The Seasonal Availability of Lysine and Tryptophan in a Sanambelean Diet

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About the Author

My name is Rebecca Turley, I am a senior in the College of Liberal Studies in the Environmental sector at Montana State University - Bozeman. I am originally from Fallon, NV but have spent time in California, Kentucky, and now Montana. I have worked for a construction company specializing in heavy civil projects for several years while attending school and I am hoping to find a permanent place with them after graduating in May.

Abstract

The diet of people, especially children, in Sanambele is very important when considering the quality of life in which they strive to live. Since kwashiorkor is a nutritional based illness it is imperative to take a look at what the children in Sanambele are eating in order for them to avoid getting this disease. The amounts of lysine and tryptophan are particularly important in the diet. It is also important to have an understanding of when the greatest amounts of these proteins can be found on a seasonal basis since these are two essential amino acids that have been observed to be lacking in the local foods. By examining the most common food items in Sanambele and when these items are readily available we will be able to tell when sufficient amounts of lysine and tryptophan are existing and when additional sources may be needed in order to fill any void that may further the susceptibility of kwashiorkor in young children.

Introduction

In the western interior of Africa sits the landlocked state of Mali. The butterfly-shaped country borders the Sahara desert so despite having regions with a sub-tropical climate, much of Mali is arid and hot. Seasonal variability includes hot and dry conditions from February through May to June, a wet or rainy season from June until early fall and then another dry yet colder few months from October to January. These seasons vary slightly with latitude since the northern part of the country is closest to the desert and the southern region is much more savannah-like (https: //www.cia.gov/library/publications/the-world-factbook/geos/ml.html). According to the CIA, there is only 3.76% of arable land in Mali with .003% of that being permanent crops.

The people of Mali are just as diverse as its climatic regions. There are seven main ethnic groups: Manding (Bambara or Bamana, Malinke) 52%, Fulani 11%, Saracole 7%, Mianka 4%, Songhai 7%, Tuareg and Maur 5% and there are about 14% designated "other" ethnic groups throughout the country. The official language of Mali is French as a result of its colonial roots however Bambara is spoken by about 80% of the population (http://www.stat e.gov/r/pa/ei/bgn/2828.htm).

To zero in on a more specific region of Mali, Sanambele is a rather primitive village of just over 1,000 residents in the southeastern region of the country not too far from Bamako. The village is located on a channel of the Niger River but nevertheless it is still a desert-like climate with long periods of drought. Sanambele is a self-sustaining village that relies on a small amount of agriculture to feed themselves along with minimal purchases from markets. There is very little income that is generated in this village so by most people's standards Sanambele would be a place to consider impoverished. However, the story of poverty is very different in Sanambele when compared to Western standards. These people may be materially unfortunate but what they lack in possessions is made up for with their rich culture, family ties, traditions, and place-based knowledge. Sanambele is a community full of happiness and cheer where singing and hard work thrives and there are few things besides family and traditions, other than life's basic necessities that are required to maintain this quality of life, the value of which is desired.

Several years ago malaria was the number one obstacle sullying the quality of life in Sanambele. However, through collaborations with the indigenous people and others from Montana State University and elsewhere, malaria is no longer a problem in the village. Through the holistic process, and years of hard work, children and adults alike have no reason to fear the consequences from malaria and further, the people of Sanambele are able to share their experiences and knowledge in combating malaria with

neighboring villages that are still facing the effects of the infectious disease. (Dunkel, personal communication, 2011)

Now that malaria is no longer an issue, the people of Sanambele have asserted that malnutrition and kwashiorkor are now impeding their quality of life. This nutritional disease affects about 23% of the village's children (Taylor, 2). Kwashiorkor potentially impacts children between ages 1-3 years old. It is usually predominant in children as they are being weaned from their mother's breast milk. This is a result of losing crucial nutrients that the breast milk provides. More specifically, kwashiorkor is an outcome of a high caloric diet which lacks in protein and essential amino acids. This deficiency can cause edema in the hands, feet and face, distended abdomen, listlessness, a reddening of the hair, loss of appetite, and most importantly the lack of these essential amino acids could result in delayed mental and physical development. In the worst cases, kwashiorkor can even be fatal (Ciliberto 2005; Gause, 4 & Williams 1925).

Due to this terrifying disease, the people of Sanambele have sought help in order to put an end to kwashiorkor. Montana State University and the class of AGSC, under the direction of Florence Dunkel have collaborated with the people of Sanambele in a holistic approach to find a cure for kwashiorkor. In the interest of preserving the strong cultural values and traditions of Sanambele, the holistic approach combines traditional, ecological understanding along with place-based knowledge and merges it with a formal education in order to meet a common goal. This school of thought is particularly important to students at MSU in the likes of not encroaching Western ways onto the people of Sanambele who wish to keep their cultural identity as strong as possible. The holistic methodology focuses on the importance of listening and understanding the needs and values of the people in Sanambele and then developing

tools which will aid in accomplishing the quality of life desired. Once this has been established, future resources are required along with a maintenance plan which can be implemented in order to sustain the standards of living which are sought after (Savory and Butterfield, 1988).

In an effort to battle kwashiorkor, the mothers of Sanambele have proposed the creation of a Children's Herd (dairy cattle). Through past research on the topic it has been discovered that dairy milk is a complete source of protein and provides all the essential amino acids that are necessary for the development of growing children (Dunkel, personal communication, 2011). Further drawing off past partnerships, the mothers of Sanambele have created a handicraft business that has allowed them the monetary means required to provide at least a small herd of dairy cattle that could help meet the required amounts of nutrition. This handicraft enterprise was critical in the freedom of malaria and the women are optimistic it will help with kwashiorkor. Surely, with their hard work, the traditional, place based knowledge, and the contribution of our research, kwashiorkor will soon be a thing of the past for Sanambele.

My energies to contribute to the eradication of kwashiorkor have been spent in studying proteins and amino acids. I have taken a look at the amino acid contents of the regular foods in a Sanambelean diet. More specifically, I focused on the tryptophan and lysine which seem to be the missing link in the village's foods and are perhaps the most important in the diets of young children; however, all "essential" amino acids are necessary in the recommended minimal amounts. In this quest to find where the amino acids are lacking, I have provided the possible availability of these two particular amino acids based on a seasonal calendar. I have hypothesized that the amounts of tryptophan and lysine in a standard Sanambelean diet meet the minimal requirements that are needed by children at the ages when kwashiorkor is a most prevalent threat and these amino acids are available for consumption on a daily, monthly and yearly basis.

Materials and Methods

In following the holistic approach I have spent time with Florence Dunkel and Keriba Coulibaly first trying to get an understanding of Sanambele as a village and what their beliefs, traditions, and values consist of. These interviews and conversations have been especially important in obtaining the best understanding of the conditions of the village as well as a way of getting to know these unique Sanambelean people and a culture unlike my own. Plus, this processes of listening and learning is the first step in acquiring and developing a holistic relationship. The emersion video along with *Dancing Across the Gap* have also provided valuable insight into the customs of Sanambele along with providing a perspective from the Native American women's experience and similarities with this village. Belco Tamboura also provided intuition from a Fulani's point of view. I feel that these resources provided the most valuable information for my research.

Along with interviews and valued conversations, I combined my research with internet searches (Appendix A) for peer reviewed journals, credible nutritional websites such as the FAO and other governmental sites, along with papers from previous PSPP students (which also provided a foundation of information). All of these resources have allowed me to combine the data into a series of charts and tables that will prove helpful to the overall research.

The tables I created are formatted in Excel spreadsheets but can be easily translated into participatory diagrams which will allow for a communicational bridge across cultural and language barriers. The tables are broken into a series of information-specific groups. First, a "Seasonal Diet Availability" chart (Appendix B) contains information on the foods that are available in Sanambele which was compiled with the help of Florence Dunkel and Keriba Coulibaly. The highlighted areas show a

general time of harvest (green) as well as the potential storage availability (light brown) of that item. The light brown shading is an estimated variable that can differ from year to year and from farmer to farmer. This chart is a seasonal and month specific record, therefore it can be capricious as well, depending on drought and wet seasons which may fluctuate from year to year, so it is important to note that exceptions on these estimates must be considered when determining annual amounts.

A second table gives the specific amounts of tryptophan and lysine in each of the foods that are available in Sanambele (Appendix C). The third table represents the amounts of amino acids that are required for children in the ages of susceptibility for kwashiorkor (Appendix D). The estimated average daily requirements of amino acids were provided by The Institute of Medicine's: "Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids". The Seasonal Diet Availability coupled with additional information can be interpreted into a participatory diagrams that would be best represented and more accurate if the farmers and villagers were included in contributing to more precise approximations on the availability of their crops. These diagrams can easily be drawn with characters that symbolize each crop as well as an illustration of a dry and wet season which would lead into the month by month calendar. Further, more data or explanation may be required in order to get a full interpretation of the message that is trying to be conveyed.

Also, in order to get a more accurate count of amino acid content in typical foods, I made tou. I learned the correct way and consistency of making tou in class. This project was necessary because when items are cooked and/or diluted they lose much of their nutrients. I made three different types of tou - cornmeal, sorghum (flour), and millet. First, I started with the cornmeal tou. I measured the weight (in grams) and volume (in milliliters) of the dry cornmeal and weighed the volume of the water as well before mixing and cooking. I then boiled the measured amount of water and then slowly stirred in the measured cornmeal. I mixed over heat the two ingredients until the approximate consistency of tou was

established. Then, I let the final product sit until it was cool enough to handle. Once it was cooled, I measured the weight and volume of the actual tou. With these numbers and the help of Florence Dunkel, I devised a table (Appendix E) and a series of formulas (Appendix F) in order to establish the estimated amounts of lysine and tryptophan in the actual final product of a cereal that the children would typically be eating.

Results and Discussion

Appendix B shows some of the most common foods in a Sanambelean diet. The results of this table illustrate that only millet, corn and sorghum, all items used in making tou, are available all year. However, their availability is variable depending on the storage capabilities. This calendar also shows that most animal items, i.e., chicken, milk, and fish are available year around as well, yet, the chart does not take into account that many of these items are only available by purchase. In this case, many of these items are too expensive to consider in a daily diet but nonetheless access to them is possible. Another feature of this table is showing that there are many items which we know to be high in proteins but of which are not available at certain times of the year: in example, the cowpea and Bambara ground nut (in comparison with Appendix C) are both high in lysine and tryptophan yet are only available about half the year.

The chart displaying the amounts of lysine and tryptophan in these seasonal foods (Appendix C) details information which is more important to the results of this study. The table will show that almost all the foods that Sanambelean people eat contain some lysine and tryptophan if even only in trace amounts. It also shows which items are

most abundant in lysine and tryptophan. Cowpeas, the Bambara ground nut and all the animal source items contain the most lysine and tryptophan therefore making them crucial to the diets of children. Other items, such as fruits or vegetables comprise little to no amounts of these two amino acids. These totals are important in understanding which food items are most critical in the diets of young children who are especially susceptible to kwashiorkor.

Appendix D compared with Appendix C will put some of the available amounts of lysine and tryptophan in food into perspective. If the numbers in Appendix D are calculated out for a child weighing 12 kilograms, it is conclusive that this child would need 540mg of lysine per day and 72mg of tryptophan per day. If these amounts are compared to the lysine and tryptophan amounts on Appendix C it will be obvious that there is most likely not those quantities in any one food item alone. (See Appendix G for explicit details)

In order to get a better understanding of how these numbers convert and compare, I did the tou experiment as explained in the methods and materials. The table shown below represents the percentages of lysine and tryptophan in a 500ml serving of tou compared to the estimated average daily requirements for a 2 year old child weighing 12kg. These numbers need to be at 100% if the children are

% of Estimated Average Daily Requirements		
Tou	lysine	tryptophan
Maize	29.6%	58.3%
Millet	33.8%	144.0%
Sorghum	25.7%	116.0%

going to stand a chance against kwashiorkor. In conclusion the results show that lysine and/or tryptophan lack in any one of the main staples in the diet of children in Sanambele.

Conclusion

In the examination of a seasonal Sanambelean diet meeting the required amounts of lysine and tryptophan, we can reject the hypothesis. The results show that if a two year old child, weighing 12kg and eating a negligible diet of cereal (millet, corn, or sorghum) only, would not meet the estimated average daily requirements of lysine and tryptophan that are needed for his/her daily functioning and growth and consequently increasing the chances of kwashiorkor.

Both these amino acids are required in full, 100% amounts each day if a child is going to avoid kwashiorkor and/or any other protein deficiency illnesses. However, just because the main ingredients in tou, the product most likely to eaten on a regular basis, are undersupplied in lysine and tryptophan does not mean that all other Sanambelean foods are lacking in the necessary amounts. Therefore, it would be fair to consider these items and their nutrient content but only if the children would be eating a sufficient amount in their daily diets. Further, we can take into account that these estimates were based on a 500ml serving size once per day; and according to Keriba Coulibaly it is more likely that a child would be getting two to three times this amount, however, that number is variable depending on the age and size of the child as well as the parents ability to provide greater quantities.

Recommendations

For the sake of this study, a minimal examination of what a Sanambelean diet entails, some recommendations listed below may be just one step in coming closer to eradicating kwashiorkor. However, there are many other factors that need to be considered in order to get a greater understanding of why this disease is affecting the village of Sanambele.

- Implement high protein snacks such as peanuts and grasshoppers into the daily diets of the children in the village.
- When possible, allow the children to eat more animal protein.
- Add milk into the daily diet in order to provide the necessary amino acids as well as other beneficial nutrients.
- Examine ways to better store seasonal items that are high in amino acids so that they can be utilized throughout the year.

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Sanambele as a village needs recognition as well. I find it particularly inspiring that they are dedicated to their traditions and cultural identity and are not willing to waiver on their beliefs. It makes it hard coming from a Western perspective however it is an attribute I admire and commend especially in this globalizing world.

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Appendixes

Appendix A – Internet Search Matrix

Appendix B – Seasonal Availability of Common Foods in Sanambele

Appendix C – The Amounts of Lysine and Tryptophan in Sanambelean Foods

Appendix D - Estimated Average Daily Requirements of Amino Acids for Children ages 1-8

Appendix E and F – Tou Making Processes and Calculations

Appendix G – Detailed Calculations on Estimating the Amounts of Lysine and Tryptophan in Food Items

Appendix A		
Internet Seach Matrix		
Database	Keywords	Hits
Google	essential amino acids	5,880,000
Google	tryptophan	7,970,000
Google	lysine	12,000,000
Google	amounts of tryptophan in foods	1,810,000
Google	amounts of lysine in foods	2,450,000
Google Scholar	amounts of tryptophan in foods	38,200
Google Scholar	amounts of lysine in foods	53,700
Google Scholar	amounts of tryptophan in cereals	12,900
Google Scholar	amounts of lysine in cereals	14,000
Google Scholar	Kwashiorkor	22,700
CAB Direct	amounts of tryptophan in foods	4,008
CAB Direct	amounts of lysine in foods	8,510
CAB Direct	amounts of tryptophan in cereals	120
CAB Direct	amounts of lysine in cereals	444

Appendix B

Seasonal Availability of Common Foods in Sanambele

	Dry Season					Wet Season				End of Wet Season		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tou												
Maize												
Millet										Harvest		
Sorghum										Harvest		
Grain/Legume												
Rice												
Peanuts												
Cowpeas									Harvest			
Bambara Ground Nut												
Fruit/Nuts												
Mango												
Orange												
Cashew												
Vegetables												
Tomato												
Onion												
Okra												
Animal												
Grasshopper												
Chicken												
Cow (Milk)												
Beef												
Fish												

Indicates availability

Indicates the availablility through storage (variable depending on storage quality)

Appendix C				
The Amounts of Lysine and Tryptophan in Sanambelean Foods				
	Total Protein	Lysine	Tryptophan	Informational Source
Tou	g/100g	g/100g		
Maize (CC)	9.5	0.254	0.067	http://www.fao.org/DOCREP/005/AC854T/AC854T04.htm
Millet (CC)	9.7	0.332	0.189	http://www.fao.org/DOCREP/005/AC854T/AC854T04.htm
Sorghum (CC)	10.1	0.204	0.123	http://www.fao.org/DOCREP/005/AC854T/AC854T06.htm
Grain/Legume				
Rice brown or husked (CC)	7.5	0.299	0.098	http://www.fao.org/DOCREP/005/AC854T/AC854T05.htm
Peanuts				
Cowpeas	23.4	1.599	0.254	http://www.fao.org/DOCREP/005/AC854T/AC854T12.htm
Bambara Ground Nut (CC)	17.7	1.141	0.192	http://www.fao.org/DOCREP/005/AC854T/AC854T11.htm
Fruit/Nuts				
Mango	0.6	0.065	0.012	http://www.fao.org/DOCREP/005/AC854T/AC854T41.htm
Orange	0.8	0.043	0.006	http://www.fao.org/DOCREP/005/AC854T/AC854T41.htm
Cashew (M)	17.4	0.942	0.378	http://www.fao.org/DOCREP/005/AC854T/AC854T18.htm
Veg				
Tomato	1.1	0.032	0.000	http://www.fao.org/DOCREP/005/AC854T/AC854T38.htm
Onion	1.4	0.063	0.020	http://www.fao.org/DOCREP/005/AC854T/AC854T35.htm
Okra	4.4	0.217	0.000	http://www.fao.org/DOCREP/005/AC854T/AC854T35.htm
Animal (not including offals)				
Grasshopper	7.6	0.484	3.750	El Adeyeye, 142
Chicken edible flesh	20	1.590	0.205	http://www.fao.org/DOCREP/005/AC854T/AC854T43.htm
Cow (Milk untreated)	3.5	0.268	0.048	http://www.fao.org/DOCREP/005/AC854T/AC854T51.htm
Beef edible flesh (CC)	17.7	1.573	0.198	http://www.fao.org/DOCREP/005/AC854T/AC854T43.htm
Fish (all kinds)	18.8	1.713	0.211	http://www.fao.org/DOCREP/005/AC854T/AC854T47.htm
Notes:	(CC): Column chromatographic method.			(M): Microbiological method.

Appendix D		
Estimated Average Daily Requirements of Amino Acids for Children ages 1-8		
	Estimated Average Daily Requirements for Children	
	Ages 1-3 years	Ages 4-8 years
Amino Acids	mg/kg/day	mg/kg/day
Tryptophan	**6**	**5**
Threonine	24	19
Isoleucine	22	18
Leucine	48	40
Lysine	**45**	**37**
Methionine	22	18
Phenylalanine	41	33
Tyrosine	41	33
Valine	28	23
Histidine	16	13

Institute of Medicine of the National Academies. 2002/2005 The National Academies Press. Washington, D.C. pp. 589-678.

Appendex E		
Weights and Volumes of Tou and invidual ingredients		
	grams (weight)	ml (volume)
water	500.0	500.0
corn meal	175.0	250.0
500ml tou	250.0	250.0
Corn	grams (weight)	ml (volume)
Total tou made from 175 mg of corn meal and 500g of water	550.0	550.0
500ml portion of corn tou	500.0	500.0
Sorghum	grams (weight)	ml (volume)
water	500.0	500.0
sorghum flour	150.0	250.0
500ml tou	512.5	512.5
	grams (weight)	ml (volume)
Total tou made from 175 mg of sorghum flour and 500g of water	525.0	500.0
500ml portion of sorghum tou	512.5	512.5
Millet	grams (weight)	ml (volume)
water	500.0	500.0
millet	200.0	250.0
500ml tou	500.0	500.0
	grams (weight)	ml (volume)
Total tou made from 175 mg of millet and 500g of water	550.0	550.0
500ml portion of millet tou	500.0	500.0

Appendix F

Formulas determine ultimately what percentage of lysine and/or tryptophan is in each cereal item cooked into tou.

	grams (weight)	**ml (volume)**
Total tou made from 175 mg of cereal and 500g of water	A	B
500ml portion of cereal tou	C	500 ml

Formulated Process:

1. _____% of total weight of A tou is the weight of C
   C/A = D (% weight of cereal)

2. D * dry weight of cereal = E (grams of cereal in a normal daily portion of a 2 year old child or child weighing 12kg in Sanambele)

3. 100g / E = F

4. F * the amount (in grams) of lysine/tryptophan in 100g of dry cereal = G

5. G (grams) = daily intake of lysine/tryptophan for a 2 year old or child weighing 12kg having a minimum tou diet

6. Then convert grams to milligrams

7. Compare the amount of milligrams in the tou to what the estimated average daily requirements are and divide that number by the amount in tou and multiply by 100% to get a percentage.

Appendix G (First page of 2 pages)

Estimated weight of a child ages 1-3 years = 7-15kg (15.43-33.06lbs)

The estimated amino acid requirements are based on a 12kg child.

Daily Requirements:

Lysine – 45mg/kg/day

45(mg) x **12**(kg) = **540mg** of lysine per day for a child weighing 12kg

Tryptophan – 6mg/kg/day

6(mg) x **12**(kg) = **72mg** of tryptophan per day for a child weighing 12kg

To provide an estimate given the child has the minimal amount of food he/she will likely receive in a day, I will use a daily serving size of **500 grams**. Keep in mind, it is more likely that a child would get 1500 grams of food per day, however the serving sizes can vary depending on the income of the parents (particularly of the mother).

Food items most likely available all year:

Maize: lysine = 0.254g/100g tryptophan = 0.067g/100g

Lysine: 0.254g x 5g = **1.25 grams** of lysine in 500 grams of dry maize

Tryptophan: 0.067g x 5g = **0.335 grams** of tryptophan in 500 grams of dry maize

Conversion: 1.27 grams = 1,270 milligrams; 0.335 grams = 335 milligrams

Millet: lysine = 0.332g/100g tryptophan = 0.189g/100g

Lysine: 0.332g x 5g = **1.66 grams** of lysine in 500 grams of dry millet

Tryptophan: 0.189g x 5g = .**945 grams** of tryptophan in 500 grams of dry millet

Conversion: 1.66 grams = 1,660 milligrams; 0.945 grams = 945 milligrams

Sorghum: lysine =0.204g/100g tryptophan = 0.123g/100g

Lysine: 0.204g x 5g = **1.02 grams** of lysine in 500 grams of dry sorghum

Tryptophan: 0.123g x 5g = **.615 grams** of tryptophan in 500 grams of dry sorghum

Conversion: 1.02 grams = 1,020 milligrams; 0.615 grams = 615 milligrams

Appendix G (second page of two pages)

Less Available Items:

Rice: lysine = 0.299g/100g tryptophan = 0.098g/100g

Lysine: 0.299g x 5g = **1.50 grams** of lysine in 500 grams of brown/husked dry rice

Tryptophan: 0.098g/100g x 5g = **0.49 grams** of tryptophan in 500 grams of brown/husked dry rice

Conversion: 1.50grams = 1,500 milligrams; 0.49 grams = 490 milligrams

Cowpea: lysine = 1.599g/100g tryptophan = 0.254g/100g

Lysine: 1.599g x 5g = **7.995 grams** of lysine in 500 grams of dry cowpeas

Tryptophan: 0.254g x 5g = **1.27 grams** of tryptophan in 500 grams of dry cowpeas

Conversion: 7.995 grams = 7,995 milligrams; 1.27 grams = 1,270 milligrams

Bambara Ground Nut: lysine = 1.141g/100g tryptophan = 0.192g/100g

Lysine: 1.141g x 5g = **5.705 grams** of lysine in 500 grams of Bambara Ground Nuts

Tryptophan: 0.192g x 5g = **0.96 grams** of tryptophan in 500 grams of Bambara Ground Nuts

Conversion: 5.705 grams = 5,704 milligrams; 0.96 grams = 960 milligrams

Cashew: lysine = 0.942g/100g tryptophan = 0.378g/100g

Lysine: 0.942g x 5g = **4.71 grams** of lysine in 500 grams of cashews

Tryptophan: 0.378g x 5g = **1.89 grams** of tryptophan in 500 grams of cashews

Conversion: 4.71 grams = 4,710 milligrams; 1.89 grams = 1,890 milligrams

Cow's Milk Untreated: lysine = 0.268g/100g tryptophan = 0.048g/100g

Lysine: 0.268g x 5g = 1.34 grams of lysine in 500 grams of untreated cow's milk

Tryptophan: 0.048g x 5g = 0.24 grams of tryptophan in 500 grams of untreated cow's milk

Conversion: 1.34 grams = 1,340 milligrams; 0.24 grams = 240 milligrams