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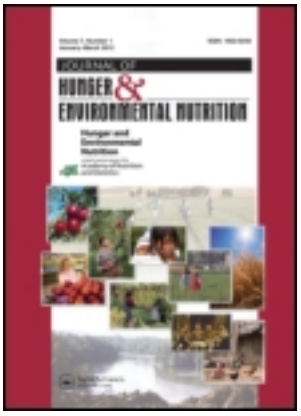

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Household Rice Choice and Consumption Behavior Across Agro-Climatic Zones of Cambodia

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A cross-sectional survey of 250 Cambodian households across agro-climatic zones was conducted to understand rice production and consumption behaviors. Forty percent of households were farmers. The results highlight diversity in varieties of rice grown and consumed, a continuing preference for traditional varieties, and a high level of awareness of rice varieties. Most households purchased rice from the market, and price was a major factor in choosing rice, in addition to taste, texture, swelling capacity, and aroma. The health implications of individual varieties are difficult to assess because price, availability, and therefore consumption of particular varieties varies by season and location.

[Supplemental materials are available for this article. Go to the publisher's online edition of the Journal of Hunger and Nutrition for the following free supplemental resource: Rice Varieties]

KEYWORDS rice, biodiversity, diet, Cambodia

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INTRODUCTION

Rice has always been relevant to global food security and socioeconomic stability as it is grown in more than 100 countries and is a staple food for nearly half of the world's population.[1] Thousands of varieties of rice are grown throughout the world.[2] This biodiversity has potentially important implications for health as well as agricultural production and environmental outcomes. However, it has been little studied. In this article we investigate rice choice and consumption behavior of a sample of households in each of the major agro-climatic zones of Cambodia, where there is substantial diversity of indigenous varieties, as well as a major effort in recent years to introduce improved varieties.

Different rice varieties vary significantly in their physical characteristics, chemical composition, and mineral concentrations.[3] Many of these differences are likely to have health implications for the rice consumer. For example, starch structure differs across varieties. Starch granules constitute approximately 90% of the dry weight of milled rice.[4] Starch is a major component of human diets, often contributing 50% to 70% of the caloric energy and providing a direct source of glucose, which is an essential substrate in brain and red blood cells for generating metabolic energy.[5] It is mainly composed of 2 types of glucose polymers: linear amylose and hyper-branched amylopectin.[6,7] Amylose is of low molecular weight and a few long branches, whereas amylopectin has a much higher molecular weight with a vast number of short branches. The balance of these polymer types has implications for digestibility, though the relationship between the structural characteristics of starch and its digestibility is not well established. It is likely that starch that is rapidly digested, and where there is little resistant starch reaching the lower gut, is associated with nutritional diseases, especially diabetes, obesity, and colorectal cancers.

There are more than 2000 rice varieties in Cambodia.[8] Cambodians tend to grow and consume different rice varieties in different zones. Geographically, Cambodia is divided into 4 different agro-climatic zones: plain, Tonle Sap, coastal, and plateau and mountain. The main types of rice ecosystems, or paddy production systems, are rain-fed upland and lowland rice, deepwater/floating rice, and dry-season rice. These can be generally classified as being wet-season versus dry-season rice. Wet-season rice is grown from May to December and dry-season rice is grown from December to March. The wet-season rice cultivated area is comprised of less than 2% of rain-fed upland rice, about 4% of deepwater rice, and more than 90% of rain-fed lowland rice.[9] About 58% of the harvested rice comes from rain-fed lowland ecologies, and 32% from deepwater ecologies.[10] Based on growing duration or timing, rice varieties for rain-fed lowland rice can be divided into early, medium, and late rice varieties.

Between 1981 and 1990, 766 traditional Cambodian rice varieties were reintroduced to Cambodia by the International Rice Research Institute (IRRI). In 1989, the Cambodia–IRRI–Australia Project (CIAP) designed and sponsored rice trials to test over 1500 varieties and breeding lines under all rice ecosystems in the country. Over 2500 varieties and breeding lines were tested in 1994. The varieties of rice grown in Cambodia vary across provinces and seasons. According to the Japan International Cooperation Agency,[11] the majority of wet-season rice production in Cambodia is based on traditional varieties cultivated for subsistence and food security purposes, whereas the majority of dry-season and early wet-season rice production is based on improved varieties of seeds like IR66 and grown for cash income purposes. It is known that the improved varieties account for 48% of the total planted area across all seasons compared with 52% for traditional varieties.[12] Moreover, it was estimated that the majority of the area under improved variety production consisted of IR66 (65% of planted area), with smaller areas devoted to improved Cambodian traditional (CAR) varieties. The promotion of improved varieties of rice, such as IR66 and CAR, met with widespread adoption because they are high-yielding varieties with quick maturation times, relative disease and pest resistance, and acceptable quality and market price.

Despite this relatively detailed information on rice production, little is known about rice choice and consumption behavior in Cambodia. The literature shows that rice consumption patterns and consumer preferences when choosing rice varieties differ across nationalities.[13] Consumption patterns have been associated with income in studies conducted in Nigeria,[14] Thailand,[15] and the United States[16] and with price in Kuwait[17] and Turkey.[18] The eating characteristics of the rice have been reported as significant in other studies, including aroma/aromatic varieties, taste, texture[14,17–22] and appearance.[14,17–19] These studies show that a range of characteristics may influence decisions about the quantities of rice to purchase and eat and the selection of particular rice varieties.

Due to the paucity of information on rice choice and consumption in Cambodia, this study was conducted to identify the rice varieties that are popularly grown and consumed by the Cambodian people in the 5 zones and to understand these in terms of the main reasons for choosing particular rice varieties, the average quantity of rice consumed per person, the sources of rice for household consumption, and the variability of household rice consumption across zones.

There is limited knowledge of starch's structural characteristics and their implications for human health. This study will be used as a point of reference in further research to investigate the relationship between the molecular structural characteristics of different varieties of rice and diabetes risk patterns.

METHODS

The study used stratified multistage sampling to obtain a representative sample of the rural and urban households in the 4 agro-climatic zones and Phnom Penh. Phnom Penh, the capital, was separated as another zone because it was expected that the consumption behavior would be different from that in other zones. The first stage of sampling used the latest list of villages from the Cambodian National Institute of Statistics,[23] stratified by zone. Within zones, the villages were further stratified by urban and rural location, because it was expected that there would be differences in rice consumption behaviors between locations. Two villages were then randomly selected from each zone with equal urban–rural proportions using random numbers.

Systematic sampling was used to select 25 households per village. In each village, a map was drawn in consultation with local authorities. Interviews began from a random central starting point in the village and followed a standard protocol for selection of subsequent households. The sampling interval used to select households in the village was calculated by dividing the total number of households in the village by the number of households to be selected. The target respondent was the decision maker for rice purchases, aged 18 and older. This gave a total sample of 250 respondents from 10 different villages, selected for direct face-to-face interviews using a structured questionnaire.

The questionnaire was mainly composed of closed-ended questions with a few open-ended questions. Socioeconomic characteristics were collected using questions adapted from the BBC World Service Trust Cambodia's questionnaire.[24] This has been validated and used for a range of research studies conducted by the trust. The remainder of the questionnaire focused on rice cultivation and rice consumption behaviors. These questions were largely modified from those used in national agricultural surveys and other related studies. The questionnaire was translated into Khmer and interviews were conducted in Khmer.

The quantity of uncooked rice consumed by the participants was assessed by asking them to take out the approximate amount of rice they consumed per meal. This was weighed by the interviewers and the weight was recorded. The same type of scale was use by all of the interviewers.

Training was provided to data collectors to provide an overall understanding of the study, the main research objectives, and the questionnaires. The sampling method and interviews were pilot tested in Kandal province where both rice growers and non-rice growers are located. After the pilot, the questionnaire was reviewed for comprehensiveness, cultural appropriateness, and validity and the final questionnaire was modified accordingly. Completion of the interviews took approximately 15 minutes.

In the data collection process, the first author worked as the team leader with responsibility for field supervision and data quality assurance, including

questionnaire editing. Every questionnaire was checked for accuracy, completeness, eligibility, and consistency in the field. Informed consent was obtained from the participants at the time of the interview.

Ethics approval for the study was given by The University of Queensland School of Population Health Research Ethics Committee (Approval number SS121210).

Data entry and analysis were performed using SPSS (version 16.0, SPSS Inc., Chicago, Illinois). Frequencies were generated for the variables and comparisons of means between groups were tested at $P \leq .05$ using Student's *t*-test and one-way analysis of variance.

RESULTS

Socioeconomic Characteristics of Respondents

Two hundred and fifty respondents including 47 males and 203 females took part in the survey (Table 1). Respondents were distributed equally across the 5 agro-climatic zones and the 50:50 urban : rural proportion was maintained as per the sample design. Thus, all people selected in the initial sample were available for the analysis.

The gender distribution of 19% males and 81% females reflects the distribution of responsibilities for rice buying/growing in the study population. The household size was between 4 and 6 people for 58% of the respondents, with 26% of remaining households being larger. The majority of respondents (79%) were married. A large majority of the respondents (84%) had some form of formal education.

Agriculture, and sales and service, were the 2 main income-generating activities for the respondents (38% and 30%, respectively). Only a small fraction (5%) was unemployed.

Rice Varieties Grown in Different Agro-Climatic Zones

Forty percent of the 250 households grew rice ($n = 99$). Two thirds of these ($n = 67$) grew wet-season rice only, and 30% ($n = 30$) grew both wet-season and dry-season rice, with only 2 households growing only dry-season rice.

The 99 rice-growing households reported growing a total of 34 different rice varieties, including 27 wet-season only, 4 dry-season only, and 3 for both seasons; 17 households reporting other varieties (see Supplementary Materials for a complete listing). There was great diversity across households in the rices grown, with only 6 varieties grown by 10% or more of rice-growing households (Figure 1).

There were also important differences across zones, with only 6 wet-season and 2 dry-season varieties grown in more than one agro-climatic zone (see Supplementary Materials). These differences are seen in Figure 2, which shows the percentage of households in each zone growing each of

TABLE 1 Demographic and Socioeconomic Characteristics of Respondents ($n = 250$)

Variables	%	Number of respondents
Zone		
Phnom Penh	20.00	50
Plain	20.00	50
Tonle Sap	20.00	50
Plateau	20.00	50
Coastal	20.00	50
Location		
Urban	50.00	125
Rural	50.00	125
Age range (years)		
18–35	30.00	75
36–55	53.20	133
56–75	16.80	42
Gender		
Male	18.80	47
Female	81.20	203
Household size		
1–3	16.40	41
4–6	57.60	144
7–10	23.20	58
>10	2.80	7
Marital status		
Single	5.20	13
Married	78.80	197
Widowed	13.60	34
Divorced	2.40	6
Education		
No formal education	16.00	40
Primary school	44.80	112
Secondary school	28.40	71
High school and tertiary	10.80	27
Main occupation		
Agriculture	37.60	94
Sales and service	29.60	74
Housework/housewife	8.40	21
Manual–skilled	8.00	20
Government officer	4.80	12
Unemployed	4.80	12
Manual–unskilled	4.00	10
Student	1.60	4
Fisherman	0.80	2
Professional, technical, management	0.40	1
Rice growing		
Yes	39.60	99
No	60.40	151
Type of rice growing		
Dry-season rice only	0.80	2
Wet-season rice only	26.80	67
Dry-season and wet-season rice	12.00	30
Total	100	250

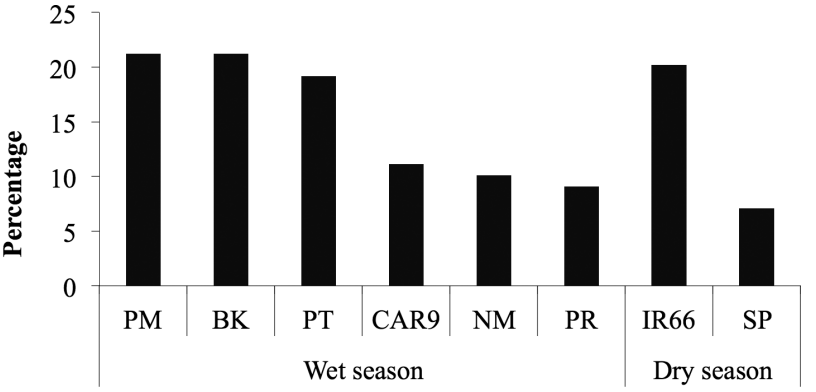

FIGURE 1 Most popular grown rice varieties (percentage of households as a proportion of total rice growers).

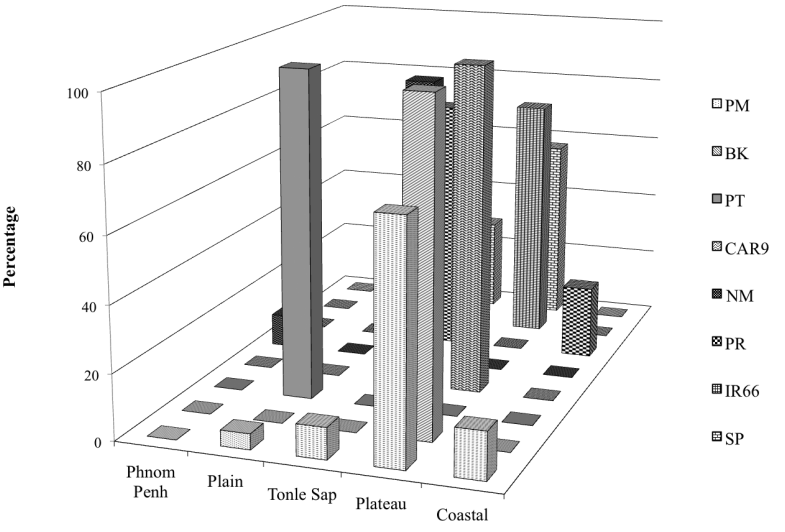

FIGURE 2 Distribution of the most popular varieties grown across zones (percentage of households as a proportion of total rice growers within each zone).

the 6 and 2 most popular wet-season and dry-season varieties, respectively. It is notable that wet-season rice was grown in all 5 zones, whereas the dry-season rice was grown in only 3 of the 5 zones (not grown in Phnom Penh and coastal zones). In terms of individual varieties, Phka Malis was grown in all zones except for Phnom Penh. Neang Minh was the only variety grown in the semi-urban region of Phnom Penh.

The results also indicated that several improved varieties (Phka Rumduol, Sen Pidoa, Kroya, and IR and CAR varieties) were grown by the farmers across the zones.

Rice Varieties Consumed in Different Agro-Climatic Zones

The 250 study households reported consuming 36 different rice varieties, with 15 not specifying the variety and 8 households reporting that they ate "mixed rice" (see Supplementary Materials for complete listing). Figure 3 shows the percentage of households in each zone consuming each of the 10 most popular varieties. Only 5 varieties were consumed across all zones: Neang Minh (32% of the 250 households), Phka Kagney (16%), Phka Malis (16%), Neang Khon (15%), and Sen Pidoa (4%).

Considering the most popular varieties in each zone, one would need to select 6 varieties to have a selection of rices consumed by at least two thirds of the sample households in all zones: Neang Minh, Phka Kagney, Phka Malis, Neang Khon, Phka Tean, and Bei Katam.

Rice Consumption Behavior

The average amount consumed was 180 g of uncooked rice per person per meal, with differences by location, gender, and other characteristics (Table 2). Those consuming the most were rural, males, rice growers, with primary or lower education, and those in Tonle Sap. Nearly half of the respondents (49%) ate rice twice per day, with most of the remainder eating rice 3 times per day.

The mother (79%) was the main person deciding on rice varieties (Table 3). Half of the respondents bought their rice for daily consumption

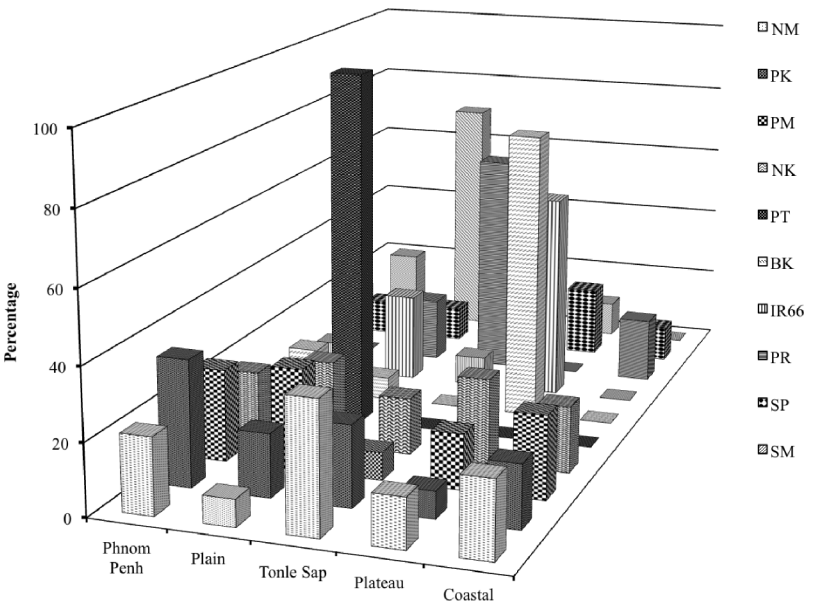

FIGURE 3 Distribution of the most popular rice varieties consumed across zones (percentage of households as a proportion of total rice consumers within each zone).

TABLE 2 Quantity of Uncooked Rice Consumed per Person per Meal (g)

Variable	*N*	Mean	Standard Deviation	Significance
Location				
Urban	125	168.55	76.08	.016
Rural	125	192.53	79.74	
Gender				
Male	47	217.10	91.83	.000
Female	203	172.07	73.01	
Rice growing				
Rice grower	99	200.16	77.24	.001
Non-rice grower	151	167.67	77.22	
Age range (years)				
18–35	75	183.87	85.41	.126
36–55	133	185.76	80.21	
56–75	42	158.07	55.82	
Education level				
No formal education	40	174.25	73.23	.001
Primary school	112	199.35*	80.95	
Secondary school	71	169.99	76.31	
High school and tertiary	27	139.59*	63.20	
Zone				
Phnom Penh	50	166.48	73.04	.050
Plain	50	180.64	74.92	
Tonle Sap	50	202.28	89.02	
Plateau	50	192.01	88.79	
Coastal	50	161.30	59.38	
Total	250	180.54	78.7	

*Significant at .05 level.

from the stores in the market and about one third relied on their own rice production. Few respondents reported buying the rice from the miller, obtaining rice from relatives, or buying from a supermarket (10%, 7%, and 1%, respectively). A third of the consumers changed their rice by season.

All respondents were asked to provide the main reasons for choosing rice varieties for their household consumption and to nominate the single most important reason. The responses to these 2 questions are shown in Figure 4. The majority of the respondents (70%) considered taste among the main reasons for selecting rice varieties for consumption, and more than half of the respondents considered texture and price (66% and 56%, respectively) important. Swelling capacity and odor were also important for many households. Among these, the price of rice, taste, and texture were the most important (38%, 30%, and 18%, respectively).

DISCUSSION

This study confirms the diversity in varieties of rice grown and consumed in Cambodia and a high level of awareness of the rice varieties. Thirty-four

TABLE 3 Consumption Behavior of Rice Consumers ($n = 250$)

Variable	%	Number of respondents
Who decides on the type of rice for consumption/growing? (Multiple answers)		
Mother	79.20	198
Father	22.40	56
Children	6.00	15
Brother/sister	2.40	6
Grandparent	1.20	3
Other	0.80	2
Where do you obtain rice for daily consumption? (Multiple answers)		
Buy from stores in the market	51.20	128
From own rice production	35.60	89
Buy from retailers in the village	12.80	32
Buy from stores selling at home itself	11.60	29
Buy from the miller	9.60	24
From relatives	6.80	17
Buy from supermarket	1.20	3
Other	2.40	6
Did you consume different rice last season?		
Yes	31.20	78
No	68.80	172
How often do you consume rice per day?		
Two times	48.80	122
Three times	48.00	120
More than 3 times	3.20	8
Quantity of uncooked rice consumed each time per person (g)		
50–100	10.80	27
>100–200	54.80	137
>200–300	30.80	77
>300	3.60	9
Total		250

individual varieties were identified as grown by the 99 rice-growing households, with 36 varieties identified as consumed by the overall sample. Although there was substantial overlap between these lists, they were not identical, with 5 grown but not reported as consumed by any of the households in the sample and 5 consumed but not grown by the households in the sample. Even though some varieties were clearly more popular than others, no individual variety was reported by more than a third of households.

Our results can be compared with those on rice production reported by the Japanese International Cooperation Agency in 2001.[11] They conducted a survey of 900 farmers in 9 provinces (excluding Phnom Penh). For this larger sample size they recorded 360 varieties grown, but as with our study most of the wet-season rice was local varieties, and the dry-season rice was mainly improved varieties. Based on their estimates, only 18% of rice production was dry-season rice, showing how local varieties dominate despite the better

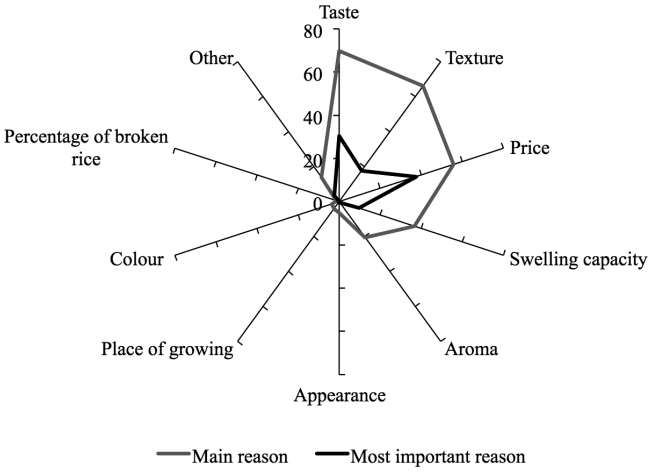

FIGURE 4 Main and most important reasons for choosing a rice variety for household consumption.

production from improved varieties. This reflects the limited irrigation infrastructure in Cambodia, with rice growing mostly using rain-fed cultivation, but also limitations associated with postharvest handling and inadequate supply systems for new seed.[11] A similar pattern was shown by a more limited study of farmers in 29 villages in 4 districts of Kompot province undertaken by the Cambodian Center for Study and Development in Agriculture. In this relatively small sample they found 24 varieties being grown, again with a majority of local varieties.[25]

Diversity was also a feature for rice consumption. Of the 36 rice varieties named by the 250 consumers in our study, the most popular variety was only consumed by a third of households, and only 5 varieties were consumed across all zones. Our results showed that the most important reason for choosing a particular rice variety was price, with taste and texture reported as the other important attributes. As noted earlier, the literature shows that consumer preferences when choosing rice varieties and the reasons for choosing particular varieties differ across populations. Our results were similar to studies conducted in Kuwait[17] and Turkey.[18] However, several other studies have noted that household income is an important factor and therefore it would be expected that price would be an important determinant across low-income communities more broadly, which applies to much of the population in Cambodia.

Regarding the sources of rice for household consumption, we found that half of respondents bought the rice from stores in the local market and one third of the respondents (the farmers) consumed rice from their own rice production. Very few respondents reported buying rice from a supermarket ($n = 3$). This is similar to other populations where supermarkets are not yet well established, such as in Kuwait, where 70% of rice purchases were made

in the local open rice markets and 6% were made in the supermarket.[17] In our study the total of purchasing locations reported exceeded the number of households (131%), which means that many households purchased rice from more than one location.

Total quantity consumed will clearly have important health effects. The current study reports an estimate of 462 g of rice consumed per person per day on average (uncooked weight). This meets the Cambodian government's target of 414 g per capita/day (151.2 kg per capita/annum) to provide 68% of average energy requirements.[11] Our study also found that rural households consumed significantly more rice than those in urban areas. This would be expected based on lifestyle differences, such as the heavier physical workloads for most people in rural communities and the greater diversity of foods available in urban areas, leading to less dependence on rice. This is similar to findings reported from Thailand.[15]

Integrating our findings with those of other studies shows that the rice consumption behaviors of Cambodian households has not changed much over the last 10 years. The mother/wife was the main person responsible for purchasing rice for daily household consumption. The common important attributes in purchasing rice for consumption were price, taste, and texture. Urban consumers tended to pay more attention to the taste, texture, color, and appearance of rice, whereas the price and swelling capacity of the rice were more important to rural consumers. Households normally bought their rice in the local markets. Those who consumed rice from their own rice production consumed rice differently by season, especially those who grew both dry- and wet-season rice. Rice eating habits, particularly the quantity of rice consumed, were found to differ by gender, location and education level of consumer. The study population usually ate rice between 2 and 3 times per day with an average amount of 180 g per meal per person (uncooked weight). This shows that rice continues to be an important staple food across the agro-climatic zones in Cambodia, including in Phnom Penh.

CONCLUSIONS

This study confirms that farming households continue to grow and all households continue to consume a range of rice varieties across all agro-climatic zones in Cambodia. Most of the varieties identified were traditional varieties, suggesting that these continue to comprise the majority of rices consumed.

Only 5 varieties were consumed across all zones, though most households reported consuming several varieties and the most popular rice varied across zones. Nonetheless, some of the varieties were sufficiently popular that one would need to select only 6 varieties to include a selection consumed by at least two thirds of the sample households in all zones.

The rice distribution and marketing system appeared to have an important influence on the pattern of consumption, with many households consuming rice varieties not grown locally, most purchasing rice from stores in the market, and price being a major factor in the choice of rice. However, other factors were also important for particular households, including taste and texture, swelling capacity, and aroma, with the relative importance of these changing across locations.

In terms of potential health effects, individual households may have a restricted selection of rice that they routinely consume, which might have a pronounced effect on their health due to the rice variety's particular structure and nutrient composition. However, at a community level this is likely to be less pronounced because price, availability, and therefore consumption of particular varieties varies by season and location, with the effects of specific varieties likely to be less pronounced. This presents a significant challenge for directly assessing the health effects of a particular rice variety for a community.

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