cuts and breads, while ghee is used on chapatis, in rice, and for preparing vegetables and sweets. In a particular survey the average quantities taken per person weekly were: 1 lb. (454 g.) cottonseed oil; 11/4 lb. (230–340 g.) ghee; 1/4 lb. (114 g.) full pints milk; and 1 oz. (30 g.) cheese. It is that fats and oils provide a large proportion of the caloric intake in the Asian community whatever the type dietary group. The estimated daily intake of meat that contributed by meat, is estimated at 3 to 12% of total caloric intake.

Selection of Subjects

Selection and matching of comparable groups at ages in the African and Asian communities is not possible.

African group religious and sectarian differences made with differences in diet, while in the African the rapidly changing social and economic patterns among the various ages who could be said to represent a gradient along the "normal" pattern of a particular group in their childhood and youth those in the over-40 have certainly experienced a nutritional background far better than that which obtains in schoolchildren and today. These latter groups in turn will contribute to the new middle and professional classes with a standard far above that found in the present over-40.

African group.—96 children were selected from two schools near Kampala; most were Baganda and few were from the poor families. The average age was 11.8.

African group.—New students entering Makerere College, spent three to six months at home on local diets, were fasted within three weeks of arriving at College, and selected sera were used. The students came from the African territories and a wide variety of tribes. The average age was 20.3.

African group.—120 men were selected from outpatients Mulago Hospital for minor complaints. There were 24, 22 Ruanda, and 37 from other tribes. The average age was 50. All appeared to be in good health and none admitted to hospital or referred to consultant clinics. In selection existed it was towards excluding any who were thin or malnourished.

African group.—120 children were selected from two schools; most came from one Muslim school and were vegetarian. The average age was 12.

African group.—104 students were bled from five schools. Two-thirds were non-vegetarian, and one-third were vegetarian. The average age was 19.

African group.—141 men were selected by general practice from Kampala from persons attending their surgeries for minor complaints. 11 subjects known to have diabetes mellitus or heart-disease were excluded. Of the remaining 94, 94 were vegetarian and 36 non-vegetarian, a bias by the larger number of Hindu doctors in general. The average age was 49.

Methods Used

Specimens were collected early in the morning. In the 12- and 20-year groups specimens were usually collected in the first four or five hours after the midday meal and evening meal.

Tourniquet was applied, and venous blood was collected in a hypodermic needle size 0 (length 41-5 mm.), attached a length of translucent plastic tubing. Clot had occurred the clot was loosened from the tube and the tube centrifuged. Serum was separated and stored at minus 10°C until used; all testing was completed within ten days of collection. The method of Sackett as described by King (1946) was used to determine serum-cholesterol.

The standard error of difference between means (s.e.d.) and the difference between the means (D) was calculated; where D/s.e.d. was greater than 2, the series were considered significantly different (Chambers 1955).

Findings

The mean serum-cholesterol levels and standard deviations in 354 Asian and 317 African males in the three age groups selected for study are summarised in Table I.

The slight difference in mean value between the 12-year and 20-year Asian groups is not statistically significant, but there is a substantial difference in mean value between these levels and those seen in the over-40 group. The Asian results at 20 and over 40 years are very similar to those found in American men in Minnesota by Keys and Keys (1954).

The mean serum-cholesterol levels in the 12-year and 20-year African groups are almost identical, despite the fact that the former group represents predominantly one local tribe while the latter is composed of tribes from all over East Africa. In the adult African group the mean level falls to 144 mg. per 100 ml.; and, as these subjects were unselected, the possibility of there being a chance predominance of one or other socioeconomic group was considered. The subjects were grouped by tribes, there being 61 Baganda, 22 Ruanda, and 37 from other tribes.

Table II shows the mean serum-cholesterol concentrations in Asian vegetarians and non-vegetarians in Kampala, Uganda.

Numbers in parentheses are numbers of subjects in each group.

With mean serum-cholesterol concentrations of 152, 124, and 144 mg. per 100 ml. respectively. Even if the Baganda alone were considered, as representing the highest socioeconomic group of the three, there would be no rise in mean concentration with age, such as is seen in those communities susceptible to coronary heart-disease (Keys and Keys 1954). The mean levels when grouped by tribes suggest a definite correlation with the socioeconomic position in the community.

As pure vegetarians have been shown to have considerably lower serum-cholesterol levels than non-vegetarians (Hardinge and Stare 1954), we analysed the results to determine whether the vegetarians and non-vegetarians in the Asian community displayed differences (Table II). In point of fact, many who professed pure vegetarianism were found to be lacto-ovo-vegetarians, and many took meat on occasion. Whatever the dietary group, food was prepared with the same fats and oils—i.e., cottonseed oil and ghee.
SERUM-CHOLESTEROL, DIET, AND CORONARY HEART-DISEASE IN AFRICANS AND ASIANS IN UGANDA

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In the African population of Uganda coronary heart-disease is almost non-existent. This statement is confirmed by adequate necropsy evidence (Davies 1948). In the Asian community, on the other hand, coronary heart-disease is a major problem. During the three years 1956-58 the Kampala health department registered 102 male and 45 female deaths over 30 years of age among Asians and of these 46 (44 male and 4 females) were certified as due to coronary heart-disease ("myocardial infarction"; "coronary thrombosis"). Though the errors inherent in certification must be borne in mind, it is noteworthy that 43% of male deaths and 9% of female deaths over 30 years of age were attributed to coronary heart-disease.

While the significance of a high serum-cholesterol level in the pathogenesis of coronary atherosclerosis cannot yet be taken as proven, it is supported by much indirect evidence.

In a survey of a multisocial community in Cape Town Bronte-Stewart et al. (1955) have shown that wide differences in the incidence of coronary heart-disease in different races may be associated with a parallel difference in the mean serum-cholesterol levels. Moreover the report of a prospective study (National Advisory Heart Council 1956), in which blood-lipid measurements were made in healthy men who were then observed for two years, establishes clearly that elevation of blood-lipids precedes clinical coronary disease and that mean serum-cholesterol concentrations appear to have a high predictive value for populations; although this cannot be applied to the clinical prediction of coronary heart-disease in the individual.

In view of the radically different incidences of coronary heart-disease in the two communities in Kampala and their marked differences in social, economic, and dietary backgrounds, we decided to measure serum-cholesterol concentrations in African and Asian males at three age-levels—viz., 12 years, 20 years, and over 40 years.

Socio-economic Background

Kampala is the largest town in the Uganda Protectorate with some 50,000 inhabitants (25,000 Africans, 20,000 Asians, and 5000 Europeans). It lies on a group of hills about 4000 ft. above sea level, and the temperature varies from 65 to 80°F by day with little seasonal variation. The rainfall is about 50 in. a year and the relative humidity is 60-80%.

African

The Africans live mostly in the peripheral areas of Kampala where they are predominantly agricultural smallholders growing most of their own staple foods and cash crops such as cotton and coffee.

The Baganda are the original inhabitants of the area and most have a small farm on the outskirts of the town; they form the middle and upper classes in local African society, but the majority are simple peasants. The immigrant peoples from Ruanda-Urundi and the Western Province tend to be employed in unskilled and menial work and are at the lower socioeconomic scale. The people attending Mulago hospital are mostly from other parts of the Protectorate and Rural Uganda.

The dietary habits of all groups depend on purchasing-power and partly on tradition; general two meals are taken daily—milk, eggs — and food distribution appears to differ between males. Where the man is at work all day, the poorer groups, a single evening meal is taken. Where he is at work all day, the poorer groups, no evening meal is taken. Foods vary considerably, rice, sweet potatoes, or bean formulation; green plantain and sweet potatoes, or banana leaves; cassava, yams, maize, and staple commodities, in particular of the staple cereals, while pumpkins, tomatoes, and vegetables are taken by all. The adequacy of the diet depends almost entirely on the extent to which groundnuts, and cereals are used. Most meals, with a sauce made of groundnuts, beans, and vegetables, and occasionally meat or fish are cooked in very small amounts of fat. The differences in the diets of the moderately well-off and the poor are considerable in quantity and quality of the fat than in the quantities of the staple food. Baganda can afford to do so they eat more fat than is usually recorded, and eat it in sauces (Schwartz and Dean 1955). The attending Mulago Hospital the daily fat intake of about 60 g daily and the total daily intake of about 100 g. Even in middle-class urban families meat is eaten once or twice a week, and in the labourer's diet only once a month.

Asian

The Asian community in Kampala is derived from immigration from the north and west augmented by natural increase over the past year. The Asians provide most of the skilled labour in the enterprise and are a major source of protein. This community is on the whole economically as compared with the Africans, and, while the financial status is wide, there are few families who can afford to eat reasonably well. Kampala has a large Hindu and a Musilm population, and these religious groups are closely associated with differences in diet and intake, the Hindus being traditional vegetarians, taking no alcohol. They are in fact lacto-vegetarians or eggs are eaten in small quantities by some especially by the men. The Muslim diet is similarly meat, fish, and poultry are taken and eggs are used.

The basic foods are polished rice, "okra" (green) wheat flour (for making "chapatis" [ unleavened breads] and "pooris" [unleavened in oil]), green vegetables and herbs, and oil and fruits. Pats and oils are always used in the preparation of foods, and cow tree oil and "ghee" (clarified butter) is either a "superfine" form, made from products, or one made from vegetable fats. The oil is widely used in Kampala, the dairy products more commonly, while a few better-off families own ghee in large amounts from Kenya butter is relatively expensive the proportion of cows ghee used may be greatly increased in the poor. The cottonseed oil is made locally and is used.
Discussion

The mean serum-cholesterol levels of Africans and Asians differed considerably at all the ages studied. Thus any factor or factors responsible for this difference must be present and effective at all three ages, and in the reasons for this interracial difference may be found the factors responsible for the differing racial susceptibility to coronary heart-disease. Climatic and geographic environmental factors are the same in the two groups, and Bronte-Stewart et al. (1955) have emphasised the considerable overlap from race to race despite interracial differences in mean values.

Physical activity, as suggested by Mann et al. (1955), cannot be held responsible for the difference in the mean serum-cholesterol levels of young Africans and Asians—schoolchildren and students. Moreover, Keys et al. (1956) think that differences in physical exertion cannot explain the large differences found when groups of people with different dietary habits are studied. Though work entailing physical activity may be protective against coronary heart-disease (Morris and Crawford 1958), it cannot by itself account for the differences in mean cholesterol levels seen in Western countries and the so-called primitive areas.

In South Africa Bersohn and Wayburne (1956) have demonstrated that African and European babies at birth have the same mean serum-cholesterol levels, despite significant differences in the mean levels in the African and European mothers. Sperry (1956) showed that in the first three to four days of life the total cholesterol content of the plasma increases—by an average of 76% in 15 subjects—but from the age of 4 to 25 days there was neither increase nor decrease. From the 2nd month to the 13th year the average cholesterol level in children, calculated for each year of age, does not change appreciably and is almost the same as that found in healthy adults aged 19-43 (Hodges et al. 1943). Studies in New York (Adlersberg et al. 1956) confirm that the serum-cholesterol levels in males remain constant from 2 to 19 years, after which there is a significant but gradual increase to the mid-30s. It seems likely, therefore, that for each community with its own specific nutritional background the characteristic “young adult” level is reached in the first few years of life, possibly because of the changeover to adult types of food. Our own findings in Kampala agree with this.

Various workers have differed somewhat in their reports on cholesterol levels from the mid-30s to the 6th decade. Some have found a gradual rise with age (Gertler et al. 1950, Keys et al. 1950, Lawry et al. 1957). On the other hand, Adlersberg et al. (1956), and Oliver and Boyd (1953) in Scotland showed no progressive rise in total cholesterol with age after 33, and a study by Keys (1952) on men in Naples with a low fat intake showed that a plateau was reached in the mid-30s. Thus a rise in serum-cholesterol does not necessarily accompany ageing.

Walker and Arvidsson (1954) demonstrated no significant rise with age in the South African urban Bantu, while Keys et al. (1958), in studies in Japan on men with an intake of less than 10% of total calories from fat, found only a moderate rise with increasing age. In South Africa Bronte-Stewart et al. (1955) reported a mean serum level of 166 mg per 100 ml. in African men over 40, and, as in Uganda, this group experienced little or no coronary heart-disease. The implications of their findings is that the customary dietary habits of communities may be reflected in their mean serum-cholesterol levels and that increases in cholesterol level run strikingly parallel to increases in consumption of animal fats and a rise in income. This correlation between mean serum-cholesterol levels and socioeconomic standards has been demonstrated—Africans (Edozien 1958), Johannesburg Bantu (Bernal 1958), and Israelis (Brunner and Lobl 1957, 1957).

The African adults in this Kampala study, on which fat contributes some 10–15% of total calories, a mean serum-cholesterol level roughly the same seen in the two younger age-groups. The Asian group, however, showed the progressive rise with age in other population groups with a high intake of fat. Keys (1954) maintain that in all areas where serum-cholesterol levels increase with age data has been shown to be relatively high in fat, which is about 35 to 40% of the total calories. The Kampala community, with a fat intake estimated at some 15% of total calories, provides further evidence that serum-cholesterol with age is associated with the intake of fat. Some of this fat is taken as unsaturated in oil, which might be expected to prevent a rise in cholesterol. But our results show that the more saturated as well as saturated fat, without respect to relative quantities, cannot achieve the results under experimental conditions.

Our findings (table 1) are the same as those of Hardinge and Stare (1954) in their nutritional studies of vegetarians. In young people there is a plausible physiological mechanism whereby, within certain limits of fat intake, serum-cholesterol levels are maintained or below about 200 mg per 100 ml. and with age decline in physical activity this mechanism may not cope with a heavy intake of fat. The higher cholesterol levels in the Kampala Asian non-vegetarian subject reflects his high intake of saturated fat.

The concept of an “ideal” level of serum-cholesterol has been raised—a concept which assumes an ideal relationship between the serum-cholesterol concentration and atherosclerosis. Bloomberg et al. (1958) regard a value as 170-180 mg. per 100 ml., because they believe that the level of 150 mg. per 100 ml. (Lawry et al.) is that found in primitive communities with a high level of malnutrition. Our figures in African schoolchildren and university students would support their content, for the ideal level is about 170 mg. per 100 ml., for these two groups could be said to be malnourished though their diets may be considered unsatisfactory regarding animal protein. The lower mean cholesterol levels in the African over-40 group in Kampala may be an indication of relative malnutrition in that and certainly the tribal levels obtained support this.

These observations on serum-cholesterol in different parts of the world are consistent with the hypothesis that the level of blood-lipids is raised in “successful” modern civilisations (Lawry et al.) and that this appears to be an essential condition for coronary heart-disease to become endemic in a country. While a rise of blood-lipids does not cause thrombosis undoubtedly predisposes to it.

Summary

A study was made of the dietary background and serum-cholesterol levels in African and Asian males 12 years, 20 years, and over 40 years in Kampala. These two racial groups differ markedly in their susceptibility to coronary heart-disease.

At all three ages Africans and Asians show a considerable difference in the mean level of serum-cholesterol. This corresponds to their different consumption of animal fats and other sources of fat.
The results of this survey support the view that a high serum-cholesterol level is not a necessary companion of ageing.

If an aetiopathological relationship does exist between coronary heart-disease and the serum-cholesterol concentration, a level of 170 mg. per 100 ml. is suggested as "normal".

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