obtained from cereals and roots² with diets being dominated by starchy staple foods, and nutrient-dense animal-source foods, fruits, and vegetables often being unavailable or unaffordable.³

Sago palm is a plant resource that has the most efficient carbohydrate-producing crop in the world. It produces starch and stores it in the trunk. The amount of production is between 150–300 kg of dry starch per plant or up to 25 tons of starch per hectare per year. It is approximately three to four times higher than that of rice, corn, or wheat, and 17 times higher than that of cassava. Sago palm is expected to provide a countermeasure for food insecurity resulting from the rapid population growth (95% being predicted in developing countries) and an increase in per capita food consumption. Sago can grow under natural conditions or can be cultivated in underutilized wetlands and peat swamps. However, the conversion of wetlands and peat swamps into industrial crop plantations has had a negative impact on the sustainability of sago palm production.^{4–6}

Indonesia has the largest area of sago palm plantations and sago forests in the world (estimated 85%) and the richest genetic diversity of sago palms. Sago palms in Indonesia, such as in Papua Island, Sulawesi Island, Maluku Island, Sumatra Island, Kalimantan Island, and Java Island, with the highest area being in Papua Island (estimated 95%). Papua was proposed as the center of sago palm diversity in Indonesia while Sulawesi and Kalimantan were the sources of diversity. The sago palms in Papua and West Papua grow in sago forests that have not been managed or cultivated, which can decrease the production.⁶

Before rice largely replaced these crops, sago together with taro and yam was claimed to be one of the oldest crops and former staple foods in large areas of Southeast Asia and Oceania. Papua Province has a huge sago forest of more than 1 million hectares in total. Coastal communities and the lowlanders in the Papua province consumed papeda (sticky dough, which is considered as cooked rice) and sago lempeng (roasted sago) as their food since ancient times and they still currently do so.^{6–9} Limited production and a higher price of sago compared to imported food products, subsidized particularly imported rice, resulting in a declining consumption of sago.^{6,8}

The farming behavior of indigenous Papuan farmers is similar to “home-vegetable gardening”. They cultivated plants that are resistant to disease and have a minimum risk of failure, such as taro, sweet potatoes, cassavas, and bananas. Those commodities are also limited in quantities only for their consumption. For sago-eating people, wild sago was obtained in the forest and stored for one week’s consumption. Meanwhile, rice-eating people were not cultivating rice, as an alternate, they were provided rice from the government through “rice for the poor policy”. These behaviors were influenced by two perceptions that related to local wisdom in preserving nature. First, the potential of natural resources available in the ecological environment is a source to meet the food needs of the local population. Second, the potential of foods crops in nature is perceived as “a blessing” that should not be overused. This phenomenon affects the performance of Papuan farmers such as not cultivating agricultural land regularly, not developing market-oriented agricultural commodities, and tending to grow commodities that can be consumed in limited quantities.¹⁰

Rice policy was integrated into the national transmigration program in 1954/1955 and its implementation continued between the 1970s and the 1990s. This policy was continued by the central government through the “rice for poor” policy since the 2000s.¹¹ Transmigration started in Papua in 1984 in the form of military transmigrants. Rice policy as part of the transmigration program also began and proceeded with the rice for poor policy since 2002.^{12–13} Native people who were eating sago as their staple food and changed to rice consumption were receiving rice for free from the government and maintained their home-vegetable garden of planting.¹⁰

The use of sago starch and sago-based food products spread in 21 of the 33 provinces of Indonesia as staple foods or snacks, especially in the coastal or lowland areas. Sago as local food has great potential to be developed to support food diversification because it contains high carbohydrate productivity. However, other nutrients, including proteins, are very low in sago. As a staple food, sago must be consumed together with a protein food source to fulfill the requirements of protein intake.^{7,9}

The history of coastal communities with the consumption of sago as the main staple food shows that they are healthy, physically strong people, and reliable seafarers.⁷ Mimika is a low-lying district, and people consume sago as their staple

food with less protein. Mimika is also classified as a district with a higher risk of food insecurity.¹⁴ However, to date, no report has implied protein deficiency symptoms in adults in this area, contrary to the strong muscular bodies of these people. Rice contains a certain level of protein and is consumed by local people. There is no data available on the health issues involving low protein intake among people who eat sago. This study aimed to analyze the protein-energy nutritional status of two adult populations with similar hereditary and environmental conditions, one who consumed sago with a moderately low protein intake, and the other, who consumed sago with sufficient protein intake.

Methods

2.1. Study Population and Ethics Approval

This cross-sectional-analytic study was a part of the main study on analysis of gut microbiota of the lowlanders in Mimika Regency, Papua, Indonesia, conducted in September 2019. The sample size of this study was based on the main study (50 participants with 25 in each group). The inclusion criteria were men and women lived in the lowland of Mimika Regency, Papua with ages ≥ 20 years, body mass indexes between 18.5–24.9 kg/m², those who consumed traditional carbohydrate-based food (sago) with low protein intake (< 25 g/d) or who consumed modernized carbohydrate-based food with sufficient protein intake (≥ 25 g/d). Participants who had taken antibiotics within the preceding six months, who had taken laxatives, gastric motility medications, prebiotics, or probiotics containing foods or supplements within the preceding month, had a medical history of clinically significant diseases such as cancer, gastrointestinal disorders (irritable bowel syndrome, inflammatory bowel diseases, coeliac diseases, constipation, diarrhea, excessive bloating), autoimmune disorders, diabetes, heart diseases, renal failure or previous gastrointestinal surgery, infectious diseases, smokers or those with high alcohol consumption, were excluded from the study. The study was approved by Komite Etik Penelitian Kesehatan (Health Research Ethical Committee), of the Faculty of Medicine, Hasanuddin University, Makassar, Indonesia (Approval Recommendation Number: 554/UN4.6.4.5.31/PP36/2019 and protocol code: UH19070416). This study was also approved by the Ethics Committee of Okayama Prefectural University (Protocol Code Number: 19-55). Written informed consent was obtained from all participants involved in the study.

2.2. Measures

2.1.1. Socio-demographics

A questionnaire was used to collect information on the characteristics of the participants, such as socioeconomic-demographics (age, ethnicity, education, occupation, and income), medical histories (cancer, gastrointestinal disorders, autoimmune disorders, diabetes, heart diseases, renal failure, previous gastrointestinal surgeries, infectious diseases), consumption of medications or supplements (laxatives, gastric motility medications, and prebiotic or probiotic-containing foods or supplements), and lifestyles (smoking and alcohol consumption).

2.1.2. Anthropometric Assessment

Participant height was measured using a mobile stadiometer (SECA 213). Body weight, body fat %, bone mass, total body water %, muscle mass, basal metabolic rate (BMR), and visceral fat were measured using a body composition monitor (TANITA BC 730). The measuring platform was placed on a hard, flat surface with minimal vibrations to ensure a safe and accurate measurement. Measurements were taken with minimal clothing and on an empty stomach (no meal before). The socks were removed, and the soles of the feet were cleaned before the participant stepped onto the measuring platform. Before measuring, personal data such as birth dates, gender, and height were input. The participant was asked to step onto the scale after the scale turned on, stand unassisted in the center of the platform and look straight ahead while standing relaxed but still. The participant was allowed minimal clothing, but a mobile phone, a wallet, and anything heavier were removed. After the measurements were taken, the readings were displayed automatically, including body weight, bone mass, total body water percentages, muscle mass, BMR, visceral fat, and body fat percentages. The assessment was performed twice, and the average was used for the analysis. One of the most common methods for measuring muscle strength is the isometric grip strength test. We measured the isometric grip strength using a handgrip dynamometer. The participant was asked to squeeze the dynamometer as hard as possible with each hand while in a standing position. Before beginning the grip strength testing procedures, the participant was asked a series of questions to obtain information about muscle conditions (any visible limitations for either hand, any surgery of his/her hand, any pain, aching or stiffness, right-handed, left-handed, or equally). The participant remained seated during the preparation and warm-up periods.

2.1.3. Dietary assessment

The intake of energy, macronutrients (carbohydrate, protein, fat), micronutrients, and fiber were measured using basically 3-day non-consecutive days of a 24-hour food recall (only one person had two-day non-consecutive days). This

assessment was performed on one or two weekdays and on one weekend day to obtain their usual dietary intakes. Face-to-face interviews were conducted to recall their food intake in the last 24-hour. On estimating portion sizes of the food, plastic food models were used with information on portion sizes, for example, food model of standardized rice with portion sizes information or food model of standardized fish with portion sizes information. Common household measures such as household cups, bowls, spoons, rice spoons, and food photographs were also used to assist the individuals in estimating their portion of the food consumed. Observations on the fish seller were conducted to have accurate data on the type and the portion size of fish. Cooking methods of their local staple food have also been observed to have a precise recipe. At the beginning of the study, a meeting was held together with the head of the public health center to explain the purpose, the benefits, the measurements, and the team member of the study to establish communication with our study population. On collecting food intake data, we were accompanied by staff from the public health center, who is familiar with our study population. The dietary intake was analyzed using the Nutrisurvey 2007 application (www.nutrisurvey.de).

2.1.4. Blood Test

The complete blood counts and plasma albumin levels were measured by Prodia Laboratory, Jayapura, Papua, Indonesia.

2.3. Statistical Analysis

All the data were expressed as means $\pm$ SDs and medians (minimum, maximum). The data normality distribution was determined using the Shapiro-Wilk test. The differences between groups were determined by the independent t-test (normally distributed data) or Mann-Whitney test (non-normally distributed data). The Pearson test was used to evaluate the correlation between albumin levels and other parameters because albumin was normally distributed. Parameters that correlated with albumin ($P < 0.25$) were further included in multivariate linear regression analyses. Multivariate regression tests were performed on both the rice and sago groups. The results of the regression models are shown as B, standard error, β , t, and p values. The Pearson's test was also used to evaluate the correlation of the laboratory profiles, anthropometry profiles, and intake profiles of both the rice and sago groups. All the statistical analyses were performed using the Statistical Package for the Social Sciences version 27 (SPSS Inc, Chicago, IL, USA). Statistical significance was established at a P-value < 0.05 .

Results

3.1. Socio-characteristics and Nutrient Intake of the Study Participants

Fifty participants were recruited with 25 each with 12 male and 13 female in the rice and 11 male and 14 female in sago groups. Participants in the sago group were significantly older than those in the rice group (52.91 vs. 43.28-year, $P < 0.05$). Most of the participants in both groups were of Kamoro ethnicity (Table 1). The educational background of both groups was predominantly 6–9 years of schooling. However, > 9 years of schooling was the second most common (24%) educational background in the rice group. Farming with a home-vegetable garden was the most common occupation in both groups; however, temporary employment was the second most common occupation in the rice

Table 1. Socio-demographic characteristics of the study population.

	Rice (n = 25)	Sago (n = 25)
Age (year)	43.28 $\pm$ 13.72	52.91 (25.00, 64.00) *
Gender (%)		
Men	48	44
Women	52	56
Ethnic (%)		
Kamoro	92	100
Others	8	0
Marital status (%)		
Married	72	88
Divorced	20	12
Not married	8	0

Variables are presented as means $\pm$ SDs, medians (minimum, maximum), and percentages. Abbreviations: SD standard deviation; % percentage; IDR Indonesia Dollar Rupiah; P probability. *Significantly different ($P < 0.05$) by Mann-Whitney U test with the rice group

group. Most of the participants in both groups had incomes < 1.000.000 IDR per month; however, in the rice group, 8% had an income > 2.000.000 IDR per month.

The intake of most of the nutrients between the rice and sago groups was significantly different. Protein intake in the sago group was significantly lower than in the rice group (19.9 g/d vs. 36.7 g/d, $P < 0.001$). However, the carbohydrate and fiber intake were higher in the sago group than in the rice group (245.5 g/d vs. 171.7 g/d, $P < 0.001$; 5.0 g/d vs 3.3 g/d, $P = 0.001$, respectively). The micronutrient intake profile of the rice group was significantly higher than that of the sago group (Table 2).

Our food groups showed that the rice group gained the largest energy from the rice (607 kcal/day), while the sago group did it from sago (810 kcal/day). Rice (11.0 g/day) and fish (13.1 g/day) were the sources of protein in the rice-eating group, while in the sago group, fish (12.2 g/day) was the major source of the protein (Table 3 and 4).

3.2. Anthropometric and Laboratory of the Study Participants

Body composition (muscle mass, fat mass, visceral fat, and basal metabolic rate) showed no significant differences between the rice and sago groups. The hand-grip strength did not differ between the groups (Table 5). Muscle strength of both groups showed within in normal range. In the rice group, men had a median of 37.3 kg and women had a mean of 22.3 kg with the reference value in men 35.5–55.3 kg and women 18.9–32.7 kg for 40–44-year-old. While in the sago group men had a median of 36.7 kg and women had a median of 22.5 kg with the reference value in men 34.7–54.5 kg for 45–49-year-old and women 17.7–31.5 kg for 55–59-year-old.

Laboratory profiles showed a significant difference between the rice and sago groups in the hemoglobin and hematocrit levels of the males (13.7 g/dL vs 12.6 g/dL, $P = 0.044$; 43% vs 41% $P = 0.027$, respectively). Men in the rice group had normal hemoglobin levels, while those in the sago group had hemoglobin levels lower than the reference values. Meanwhile, the hematocrit levels of the men in both groups were within the reference values. The hemoglobin levels in the women in both groups were lower than the reference values but did not differ between the groups. A lower MCV value than the reference value was found for both rice and sago groups. Iron intake did not differ between groups of men and women but was lower than the reference value Serum albumin levels did not differ between the rice and sago groups and were within the reference values (Table 6).

Table 2. Nutrient intake of the study population.

	Rice (n = 25)	Sago (n = 25)	P value
Energy intake (kcal)	1029 ± 373	1233 ± 381	0.062
Protein intake (g)	36.7 ± 16.0	19.9 ± 8.0	< 0.001 ^a
Fat intake (g)	20.0 (4.6; 67.7)	16.2 ± 10.0	0.295
Carbohydrate intake (g)	171.7 (64.9; 319.8)	245.5 ± 79.5	< 0.001 ^b
Fiber intake (g)	3.3 ± 1.2	5.0 ± 1.9	0.001 ^a
Vitamin A intake (μg)	262 (48; 854)	162 ± 108	0.008 ^b
Vitamin B1 intake (mg)	0.33 (0.17; 0.60)	0.23 ± 0.14	0.006 ^b
Vitamin B2 intake (mg)	0.30 (0.13; 0.87)	0.13 (0.03; 0.43)	< 0.001 ^b
Vitamin B6 intake (mg)	0.7 ± 0.2	0.3 (0.1; 0.9)	< 0.001 ^b
Vitamin C intake (mg)	20 ± 12	13 ± 10	0.031 ^a
Sodium intake (mg)	74 (18; 618)	78 (35; 629)	0.600
Potassium intake (mg)	791.8 ± 313.3	555.6 ± 253.5	0.005 ^a
Calcium intake (mg)	122 (42; 440)	69 (26.; 262)	0.008 ^b
Magnesium intake (mg)	122 (56; 205)	75 ± 29	< 0.001 ^b
Phosphorus intake (mg)	515 ± 210	272 (149.; 749)	0.002 ^b
Iron intake (mg)	3.2 (1.6; 9.5)	3.2 ± 1.3	0.393
Zinc intake (mg)	3.27 (1.13; 11.53)	1.43 (0.57; 4.17)	< 0.001 ^b

Variables are presented as means ± SDs and medians (minimum, maximum). Abbreviations: SD standard deviation; kcal kilocalories; g gram; μg microgram; mg milligram; P probability; ^aSignificant difference between the rice and sago groups with the independent t-test; ^bSignificant difference between the rice and sago groups with Mann-Whitney U test.

Table 3. Food groups consumed per day of the rice group.

	The amount (g/day)	Energy (kcal)	Protein (g)	Fat (g)	Carbohydrate (g)
Rice	467.0 (167.0; 533.0)	607 (217; 813)	11.0 (4.0; 14.0)	1.0 (0.0; 18.0)	129.0 (48.0; 153.0)
Sago	0.0 (0.0; 121.0)	0 (0; 461)	0.0 (0.0; 0.0)	0.0 (0.0; 3.0)	0.0 (0.0; 110)
Sweet potato	0.0 (0.0; 67.0)	0 (0; 75)	0.0 (0.0; 2.0)	0.0 (0.0; 0.0)	0.0 (0.0; 18.0)
Noodle	0.0 (0.0; 33.0)	0 (0; 94)	0.0 (0.0; 3.0)	0.0 (0.0; 0.0)	0.0 (0.0; 19.0)
Fish	76.2 ± 45.5	80 (10; 288)	13.1 ± 8.0	5.0 (0.0; 21.0)	0.0 (0.0; 0.0)
Meat	17.0 (0.0; 80.0)	47 (0; 221)	4.0 (0.0; 18.0)	3.0 (0.0; 16.0)	0.0 (0.0; 2.0)
Egg	0.0 (0.0; 67.0)	0 (0; 125)	0.0 (0.0; 8.0)	0.0 (0.0; 10.0)	0.0 (0.0; 1.0)
Tempeh/tofu	0.0 (0.0; 67.0)	0 (0; 186)	0.0 (0.0; 10.0)	0.0 (0.0; 14.0)	0.0 (0.0; 8.0)
Green leafy vegetables	71.6 ± 40.7	23 (2; 83)	1.0 (0.0; 3.0)	2.0 (0.0; 7.0)	2.0 (0.0; 5.0)
Other vegetables	0.0 (0.0; 42.0)	0 (0; 14)	0.0 (0.0; 1.0)	0.0 (0.0; 1.0)	0.0 (0.0; 3.0)
Sugar	13.0 (0.0; 47.0)	48 (0; 181)	0.0 (0.0; 0.0)	0.0 (0.0; 0.0)	13.0 (0.0; 47.0)
Tea/coffee	1.0 (0.0; 16.0)	1 (0; 21)	0.0 (0.0; 1.0)	0.0 (0.0; 0.0)	0.0 (0.0; 4.0)
Snack (cake, bread, fried banana, doughnut)	17.0 (0.0; 117.0)	45 (0; 384)	0.0 (0.0; 8.0)	1.0 (0.0; 16.0)	5.0 (0.0; 54.0)
Fruit	0.0 (0.0; 67.0)	0 (0; 54)	0.0 (0.0; 1.0)	0.0 (0.0; 0.0)	0.0 (0.0; 14.0)
Milk	0.0 (0.0; 35.0)	0 (0; 159)	0.0 (0.0; 6.0)	0.0 (0.0; 5.0)	0.0 (0.0; 21.0)
Seafood	0.0 (0.0; 100.0)	0 (0; 87)	0.0 (0.0; 17.0)	0.0 (0.0; 1.0)	0.0 (0.0; 1.0)

Variables are presented as means ± SDs and medians (minimum, maximum). Abbreviations: SD standard deviation; g gram, kcal kilocalories.

3.3. Multivariate Analysis Results

A multivariate analysis of albumin for both groups was conducted to analyze the correlation of body composition and laboratory profile with albumin. Multivariate linear regression analysis showed that a better prediction of albumin in the rice group was featured by hemoglobin ($\beta = 0.354$, $P = 0.089$), and the white blood cell counts ($\beta = 0.396$, $P = 0.059$). This model explained 12.8% of the albumin variability (Table 7). We accepted this model even though P -value > 0.05 (the software was set to maintain variable at least P -value = 0.1) because hemoglobin and albumin were found to be correlated in anemic patients. While albumin and white blood cell were reported to be correlated in diabetic patients.

On the one hand, in the sago group, the better model for the multivariate association in determining albumin was characterized by the MCV ($\beta = -0.524$, $P = 0.007$). This model explained 24.3% of albumin variability in the sago group (Table 8).

In the sago group, there were significant correlations with the MCV and visceral fat ($r = 0.415$, $P = 0.039$), the visceral fat and basal metabolic rates ($r = 0.507$, $P = 0.010$).

Discussion

The present study showed that there were no differences in the body composition and serum albumin levels between the sago-moderately low protein and rice-sufficient protein groups. The hemoglobin and hematocrit levels in the males were the only items that were significantly different between the two groups. This study also analyzed the serum albumin level as a marker for protein-energy malnutrition caused by insufficient protein intake. The multivariate analysis revealed that the predictive factors of serum albumin levels were different between the two groups. Hemoglobin and white blood cell (WBC) counts were the determinants of the serum albumin level in the rice-sufficient protein group. On the other hand, the mean corpuscular volume (MCV) was a predictor of the serum albumin levels in the sago-moderately low protein group.

The sago-eating participants were older than the rice-eating participants. A similar finding was reported in a study in Riau Province, Indonesia, where the people who consumed more sago were older (> 50 years old) compared to the those who consumed less sago.¹⁵ Sago is considered to be the major food of ancient times in the sago-producing areas of Indonesia.

Table 4. Food groups consumed per day of the sago group.

	The amount (g/day)	Energy (kcal)	Protein (g)	Fat (g)	Carbohydrate (g)
Rice	67.0 (0.0; 233.0)	87 (0; 303)	2.0 (0.0; 6.0)	0.0 (0.0; 6.0)	19.0 (0.0; 67.0)
Sago	219.4 ± 78.6	810 ± 304	1.0 (0.0; 2.0)	0.0 (0.0; 17.0)	189.0 ± 73.6
Sweet potato	0.0 (0.0; 110)	0 (0; 233)	0.0 (0.0; 1.0)	0.0 (0.0; 5.0)	0.0 (0.0; 46.0)
Noodle	0.0 (0.0; 60.0)	0 (0; 85)	0.0 (0.0; 3.0)	0.0 (0.0; 0.0)	0.0 (0.0; 17.0)
Fish	69.4 ± 34.6	95 ± 58	12.2 ± 5.9	2.0 (0.0; 18.0)	0.0 (0.0; 0.0)
Meat	0.0 (0.0; 33.0)	0 (0; 111)	0.0 (0.0; 9.0)	0.0 (0.0; 8.0)	0.0 (0.0; 1.0)
Egg	0.0 (0.0; 17.0)	0 (0; 32)	0.0 (0.0; 2.0)	0.0 (0.0; 3.0)	0.0 (0.0; 0.0)
Tempeh/tofu	0.0 (0.0; 40.0)	0 (0; 82)	0.0 (0.0; 3.0)	0.0 (0.0; 8.0)	0.0 (0.0; 1.0)
Green leafy vegetables	48.6 ± 43.0	10 (0; 64)	1.0 (0.0; 2.0)	0.0 (0.0; 5.0)	1.0 (0.0; 4.0)
Other vegetables	0.0 (0.0; 42.0)	0 (0; 14)	0.0 (0.0; 1.0)	0.0 (0.0; 0.0)	0.0 (0.0; 3.0)
Sugar	13.0 (0.0; 57.0)	52 (0; 219)	0.0 (0.0; 0.0)	0.0 (0.0; 0.0)	13.0 (0.0; 57.0)
Tea/coffee	0.0 (0.0; 8.0)	0 (0; 9)	0.0 (0.0; 1.0)	0.0 (0.0; 0.0)	0.0 (0.0; 2.0)
Snack (cake, bread, fried banana, doughnut)	8.0 (0.0; 117.0)	13 (0; 372)	0.0 (0.0; 8.0)	1.0 (0.0; 17.0)	1.0 (0.0; 52.0)
Fruit	0.0 (0.0; 67.0)	0 (0; 61)	0.0 (0.0; 1.0)	0.0 (0.0; 0.0)	0.0 (0.0; 16.0)
Milk	0.0 (0.0; 20.0)	0 (0; 93)	0.0 (0.0; 4.0)	0.0 (0.0; 4.0)	0.0 (0.0; 10.0)

Variables are presented as means ± SDs and medians (minimum, maximum). Abbreviations: SD standard deviation; g gram, kcal kilocalories.

Table 5. Body composition of the study population.

	Rice (n = 25)	Sago (n = 25)	P value
Height (cm)	158.5 ± 6.8	160.5 ± 4.1	0.208
Body weight (kg)	55.3 ± 6.8	56.9 ± 6.0	0.375
BMI (kg/m ²)	22.0 ± 1.8	22.1 ± 1.9	0.852
Muscle mass (kg)	37.4 (29.6; 54.4)	36.4 (17.8; 52.1)	0.823
Muscle mass (%)	71.4 ± 7.0	68.2 (30.9; 86.5)	0.327
Muscle strength (kg)	25.7 (15.8; 78.0)	27.7 (16.7; 41.0)	0.786
Fat mass (%)	25.0 ± 7.3	25.7 ± 7.3	0.756
Basal metabolic rate (kcal)	1196 ± 194	1201 (986; 1518)	0.938
Bone mass (kg)	2.2 ± 0.4	2.2 (1.9, 2.9)	0.632
Visceral fat (rating)	6.0 (1.5; 16.0)	7.2 ± 3.4	0.397
Total body water (%)	52.3 ± 4.5	51.2 ± 4.5	0.395

Variables presented as means ± SDs and medians (minimum, maximum). Abbreviations: SD standard deviation; cm centimeter; kg kilogram; % percentage; kcal kilocalories; P probability.

Recently sago consumption has been reduced and replaced by the consumption of rice. The socioeconomic status of the rice consumers in our study showed that they had higher educational backgrounds, occupations, and incomes than the sago consumers. A study in Maluku, Indonesia also showed that better household incomes and education will reduce sago consumption and production, shifting to rice consumption. Rural people also perceived sago as inferior food, while rice perceived as superior food^{8, 11}.

Most of the nutrient intakes of sago-eating participants such as protein and micro-nutrient intake were lower than that those of rice-eating participants in our study. Energy intakes, carbohydrate intakes, and fiber intakes were higher in the sago group than in the rice group. Syartiwidya et al had similar findings that participants consumed more sago (> 140 g/day) compared to participants who consumed less sago (< 140 g/day) and had higher percentages of severe

Table 6. Laboratory profile of the study population.

	Rice (n = 25)	Sago (n = 25)	P value	Normal Value
Hemoglobin (g/dL)	13.7 (12.3; 19.6)	12.6 ± 1.4	0.045*	13.2—17.3 (man)
	10.4 ± 1.0	10.9 ± 1.3	0.265	11.7—5.5 (woman)
Hematocrit (%)	43 (38; 60)	41 (11; 43)	0.027*	40—52 (man)
	32 (12; 38)	36 (15; 41)	0.058	35—47 (woman)
Red blood cell (10 ⁶ /μL)	5.6 ± 0.9	5.3 (1.4; 6.0)	0.452	4.4—5.9 (man)
	4.7 (1.2, 5.4)	4.7 (1.8; 5.8)	0.458	3.8—5.2 (woman)
MCV (fl)	75 (57; 104)	75 ± 5	0.861	80—100
MCH (pg)	25 (17; 86)	24 (19; 79)	0.861	26—34
MCHC (g/dL)	32 (29; 88)	32 (29; 94)	0.786	32—36
RDW-CV (%)	15.8 ± 2.5	15.1 (12.9; 25.0)	0.977	11.5—14.5
Thrombocyte (10 ³ /μL)	269 ± 95	233 ± 95	0.188	150—400
White blood cell (10 ³ /μL)	7.8 ± 2.5	7.0 ± 1.4	0.358	3.8—10.6 (man)
	8.9 ± 2.4	6.8 (5.4, 18.8)	0.055	3.6—11 (woman)
Albumin (g/dL)	4.1 ± 0.3	4.0 ± 0.4	0.455	3.4—4.8

Variables are presented as means ± SDs and medians (minimum, maximum). Abbreviations: SD standard deviation; g gram; dL deciliter; μL microliter; fl femtoliter; pg picogram; % percentages; MCV mean corpuscular volume; MCH mean corpuscular hemoglobin; MCHC mean corpuscular hemoglobin count; RDW-CV red blood cell distribution width; p probability. *Significantly different between the rice and sago groups with Mann-Whitney U test.

Table 7. Multivariate analysis of factors related to albumin of the rice group.

Model		B	S.E.	β	T	P value
1	Constant	3.206	0.391		8.188	< 0.001
	Hemoglobin (g/dL)	0.042	0.023	0.354	1.780	0.089
	White blood cell (10 ³ /μL)	0.046	0.023	0.396	1.989	0.059

Analysis with multivariate linear regression backward method found that Albumin = 3.206 + 0.042*hemoglobin + 0.046*WBC (R²=12.8%) in the rice group. All linear regression assumptions (linearity, normality, zero residue, no outlier residue, independent, constant, and homoscedasticity) were fulfilled. Abbreviations: WBC white blood cell; kcal kilocalories; kg kilogram; g gram; dL deciliter; μL microliter; d day; B unstandardized beta; SE standard error; β standardized beta; t the t-test statistic; P probability.

Table 8. Multivariate analysis of factors related to albumin of sago group.

	Model	B	S.E.	β	t	P value
1	Constant	7.192	0.945		7.612	< 0.001
	MCV (fl)	-0.034	0.012	-0.493	-2.832	0.010
	Muscle mass (%)	-0.009	0.006	-0.263	-1.509	1.46
2	Constant	6.733	0.919		7.326	0.000
	MCV (fl)	-0.036	0.012	-0.524	-2.950	0.007

Multivariate linear regression backward analysis revealed albumin = 6.733 + (-0.036) *MCV (R²=24.3%) in the sago group. All linear regression assumptions (linearity, normality, zero residue, no outlier residue, independent, constant and homoscedasticity) were fulfilled. Abbreviations: MCV mean corpuscular volume; fl femtoliter; g gram; kg kilogram; d day; % percentage; B unstandardized beta; SE standard error; β standardized beta; t the t-test statistic; P probability.

deficits in the adequacy of protein levels (43% vs. 38.3%).¹⁵ Based on the Indonesian Nutrient Composition Food, while sago per 100 g edible portion had a higher carbohydrate content than white rice cooked (85.6 g vs. 26.0 g) it had a lower protein content (0.6 g vs. 2.4 g).¹⁶

This is the first study on the dietary intake of lowlanders in Papua, Indonesia with energy and protein intake were 1029 kcal and 36.7 g for the rice group and 1233 kcal and 19.9 g for the sago group. A study by Okuda, T et al in 1981 on

Papua New Guinea highlanders showed that the mean daily energy intake was 2390 kcal, and the daily protein intake was 35.2 g. This profile was exceptionally high because there was a yearly festival season in the village when the data were collected. In comparison with them, our result on lowlanders in Papua, Indonesia had lower energy intake. The lowlanders in Papua, Indonesia were having daily foods with small varieties and in contrast, the highlanders in Papua New Guinea were having special food for the yearly festival. The yearly festival season on highlanders and the wages from coffee plantations can affect these differences.¹⁷

The dietary intake of the two groups showed that the main differences were in the source of carbohydrate and protein intake. Resistant starch type 3 (RS 3) derived from sago contained higher RS (31—38%) than those derived from rice starch (21—26%). This implicated on the production of short-chain fatty acid (SCFA) mainly butyrate as the preferred energy source for colonocytes.¹⁸

Stunting was a nutritional problem in Indonesia. According to Indonesian National Health and Research Survey in 2018, national data showed there was a decreasing prevalence of severe stunting from 18.0% in 2013 to 11.5% in 2018 but slightly increased stunting from 19.2% in 2013 to 19.3% in 2018.¹⁹ Mimika district had better stature compared to other districts in Papua province (Mimika profile is 5.68 percentage of severe stunting, 14.29% of stunting, and 80.03% of normal).²⁰ A study by Fikawati, S. et al in 2021 among preschool children in Central Jakarta, Indonesia found that children who lacked energy and protein intakes were at a higher risk of stunting than children who had sufficient intakes. Macronutrient intakes are important and should be consumed in sufficient quantities every day to prevent stunting.²¹ Inadequate energy and protein intake in our population study can be the risk of having stunting on their children. Height among our participants showed that their height was comparable to the highlanders of Papua New Guinea. Highlanders of Papua New Guinea had a height of 158.3 cm, and it was similar to our height lowlanders of Papua Indonesia 158.5 cm for the rice group and 160.5 cm for the sago group.¹⁷ The sago-eating people can get more resistant starch 3 compared to rice-eating people. This implicated to have a higher production of short-chain fatty acid (SCFA) mainly butyrate, the energy source for colonocytes in the sago-eating people than rice-eating people.¹⁸ Meanwhile, the inadequate protein should be corrected to the level adequate to prevent stunting in children in their family members.

The amount of protein intake in the sago and rice groups was 0.35 g/kg/d and 0.66 g/kg/d, respectively. The minimum intakes for nitrogen equilibrium were the main factors of the lower limits of successful adaptation at which an appropriate body composition can be maintained. The mean adult requirement value of 0.66 g/kg indicated by the nitrogen balance studies implied an overall efficiency of utilization of dietary proteins of approximately 50% in replacing the obligatory nitrogen loss. The risk of protein deficiency started to increase when the intake decreased to below the range of the true minimum requirements (that is, a value that is currently unknown but likely to be between 0.40 and 0.50 g/kg/d).²² A series of studies of highlanders in Papua New Guinea, who depended largely on sweet potatoes and vegetables with low protein intake (4% of total calories) showed negative nitrogen balances with little malnutrition within the population. It was hypothesized that there was a fixation of nitrogen by the intestinal microflora.²³ A study by Huang et al suggested that there was no intestinal nitrogen fixation to occur in sweet potato eaters in slightly below requirement levels of protein intake.²⁴ Intake of protein also found significant differences at different locations on the highlanders of Papua New Guinea using a delta nitrogen stable isotope ($\delta^{15}\text{N}$), the discriminant factor between diets and scalp hair. The estimated $\delta^{15}\text{N}$ values were correlated negatively with several indicators of animal protein intake.²⁵ A study developing and validating a semi-quantitative food frequency questionnaire (FFQ) for assessing protein intake found that the highlanders of Papua New Guinea did not meet the biologically required protein intake. Although closer to an urban center, it showed higher protein intake than the more remote communities.²⁶

Serum albumin levels in the sago group did not differ from those in the rice group and fell within the normal range. Multivariate linear regression analysis showed different predictive factors for albumin levels in these groups. Hemoglobin and white blood cells were factors related to albumin in the rice group, while MCV was a predictor of albumin in the sago group. Based on our working hypotheses, basal metabolic rate influences serum albumin levels in the sago group indirectly. Protein intake in the sago group can be classified as a moderately low protein intake. A moderately low protein intake does not change the basal metabolic rate or energy expenditure. Serotonergic and β -adrenergic systems are believed to be involved in the mechanism of the changes in energy balance. These are only two of the neurotransmitter systems involved in regulating food intake. Moderately low protein-high carbohydrate increases adiposity and fat in the liver. In an animal study, the lowest protein consumption increased the proportion of energy deposited as carcass fat. The higher the fat in the liver, the lower is the iron in the liver tissue. In this study, lower iron levels were marked by a lower level of MCV. This condition induces an adaptation mechanism of protein metabolism to maintain body protein balance (albumin within normal range). We assumed that there was decreased protein turnover (protein synthesis, amino acid oxidation, protein degradation) with maintained post-absorptive whole-body protein and basal muscle protein synthesis as the mechanism of long-term of low proteins intakes in our participants (Figure 1).

Figure 1. Flow chart of the working hypotheses on how basal metabolic rate influences albumin in the sago group. Abbreviations: *MCV* mean corpuscular volume; *g* gram; *dL* deciliter; *fL* femtoliter; *kcal* kilocalories; *kg* kilogram, *d* day.

The serum albumin levels in the moderately low protein sago diet showed a negative prediction according to the MCVs. Similar findings were obtained in a study by Suk-Hwan Yang on the relationship between liver function tests and MCVs in 157 persons (patients with liver disease and a healthy control group) indicating that albumin was related significantly and negatively with MCVs (stepwise multiple regression analysis). The MCV levels were higher, but albumin levels were lower in patients with liver disease than in the controls.²⁷ The adaptation mechanism of albumin in the present study was triggered by a decrease in the MCV levels (iron serum). An *in vitro* study by Higashida et al found that iron deficiency decreases iron-containing protein and reduces protein synthesis in basal and BCAA- and insulin-stimulated conditions in muscle cells.²⁸ Animal and human studies have shown that there is a reduction in the synthetic and catabolic rates of albumin in protein-deficient states. There was an increasing transfer of albumin from the extravascular pool to the intravascular pool to maintain the serum albumin within normal levels.^{29,30} Animal studies have also shown a decrease in albumin synthesis (as a percentage of total liver protein synthesis) from 15% to 8% on a protein-free diet (2-9 days) in rats.³¹ Reducing the protein intake of humans from required intake (0.6 g/kg/d) to inadequate level (0.1 g/kg/d) will decrease leucine flux, body protein synthesis, and protein breakdown with a smaller reduction in leucine oxidation.³²

The rate of albumin synthesis in healthy participants consuming a diet with very low protein (e.g., 10 g/day) in an isocaloric diet, showed a decrease in albumin synthesis by 20%–65%. However, when both protein and calories are restricted (i.e., starvation), albumin synthesis remained close to normal. The catabolism of body proteins to provide energy, released sufficient amino acids to maintain normal albumin synthesis.³³ Albumin synthesis was also modulated by the proportion of animal and vegetable protein in the diet. Studies on isoenergetic and isonitrogenous diets in healthy men showed that the albumin synthesis rate in the group consuming 63% of vegetable protein was reduced in comparison with the group consuming 74% of animal protein.³⁴ Albumin is the most abundant antioxidant in whole blood, and oxidative stress has now emerged as a major pathway with pathological relevance for many cardiovascular diseases, such

as atherosclerosis, coronary artery diseases, heart failure, atrial fibrillation, strokes, and venous thromboembolism.³⁵ A study on the very old, centenarian, and supercentenarian in Japan showed that plasma albumin levels were almost associated with all-cause mortality in these populations. Plasma albumin levels were correlated significantly with cholinesterase levels, inflammation, and NT-pro BNP levels (biomarkers of endogenous cardioprotective molecules).³⁶

Muscle mass in the moderately low protein sago diet was not significantly different from that in the sufficient protein rice diet. Healthy humans can maintain lean body mass and body protein balance when protein intake is restricted. Integrated and adaptive metabolic changes in the body occur by decreasing amino acid oxidation and protein degradation with a more efficient use of amino acids derived from protein degradation. Maintaining skeletal muscle protein synthesis is an important component of the “adaptation” to low protein intake.³⁷ A randomized parallel study by Hursel et al, with 15 participants either high (2.4 g/kg/d) or low protein intake (0.4 g/kg/d) showed that low protein intake induces prolonged adaptation of body mass and fat-free mass by lowering body protein turnover rates (protein synthesis, protein breakdown, and protein oxidation), but maintains post-absorptive whole body net protein balance and maintains basal muscle protein synthesis in 12 weeks.³⁸ Mosoni et al showed that short-term food deprivation induced the inhibition of muscle protein synthesis and liver protein synthesis after 112–114 hours of food deprivation and 5–7 hours of re-feeding in rats. After re-feeding, liver synthesis was more stimulated than muscle protein synthesis. A coordinated response of liver and muscle protein metabolism allowed sparing of muscle proteins during food deprivation at the expense of liver proteins.³⁹

Visceral fat and MCV were correlated positively in the moderately low protein sago group. Different findings from an animal study by Visscher et al (2017) showed that the level of fatty acids in the liver had a strong negative correlation with the iron content. The livers of turkeys that died from hepatic lipidosis were analyzed for their fat and iron levels. The higher the fat content in the liver, the lower the iron content in the liver tissue.⁴⁰ A study by Siddique et al, on nonalcoholic fatty liver disease patients, found that iron deficiency was prevalent, and this was associated with the female sex, increased body mass indexes, and non-white race. Interestingly, serum hepcidin levels were low in iron-deficient participants, indicating that serum hepcidin was not a primary cause of iron deficiency, rather it was a physiological response to decreasing levels of iron.⁴¹ Hepatic iron can cause liver injury. Adipose tissue iron can be linked to adipose tissue function, including the dysregulation of adipokines, enhanced adipose tissue lipolysis, and adipose tissue inflammation. These might be the possible mechanisms linking adipose tissue iron to liver injury.⁴² Unfortunately, serum iron and other iron profiles were not assessed in our study, but low MCV was related to iron deficiency. Low MCV was found in both groups, and iron intake was below the requirement. We assumed that the iron levels were related to the visceral fat in the sago-moderately low protein group but not in the rice-sufficient protein group.

In our study, sago-eating participants with a moderately low protein diet showed more visceral fat (liver fat) than rice-eating participants. A study by Du et al, on food intake, energy balance, and serum leptin concentrations in rats fed low-protein diets found several low levels of dietary proteins from total calories (2%, 5%, 8%, 10%, 15%, and 20% casein) influenced their energy intake and body fat. The lowest protein consumption increased the proportion of energy deposited as carcass fat. The body fat content showed a positive correlation with serum leptin concentrations.⁴³ Another animal study by Pezesghi et al, showed that diets with 10% moderately low protein calories in obesity-prone rats had an increased liver fat percentage (hepatic lipidosis). While this moderately low protein diet caused hyperphagia (increasing energy intake) without altering energy expenditure, body fat, and lean mass, it promoted hepatic lipidosis.⁴⁴

The sago group with moderately low protein intake showed a similar basal metabolic rate compared to the rice group. A study by Pezesghi et al, on the effects of diets varying in protein concentrations on energy balance in obesity-prone rats found that protein-free (0% protein calories) diets decreased energy intake and increased energy expenditure, very low protein (5% protein) diets increased energy intake and expenditure, whereas moderately low protein (10% protein) diets increased energy intake without altering expenditure, relative to the control diet (15% protein). Serotonergic and β -adrenergic signaling coupled with the upregulation of key thermogenic markers in brown fat and skeletal muscle were thought to be the mechanism of the change in energy balance.⁴⁴ Different findings by Miyatani et al on the basal metabolism of various types of protein diets with the rice diet and sweet potato diet of the Papua New Guinea highlanders found that there were no significant differences in the basal metabolic rates (BMRs) among the sweet potato diet with low protein (0.3 g/kg/d), the sweet potato diet with protein (0.5 g/kg/d), rice diet with low protein (0.6 g/kg/d), and rice diet with protein (1.4 g/kg/d), however, the respiratory quotients were different.⁴⁵

Our study found that body composition and serum albumin levels were not significantly different between the groups of lowlanders of Mimika, Papua, Indonesia. Multivariate linear regression showed that there were different predictors of albumin between the sago-eating group and the rice-eating group. An adaptation mechanism for the sago-moderately low protein intake may have maintained the albumin levels within the normal range.

This study was a part of the main study on analysis of gut microbiota of rice-eating people with sufficient protein intake and sago-eating people with low protein intake of the lowlanders in Mimika Regency, Papua, Indonesia. We are interested in their habitual low protein intake of sago-eating people, but they appeared to be healthy. Therefore, the measurement of protein intake was carried out carefully. Besides using plastic fish models with the portion size, we also looked at the fish that they consumed in the fish seller and compare them with our plastic models. On the other hand, on the measurement of carbohydrates, we used plastic rice models with the standard portion size such as “100 grams of rice on a plate”. This standard portion sizes of plastic models may not capture their real carbohydrate intake precisely. They might have eaten more than they reported. Underreporting energy intakes were prevalent in economically deprived populations, and this is one of our limitations in this study. Therefore, we think that underreporting of energy intake is from underreporting of carbohydrate intake. A review article by Maurer, J. et al, 2006, on the psychosocial and behavioral characteristics related to energy misreporting explained that lower carbohydrate intake was one of the commonest dietary patterns of underreporting.⁴⁶ Underreporting of energy intakes in our study also can be influenced by their education level and their social-economic status. A study by Olendzki, B.C., et. al in 2008 found that energy intake underreporting was prevalent in the low-income, low literacy of the Caribbean Latino population.⁴⁷ Other factors associated with misreporting energy intake were demographics and diet. Women, older adults, and people with less education tend to underreport energy intake.⁴⁶ A study by Sawaya, A.L. et, al in 1996 on comparing four different methods of the dietary survey such as a 7 day-weighing method, a 24-hour food recall (in duplicate), and two types of food intake frequency survey among young and older women with doubly labeled water (DLW) found that the total energy intake (TEI) by the 24-hour food recall method was the closest to the total energy consumption calculated by DLW for young women. The TEI/DLW was 86.7 percentage for young women (mean age 25.2 ± 3.5 years) and for older women (74.0 ± 4.4 years) was 75.2 percentages.⁴⁸

Another limitation in our study was the limited number of indicators for assessing the energy-protein nutritional status such as urinary excretion of nitrogen per unit of creatinine to measure nitrogen losses. No data on menopause in relation to iron metabolism (there were eleven women with the age 55 to 64 years old and it was the age of menopause period according to WHO) were obtained. The other limitation of the study was the mismatch in some parameters of the two groups (the sago group was older than the rice group, some participants in the rice group had better socioeconomic status). Further research is needed to examine the interactions between the liver (fatty acid, iron, and albumin profiles) and the muscles (amino acid profile) with the regulatory hormones in participants with prolonged sago-moderately low protein intakes.

Investigating the adaptation mechanisms of protein metabolism to maintain albumin levels within the normal range may have a beneficial impact on gerontology. Malnutrition, with hypoalbuminemia as an indicator, among the aged population is an important health care problem, as this problem is prevalent across the world, especially among the elderly aged 75 years or older. Malnutrition was not confined to institutionalized or hospitalized elderly individuals but was also seen in community-dwelling geriatrics. The result of a 5-year and 7-year longitudinal study in Japan showed that decreasing albumin level was associated significantly with aging among community-dwelling older adults aged 65 and over.^{49,50} An epidemiological survey found that lower albumin levels, even within the normal range, were related factors of frailty measures, trace elements, and inflammation markers in the general population.⁵¹

Conclusions

Protein inadequacy was prevalent in developing countries including Indonesia, because their diet comprises mainly starchy staples. Our study on local people found no differences in the body compositions and albumin levels in the sago-moderately low protein intake group with the rice-sufficient protein intake group. Albumin, as an indicator of long-term adaptation, had different determinant factors in both groups. Albumin in a moderately low protein intake-sagodiet was predicted negatively by MCV, while in a sufficient protein intake-rice diet, it was predicted positively by the hemoglobin and WBC. The mechanism of adaptation to albumin in a moderately low-protein diet was induced by low levels of MCV (iron deficiency). Decreasing protein turnover (protein synthesis, amino acid oxidation, protein degradation) and the maintenance of post-absorptive whole-body protein and basal muscle protein synthesis preserved albumin levels within the normal range. This mechanism can be beneficial for the elderly (as an increase in the population around the world) who have low albumin levels. Further studies are needed to examine the interactions between the liver (fatty acid, iron, and albumin profile) and muscle (amino acid profile) with the regulatory hormones for the long-term adaptations of a moderately low protein intake- sago diet.

Data availability

Underlying data

Figshare: Data Protein-Energy Nutritional Status of Lowlanders Mimika, Papua, Indonesia

<https://doi.org/10.6084/m9.figshare.17104568.v3>

The project contains the following underlying data:

Raw data of socio-economic, nutrient intake, food groups, body composition, and laboratory profile.

Data are available under the terms of the Creative Common Zero “No rights reserved” data waiver (CCO1.0 Public domain dedication).

Figshare: Example menu of moderately low protein intake-sago diet and sufficient protein intake-rice diet of lowlanders Mimika, Papua, Indonesia.

<https://doi.org/10.6084/m9.figshare.17111075.v3>

The project contains the following underlying data:

Example menu of the sago diet and the rice diet in a day. Data are available under the terms of the Creative Common Zero “No rights reserved” data waiver (CCO1.0 Public domain dedication).

Figshare: Iron intake of moderately low protein intake-sago diet and sufficient protein intake-rice diet of lowlanders Mimika, Papua, Indonesia based on sex.

<https://doi.org/10.6084/m9.figshare.18394394.v3>

The project contains the following underlying data:

Iron intake profile of the sago diet and the rice diet based on sex.

Data are available under the terms of the Creative Common Zero “No rights reserved” data waiver (CCO1.0 Public domain dedication).

Figshare: Correlation between MCV level, visceral fat, and basal metabolic rate of moderately low protein intake-sago diet of lowlanders Mimika, Papua, Indonesia.

<https://doi.org/10.6084/m9.figshare.18394433.v3>

The project contains the following underlying data:

Correlation test between MCV level, visceral fat, and basal metabolic rate of moderately low protein intake-sago diet.

Data are available under the terms of the Creative Common Zero “No rights reserved” data waiver (CCO1.0 Public domain dedication).

Extended data

Figshare: STROBE Guideline Checklist of Cross-Sectional Study of Protein-Energy Nutritional Status of Lowlanders, Mimika, Papua, Indonesia. <https://doi.org/10.6084/m9.figshare.17109269.v3>

The project contains the checklist of STROBE guidelines of observational studies (cross-sectional study of protein-energy nutritional status of lowlanders, Mimika, Papua, Indonesia).

Data are available under the terms of the Creative Common Zero “No rights reserved” data waiver (CCO1.0 Public domain dedication).

Competing interests

‘No competing interests were disclosed’.

Grant information

This research was supported by JSPS KAKENHI Grant Numbers 18K17929 and 20K11560.

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Version 1

Reviewer Report 09 February 2022

<https://doi.org/10.5256/f1000research.80054.r122201>

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This is good research and finds the goals straight away and reaches the hypothesis of the study. This study also reports a new insight about how the adaptation mechanism can lower albumin levels.

Please describe how the sample (sampling method) was obtained, was it using purposive sampling or another sampling method?

There was no difference in albumin serum levels between the two groups, but please explain how long the adaptation mechanism lasted and how long it will last, based on this research or previous studies. Based on this analysis, we can also understand sago or rice's superiority.

In this study, the author did not separate between men and women, which can have different Hb (hemoglobin), suggestions to put in the discussion.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Nutrition, vitamin and mineral

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

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