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Original Article

Absorption of carbohydrate derived from rice in children aged 1-3 years

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ABSTRACT Many studies shows that rice starch is well-absorbed in gastrointestinal tract, even better as a composition with electrolyte to overcome diarrhea. Although in small number, there is still a various prevalence of carbohydrate malabsorption, both with rice starch and with other starch. Khin-Maung-U found significant (66.5%) prevalence of rice starch in Burmese children malabsorption, whereas rice starch is readily obtained in countries with rice as the population staple food, so that ability to absorb rice starch in Indonesian children need to be studied. Breath hydrogen test (BHT) was performed in 86 Indonesian children aged 1-3 years on Pejaten Barat Subdistrict, Pasar Minggu, South Jakarta. Among the 86 children given meal test with rice starch cakes 80 g for each children, 82 children (95.3%) can absorb rice starch well, but 4 children (4.7%) suffered from rice starch malabsorption. Currently it is unknown certainly the type of the malabsorption. Previous researchers found that rice malabsorption is due to enzyme deficiency and intestinal motility disturbance. In this study there were 16 children (18.6%) coming from social-economically underprivileged family, most of the mothers with junior high school and lower educational level, and the majority of parent occupation were on private and labor sectors. There was no significant relation (p >0.05) between diarrhea effects on rice starch malabsorption in 6 children (7%), history of low birth weight baby (15.1%), undernourished or malnutrition status in 35 children (40.7%), and worm and/or fungal infection in 17 children (19.8%). **[Paediatr Indones 2001; 41:132-140]**

Keywords*: carbohydrate absortion, breath hydrogen test, children, infection*

STARCH IN RICE IS THE MOST IMPORTANT AND THE greatest number of carbohydrate source which is cheap and easy to get.[1-4] In Indonesia, rice is the staple food and the source of energy and protein, 58% and 50%.[2] Nowadays, the number of poor family in Indonesia is almost 17.5 million (39.78%).[5] According to SKRT 1995, the number of children under 5 years with malnutrition is 28.6% and 8.1% of them is severe.6 Since monetary crisis in 1997, more than 4 million children under 5 years suffer from malnutrition.[5] Considering that the pattern of food consuming on 1-3 year-old child still depend on what is available (passive consumer), meanwhile physical growth is less than in infant period. They have more activities, those fact, make children in this period is more vulnerable to get infection and malnutrition.[7] Factors which can cause carbohydrate malabsorption in 1-3 year old children are LBW history, malnutrition, diarrhea, infection, worm's parasite infection, low family social economic, and mother's education history, etc.[8-10] Levitt[11] observed many kinds of carbohydrate in healthy people and apparently, it's only rice and wheat flour-gluten free which is completely absorbed where as others cereals nutrient have partial malabsorption. Starch in rice is one of important nutrients in management of children with malnutrition. Khin-Maung-U[12] et al, in Burma (1988), on carbohydrate absorption research with BHT, found that 133 children under 5 year old (66,5%) had malabsorption in 200

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children under 5 observed. It might have no association with malnutrition state but the state is often result from gastrointestinal tract and respiratory tract infection and also decrease of intake. Firmansyah[13] observed starch from maizena, wheat, rice, manihot, sago absorption in white mouse and found that white mouse gut mucous could digest and absorb those starch well. So far, nobody has ever done any research about carbohydrate absorption that comes from rice in 1-3 year old children in Indonesia. The purpose of this research is to get basic data about carbohydrate absorption on 1-3 year old children in Department of Child Health, Medical School, University of Indonesia, Jakarta.

Methods

This was a prospective, cross-sectional study aimed to find out the prevalence of carbohhydrate derived from rice malabsorption. The study was carried out on Pejaten Barat Subdistrict, Pasar Minggu, South Jakarta and on Department of Child Health, Medical School, University of Indonesia, extending from December 1998 to July 1999. Accessible population was children aged 1-3 years visiting integrated health post (Posyandu) on Pejaten Barat Subdistrict, Pasar Minggu, South Jakarta. Exclusion criteria were respiratory disorder, history of gastrointestinal surgery and refuse to participate in the study.

The study was done by recording all necessary subject data into a special form, physical examination and nutritional status of each child was determined using weight for age criteria as recommended by Workshop on Nutritional Anthropometry in 1975, issued by the Ministry of Health which is the Harvard standard modification by using growth chart named KMS.[9,14] Body weight was measured using a Dacin weight scale as usually utilized at integrated health post with an accuracy of 0.1 kg and issued by the Ministry of Health. Body weight value on the uppermost growth line on growth chart is 100% to Harvard median (50% Harvard), and dotted line is 80% to Harvard median. Well-nourished between dotted line till the uppermost growth line on KMS (80%) and below this dotted line was undernourished or malnourished.

Effect of nutritional status on malabsorption is undernutrition or malnutrition on gastrointestinal tract that may cause maldigestion and malabsorption. The more severe degree of malnutrition that may cause more severe malabsorption.[15] Variables that were used in the study included undernutrition and well-nourished states. Diarrhea was define as increased frequency of defecation, change of stool consistency to be looser or increased stool volume than usual. The change of stool consistency is usually more important than the stool volume itself.[16]

Variable used in diarrhea episode in the study was when diarrhea frequency was more than 3 times a day with liquid consistency. Duration and frequency of diarrhea occurrence influenced nutritional state and gastrointestinal tract function.[17] Diarrhea frequency was diarrhea occurrence at least once a month over 3 months consecutively or diarrhea occurred for more than 7 days. Subjects of the study were divided into two group; group with frequent diarrhea and group of infrequent diarrhea. Feeding pattern: Food supplement administered too early and inappropriately might result in maldigestion and malabsorption.[18] Variable used in the study was breast feeding/formula pattern and age of solid food introduction.

On breast feeding pattern, the subjects were divided into 2 groups namely group with exclusive breast feeding for 4 months or more and group with breast feeding and formula for <4 months. Introduction of solid food was assessed based on age the first time the subject received solid food. Subjects were divided into 2 groups; those who received solid food before 4 months old and those who received solid food after 4 months old. History of parasitic/fungal infection: on the basic of macroscopic and microscopic stool laboratory examination. If there was a possibility of malabsorption, examination was continued with stool analysis.

Based on the results, two groups were found, group with positive and negative parasitic/fungal infection. History of low birth weight baby; assessed on the basic of subject's birth weight. Based on history of low birth weight baby, birth weight was divided into birth weight < 2500 grams (LBW) and birth weight ³ 2500 grams.[9,19] Family income level was assessed by calculating family income total (father, mother, and other member) divided then by family burden number. On the basic of national level was income per capita for Indonesia 1999 that is Rp. 42,500/month for limit of poor population, criteria determined was as follows; unwealthy per capita <Rp. 42,500/month and wealthy >Rp. 42,500/month. Respiratory disorder or disturbance was acute asthmatic attack, whereas the

history of digestive tract surgeries included history of colostomy or laparotomy, on Morbus hirschprüng case, anal atresia, anthral web, intestinal malrotation, gut shortening surgery, etc.

BHT was done on each subject using meal test, at 0 minute namely upon consuming rice starch after fasting for 5 hours, then every 30 minutes for 4 hours. Respiratory hydrogen was measured with practical 4 digits BHT portable LCD, Hoes Loos Lactometer version 1.0 CvO-HMLT (made from England). The basic principle for hydrogen measurement was detection with electrochemical censor specific to H2 gas. H2 is bound by negative electrode through reaction equation: H2 = 2H+ + 2e and oxygen (O2) was bound by positive electrode through reaction equation: $\frac{1}{2}O_2 + H+ + 2e = 2H_2O$. BHT calibration was performed using free air (200 ppm H2) as null value. Measurement range of H2 was 1-1999 ppm, with selectivity <10% due to interference by carbonmonoxide gas (CO). Respiratory hydrogen was caught and transmitted to electrode through T-piece system installed on mouth and/ or nose of the subject, for about 10-30 seconds or till condensation appear on mask, as to there was no expiratory air escape and subject was still able to breath through valve of T-piece. Results were seen directly on LCD.

Starch mean in the study was rice starch. Into the starch cool boiled water was added so that the volume reached 5-10 times (10-20% solution). To make sweet taste and as flavor Tropicana Slim syrup (low calorie and sugar free) was added then boiled for 15-30 minutes until gelatinization process took place. Rice starch malabsorption is a absorption disorder of rice starch due to hydrolitic phase inhibition of all glycosidic bonds. Undigested rice starch continued to fill in the intestinal lumen and was metabolized by bacteria into carbondioxide, hydrogen, other gases and inorganic acids as to make bloating, frequent flatulence and diarrhea.[21-23] Malabsorption was considered positive if BHT result ³ 20 ppm or < 20 ppm followed by clinical symptoms at the time of measurement such as diarrhea, abdominal pain, bloating, vomiting, flatulence, and BHT considered negative if the result <20 ppm.

Results

A. Demography

Population number of study location (RW 6 and 8) was 9520 consisting of 5123 males and 4397 females. The number of population aged 0-4 years in Pejaten Barat Subdistrict was 3209 comprised 1984 boys and 1225 girls. Live hood of most RW 8 population was tailor business. Residential environment in Pejaten Barat along Pejaten Barat street was living area for middle to upper class population, whereas most of the remaining area inhabited by those coming from middle to lower class. Aged 1-3 years children registered in integrated health post of Pejaten Barat Subdistrict was 100 children among 165 those who aged 0-4 years. The residential environment was dense enough with house line separated by narrow path, plastered ditch and stream. Children were seen do defecation into ditch or stream.

B. Subject characteristics

1. Parental Occupation

Most of parent were salaried employee monthly in private company including security unit and driver, self-employee such as trader and tailor business namely 47 people (54.7%). Follow by laborer, mostly laborer with daily/weekly salary, 31 people (36%) and the remaining 8 people (9.13%) were civil servant and irregular employee.

2. Socio-economic Status

The lowest income per capita Rp. 17,300 and highest Rp. 228,500/month. Respondent income per capita mean was Rp. 81,000/month with SD Rp. 46,000. Socio-economic state of unwealthy with low income per capita (< Rp. 42,500/month) 16 respondents (18.6%) and wealthy (> Rp. 42,500/month) 70 respondents (81.4%).

3. Maternal age

The youngest maternal age was 18 years old and the oldest was 40 years. Mean maternal age 26.5 years with SD 4.7 years.

4. Maternal educational Level

In the study, most of mothers had educational level of elementary school or not complete 53 people (61.6%), junior high school level 21 people (24.4%), and no mother with high education level. No one was illiterate.

5. History of low birth weight

The lowest birth weight was 1800 grams, whereas low birth weight proportion was 15.1%

6. Children's age and sex

The mean age of the subjects was 22.8 months with SD 7.8 months. The sex distribution were 33 boys (38.4%) out of 86 children.

7. Nutritional status

Undernourished and severe PEM (1 children) was found in 35 children (40.7%), the remaining 51 children (59.3%) were well nourished.

8. History of feeding pattern

Exclusive breast feeding 36 (42%) from breast feeding 61 (71%) , and early solid food administration 38 (44.2%) out of 86 children. In general, children were given bananas when they were 4 days old.

9. History of diarrhea

Diarrhea in children was grouped by occurrence frequency; frequent diarrhea in 6 (7%), infrequent in 80 children (93%).

10. Result of stool examination

The stool laboratory examination showed parasitic/ fungal infection in 17 children (19.8%) by; *Ascaris lumbricoides* 13 (15.11%), *Trichiuris trichiura* 3 (3.5%), and by *Candida albicans* 1 (1.2%).

C. Results of BHT

In this study 82 children (95%) can absorb rice starch well, but only 4 (4.7%) of these children showed rice starch malabsorption. Factors influence rice starch malabsorption in the study probably were: Nutritional status, history of diarrhea, history of low birth weight and parasitic/fungal infection.

1. Effects of nutritional status on rice starch malabsorption

Among 35 undernourished and severe PEM children, none of them indicated starch malabsorption, 4 out of 51 well-nourished children showed starch malabsorption (Table 1). Statistically, there was no significant relation between nutritional status and starch malabsorption.

TABLE 1 THE RELATION BETWEEN NUTRITIONAL STATUS AND RICE STARCH MALABSORPTION

Nutrirional Status	Malabsorption		
	Yes	No	Total
Undernourished	0	35	35
Well-nourished	4	47	51
Total	4	82	86

Fisher exact test x^2 =1.38; df =1; p =0.14

2. EFFECTS OF DIARRHEA HISTORY ON RICE STARCH MALABSORPTION

Out of 6 children with frequent diarrhea none of them with starch malabsorption, but 4 out of 80 infrequent children demonstrated malabsorption (Table 2). Statistically, there was no significant relation between history of diarrhea and starch malabsorption.

TABLE 2 THE RELATION BETWEEN HISTORY OF DIARRHEA AND RICE STARCH MALABSORPTION

Diarrhea Status	Malabsorption		
	Yes	No	Total
Undernourished	0	6	6
Well-nourished	4	76	80
Total	4	82	86

Fisher exact test x^2 =0.20; df =1; p =1.00

3. Effect of LBW history on rice starch malabsoption

None of 13 LBW history of children showed starch malabsorption, but 4 out of 73 non-LBW indicated starch malabsorption (Table 3). Statistically, there was no significant relation between LBW and rice starch malabsorption.

4. Effects of parasitic/fungal infection on rice starch malabsorption

None of 17 children with parasitic/fungal infection showed rice starch malabsorption, but 4 out of 69 children without parasitic/fungal infection demonstrated malabsorption Table 4). Statistically,

there was no significant relation between parasitic/fungal and rice starch malabsorption.

TABLE 3. THE RELATION BETWEEN LBW HISTORY AND RICE STARCH MALABSORPTION

LBW history	Malabsorption		
	Yes	No	Total
Undernourished	0	13	13
Well-nourished	4	69	73
Total	4	82	86

Fisher exact test $x^2 = 0.02$; df =1; p =1.0

TABLE 4. THE RELATION BETWEEN PARASITIC/FUNGAL INFECTION AND RICE STARCH MALABSORPTION

Parasiitic-Fungal infection	Malabsorption		
	Yes	No	Total
Undernourished	0	17	17
Well-nourished	4	65	69
Total	4	82	86

Fisher exact test $x^2 = 1.14$; df =1; p =0.58

5. Characteristics of 4 children with rice starch malabsorption

Malabsorption in those 4 children consisted of 3 boys and 1 girl, Three children were 17-19 months old, 1 child was 35 months old. Educational level of mothers, 3 completed elementary school and 1 completed junior high school. Result of BHT positive between 90-210 minutes of observation. From 4 children, none of them had history of LBW, frequent diarrhea, undernutrition, or parasitic/fungal infection.

Discussion

A. Demography and subject characteristics

Population number of the study in RW 6 and 8 was 9,520 (24%) consisting of 5,123 males (53.8%) and 4,397 females (46.2%), while the sexual distribution of studied subjects comprised 33 boys (38.4%) and 53 girls (61.6%). There was sexual distribution difference, namely there were more males (53.8%) compared to females (46.2%) in RW 6 and 8 otherwise there were less boys (38.4%) than girls (63.6%). Data from Pejaten Barat subdistrict shows that most parental occupation was civil servants, followed by trader/self-employee and laborer. Whereas the occupation of this study were private workers, laborers, irregular employee and civil servants. This seems to be in contrast with the data from Pejaten Barat Subdistrict. It can be explained that due to Pejaten Barat subdistrict region generally was area with inhabitants of very wealthy class, different from those of study location in which many of them participate in integrated health post was unwealthy class.

Population characteristics of middle to lower class in subjects studied had mean middle to lower income (84.9%), most of parental education level was elementary school (61.6%), followed by junior high school (24.4%), and senior high school only 14%. According to Rasjid,24 the majority of occupation in urban poor area, consecutively, were trading sector, industry, services, and other sectors. Education of poor people was also low, in urban area about 89%, whereas in this study was 61.6%. Nutritional status of undernutrition in this study was high enough (40.7%). History of feeding pattern did not find formula usage for 71% children, but 44.2% children received solid food earlier. Health service for most people was obtained from community health center and integrated health post. The population density in RW 6 and 8 was high without healthy environment causing high enough morbidity, seen on parasitic (worm) infection in this area was still high (18.6%).

B. Rice starch absorption broblem

Studies on digestion of rice starch in human were carried out by Auricchio[25] et al in 1968, using starch and glucose analysis method in stool. It was found that starch absorption in normal infants (4-7 months) and children (1-2 years) was highly efficient, the absorption coefficient was higher than 99%. This conformed to results by other investigators that rice starch is best absorbed in comparison with other sorts of cerealia starch.26-28 and in form of mill rice starch is better absorbed. Whereas Khin-Maung-U et al[12] in Burmese, in his study on rice starch absorption in

children using BHT found prevalence of rice starch malabsorption for 66.5%.

Out of 86 children aged 1-3 years who were studied, 4 children (4.7%) showed starch malabsorption, while Perman18 et al in 1984, found that starch malabsorption prevalence was less than 1% among 230 healthy people. Even though malabsorption prevalence in this study was higher than Perman18 finding, but still lower compared to results by Khin-Maung-U.[12] Were intestinal flora kinds different? King and Toskes[30], found around 10-13% of intestinal flora did not produce H2 so might give false positive results, while according to study by Strocchi31 et al, H2 non-producer were really rare. It seems that there are no difference intestinal flora types in malabsorption.

Factors affecting BHT, other than H2 non-producer intestinal flora presence, include starch type origin, starch treatment form, starch volume, activity and motility of intestinal, and history of antibiotic administration.[30,32-34]

Background of study subjects was the same as those of Khin-Maung-U,[12] namely from middle to lower socio-economic class. The difference was Khin-Maung-U12 investigation done in rural society, whereas this study was performed in suburban one, so that infection could be found prevalently. There were 107 (51%) out of under five years children with undernutrition in Khin-Maung-U12 study, whereas in this study there 35 (40.7%) out of 86 children with the same nutritional status. There is no significant difference was found between nutritional status and rice starch malabsorption. Kind of rice starch given was the same, but Khin-Maung-U[12] made it into cooked rice form until 1½ times volume and the amount of administered was 3 grams/kg bodyweight mixed with water or soup sauce. In Indonesian study what given was cake made from flour rice starch in the form of gel of 80 grams for each children aged 1-3 years. It seems that rice starch menu cause less malabsorption in this study compared to Khin-Maung [12]

Starch malabsorption in Khin-Maung-U12 investigation was finding caused by:[12] (1) Presence of oligosacharidase and polysacharidase produced by bacteria such as acarbose resulting in competitive inhibition on mamalia intestinal alpha-glicosidase enzyme action; (2) suspection at subclinical overgrowth bacteria due intestinal destruction and malabsorption because of frequent infection exposure; (3) as a secondary phenomenon of malnutrition. The cause of malabsorption in this study remains unclear.

C. Factors affecting rice starch absorption

1. Nutritional status

Malnutritional closely relates to chronic diarrhea and often associated with malabsorption due to pancreatic and brush border hypotrophy. This condition may cause the deficiency of digestive enzyme to metabolized nutrients in intestine, including glucoamylase enzyme.35 Unabsorbed carbohydrate then was fermented by bacterial overgrowth and undergo degradation into gases such as hydrogen.[9,11] These formed gases cause clinical symptoms such as bloating, vomiting, flatulence, and diarrhea. Untreated, undernutrition gradually affect under five years children growth.[36] Thus, detection of carbohydrate malabsorption can be done in undernourished children. There was no significant relation ($p > 0.05$) between nutritional status and rice starch malabsorption (table 1). Children with undernutrition, in general are susceptible to infection. Acute diarrhea occur frequently in undernourished children. Many studies about the effect of rice starch administration on acute or chronic diarrhea showed beneficial useful in the treatment of diarrhea. Defecation frequency decreased, reduce fecal volume, recovery shortened, cheap, easily available, calories and protein present in starch that increase bodyweight.[35,37-42] The prevalence of undernutrition in under five years children in this study (40.7%) increased was higher than Household Health Survey (SKRT) 1995 along with the monetary crises that has been taking place since 1997.[5,6]

2. History of Diarrhea

Diarrhea, especially chronic diarrhea may cause malabsorption.[35] The etiology of chronic diarrhea is still incompletely known. Though limited, acute diarrhea can result malabsorption by specific enteropathogen.[35] Due to carbohydrate malabsorption, fermentation by bacteria overgrowth occurred in intestines and finally worsens diarrhea and bloating. It seems this study show that overgrowth bacteria have not been existed yet. This study show no significant relation ($p > 0.05$) between diarrhea and rice starch malabsorption (table 2).

3. History of low birth weight

The low birth weight outcome in the first five years of life manifest in neurologic disorder, growth retardation, mental retardation and learning difficulties.[43] Physical growth retardation is influenced also by malabsorption in low birth weight on rice starch malabsorption. The prevalence of low birth weight in this study was 15.1%, in accord with prevalence of low birth weight reported between 14-29%,[44] The current Indonesian prevalence of low birth weight is 8%.6

4. Parasitic/fungal infection

Low socio-economic condition, low income, low parental educational and ignorancy on environmental health closely relate to worm infection.45 This kind of infection is prevalent in children of under 10 years old, can cause recurrent abdominal pain, diarrhea, growth retardation, obstruction, nausea, anorexia and may other parasitic and enteropathogenic bacteria infection in combination.[46] Complaints of recurrent abdominal pain, diarrhea and obstruction can be malabsorption symptoms. Therefore, it is important to know whether there is a relation between worm infection and malabsorption. Linklater[47] et al, found that there was significant relation between rice starch malabsorption and Ascaris lumbricoides infection. Excess growth of Candida albicans, mainly in children under 3 years can result in carbohydrate malabsorption, inhibit water and electrolyte lead to diarrhea.[3] This study, shows no malabsorption in 17 cases (100%) infected with worm/fungal infection. All mothers were in junior high school-lower educational level. Prevalence of worm/fungal infection in this study was 17 out of 86 children (19.8%). Rampen,45 in his study found the prevalence of worm infection in 46 of 76 subjects (60%), whereas according to literature in some countries, prevalence of worm infection in low socio-economic area for all ages was about 80%.

5. Others

Out of 4 children suffering from rice starch absorption, one of them has history of diarrhea, low birth weight, undernutrition or malnutrition and parasites/fungal infection. Rice starch absorption in those four children began to show positive result minutes 90-210 observation at the time of BHT examination. Three out of 4 children suffering from malabsorption were 17-19 months old. It is difficult to determine the cause of malabsorption in these 4 children because intestinal hydrogen concentration is under influence also of intestinal motility and children activities. Large samples are needed to determine the cause of the malabsorption.

Laboratory examination for fecal fat was positive for more than half of vision filed, followed by complex carbohydrate malabsorption such as starch, highly significant in demonstrating pancreatic insuficiency.48 In this study fat malabsorption was not found. Parental educational factor was one of indirect causes of undernutrition/malnutirtion.[15] The low level knowledge on nutrition of the parents result inadequate food intake and low socio-economic level is associated with low purchasing ability, influenced by low parental educational level affecting nutritional status and child morbidity.

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