of microsomal peroxidase (i.e. from 3.93 to 3.45 AU/min/mg protein) could possibly lead to the production of high amounts of total aflatoxins at day-4; and again an increase in the specific activity of this enzyme at day-7 (i.e. from 3.45 to 4.26) resulted in enhanced degradation of newly-synthesized aflatoxins, thus lowering their concentrations in *A. flavus* cultures. However, the relationship of aflatoxin degradation with increased microsomal peroxidase activities was stage-specific, with respect to both growth phase as well as temperature regimes (Figure 1 *a*, *b* and Tables 1 and 2). It is evident that the decrease or increase in the total aflatoxin level, under the influence of temperature, was consistently in accordance with the respective increase or decrease in the specific activity of microsomal peroxidase. The present findings suggested the participation of microsomal peroxidase of *A. flavus* in the *in vivo* degradation of endogenous aflatoxins under the influence of temperature. The potential role of temperature[4-6,8,9] in toxigenic aspergilli as well as of peroxidase of cell-free extracts of *A. parasiticus*[7] in aflatoxin degradation has been well documented. Moreover, the enzymatic preparations of liver microsomes have been found to degrade aflatoxins and detoxify them in various eukaryotic systems[19,20]. The role of microsomal enzymes, including peroxidase-related activity of cytochrome P-450 in biotransformation/degradation of various heterocyclic hazardous compounds in animal systems is well understood[21,22].

This paper highlights the effect of physiological growth conditions on aflatoxin production and degradation by *A. flavus*, with special reference to involvement of microsomal peroxidase in aflatoxin degradation under the influence of growth temperature from 30 to 45°C. The study also presents a possible mechanism for biological control of aflatoxins by implicating microsomal peroxidase of microbial origin.

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Uranium uptake by plants

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This paper highlights the transport of uranium present in the soil to plants. An increase in the uranium content in soil enhances its transport in various parts of plants. The transport of uranium from the soil to the grain follows the order: black gram > maize > lentil > chick-pea > rice > wheat. In certain vegetables and fruits, this order is: spinach > carrot > radish > brinjal > banana > tomato > beet. In vegetables and fruits, the stem reflects minimum percentage of uranium present in the soil. The uranium transport is appreciably high in arecanut plant. The chances of uranium transport to the human organs, are expected to be more through consumption of crops grown in uranium-rich soil.

URANIUM is regarded as the heaviest[1] trace element found in nature, and probably is a normal constituent of all organisms. All the eleven known isotopes of uranium are unstable and, as they decay, emit alpha or beta particles. The alpha particles are regarded as hazardous to mankind. Prolonged exposure to alpha emitter may ac-

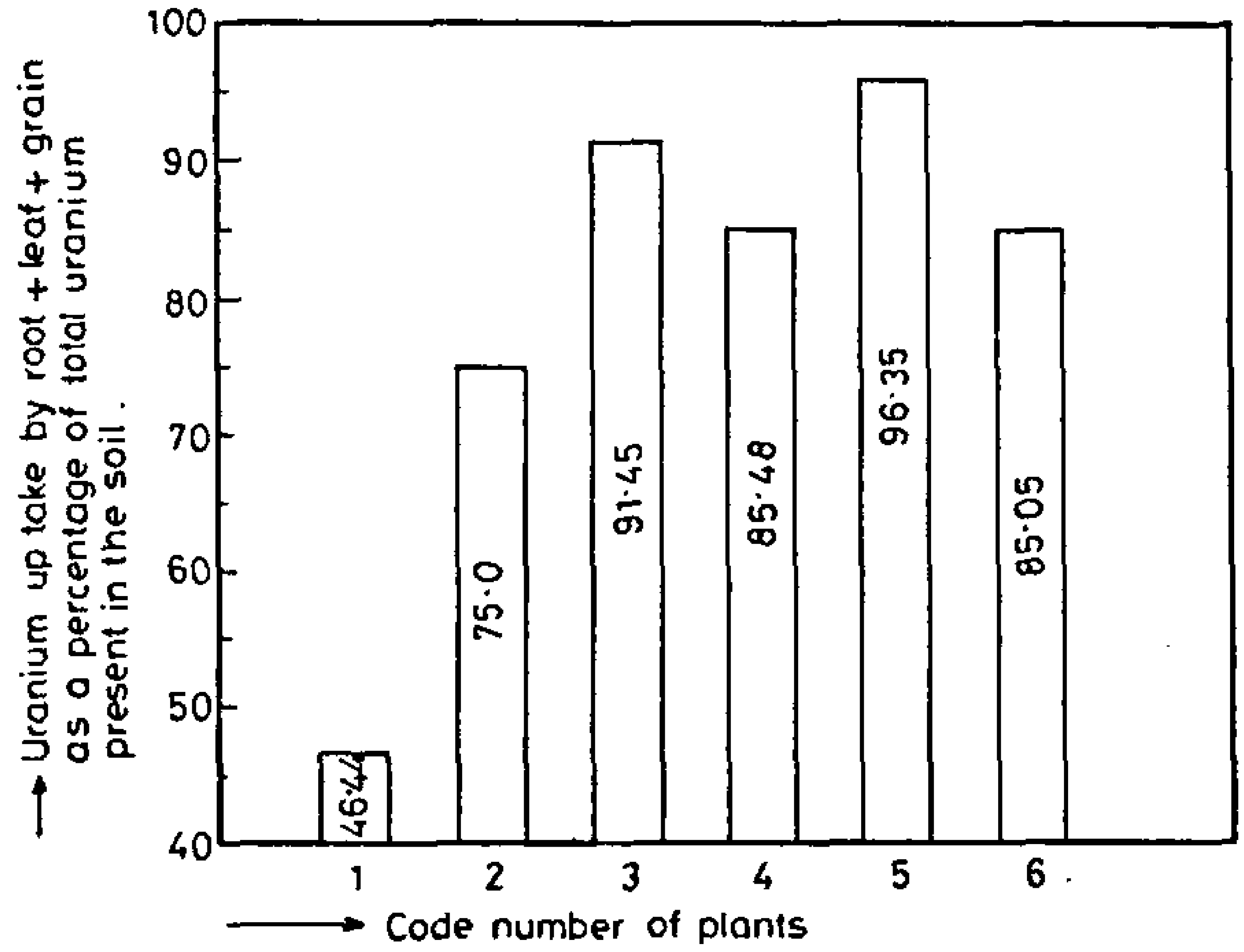

Figure 1. Uranium uptake by various plants as a percentage of total uranium in the soil. 1, Wheat; 2, Rice; 3. Chick-pea; 4, Lentil; 5, Maize; 6. Black gram. U-uptake

$$\text{by plant} = \frac{\text{U-content in (root + leaf + grain + straw) ppm}}{\text{Initial U-content in soil in ppm}} \times 100.$$

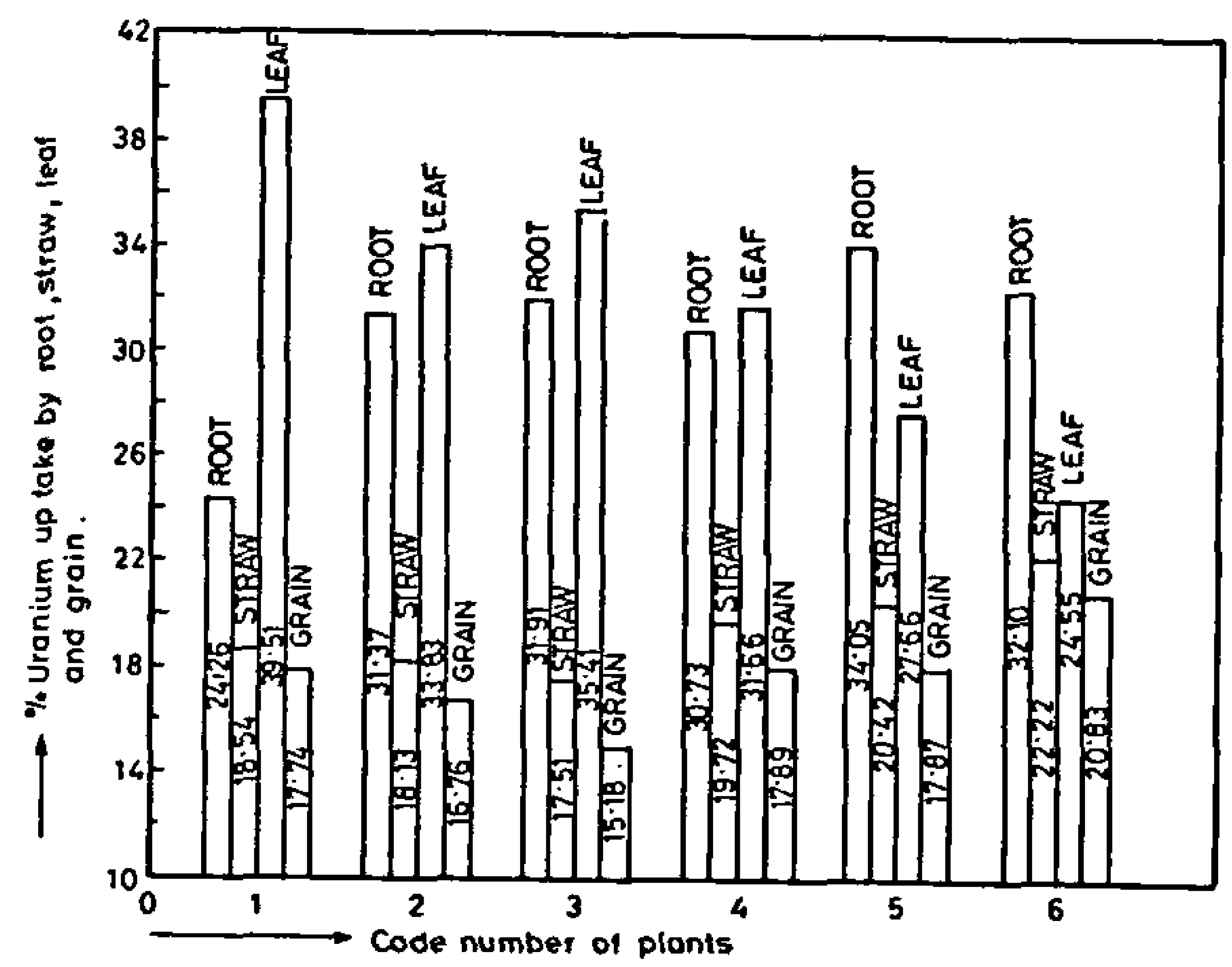

Figure 2. Bar diagram showing the percentage uranium uptake by various parts of some plants. 1, Wheat; 2, Rice; 3, Chick-pea; 4, Lentil; 5, Maize; 6, Black gram. U-uptake

$$\text{by grain} = \frac{\text{U-content in grain}}{\text{U-content in (root + leaf + grain + straw)}} \times 100.$$

count for an increasing incidence of lung cancer among mine workers[2]. High amounts of radon have also been found in areas where uranium materials are present. Radon content correlates with the presence of uranium content.

Radioactive isotopes of uranium are physically transported through environment and pass from the soil and plants to man. The presence of uranium in biological materials even in traces may have appreciable toxic effects. The uranium content in a number of edible plants, medicinal plants, cow's milk, water, and other materials has been reported[3–7]. Plants could accumulate uranium present in the soil during the process of growth and development. I investigated the transport of uranium, from the soil to the various parts of some important edible plants.

There are eleven known isotopes of uranium. Three of these, ^{234}U, ^{235}U and ^{238}U exist in nature. The eight artificial uranium isotopes (^{228}U, ^{229}U, ^{230}U, ^{231}U, ^{232}U, ^{233}U, ^{237}U and ^{239}U) have very short half-life compared to the three natural uranium isotopes. Uranium is also transported to various plants grown and other dependent members of the food chain. Uranium contents in soil under investigation ranged from 2.13 to 3.27 ppm and that in different plants from 0.22 to 1.77 ppm. The average uranium content of the soil under investigation was reported as about 2.67 ppm (ref. 4). The uranium content in soils and various parts of different plants are taken from published data[4]. Uranium uptake by various parts of plants as a percentage of total uranium in the soil has been defined as the ratio of uranium concentration in a specific part of a plant to the uranium initially present in the soil, multiplied by 100.

Uranium uptake by various plants such as, wheat, rice, chick-pea, lentil, maize, and black gram as percentage of uranium concentration in the soil is shown in Figure 1. It is evident from Figure 1 that in the case of cereals, maximum uptake is by maize and minimum by wheat. In the case of pulses, maximum uptake is by chick-pea and minimum by black gram.

Figure 2 shows the percentage uranium uptake by various parts, such as root, straw/stem, leaf and grain of some cereals (wheat, rice and maize) and pulses (chick-pea, lentil and black gram). In both the cases of cereals and pulses, uranium uptake is minimal through grains, and maximum by leaves in all the cases, except maize among cereals and black gram among pulses. In case of maize and black gram, the maximum uptake is through root. Therefore, chances of uranium transport to the animals are comparatively more than human beings.

Figure 3 shows the uranium uptake by grains as uranium present in the soil of some plants of cereals and pulses. In the case of cereals, minimum and maximum uptake of uranium is by wheat and maize respectively. In the case of pulses, minimum and maximum uptake is by chick-pea and black gram respectively.

Figure 4 shows uranium uptake by some vegetables and other important plants as a percentage of total uranium in the soil. It is clear from Figure 4 that uranium uptake by arecanut is the highest and that by beet is the lowest. In case of arecanut, a very high value of uranium uptake indicates that the uptake of uranium may be occurring through root as well as by direct deposition on foliar surfaces from the atmosphere.

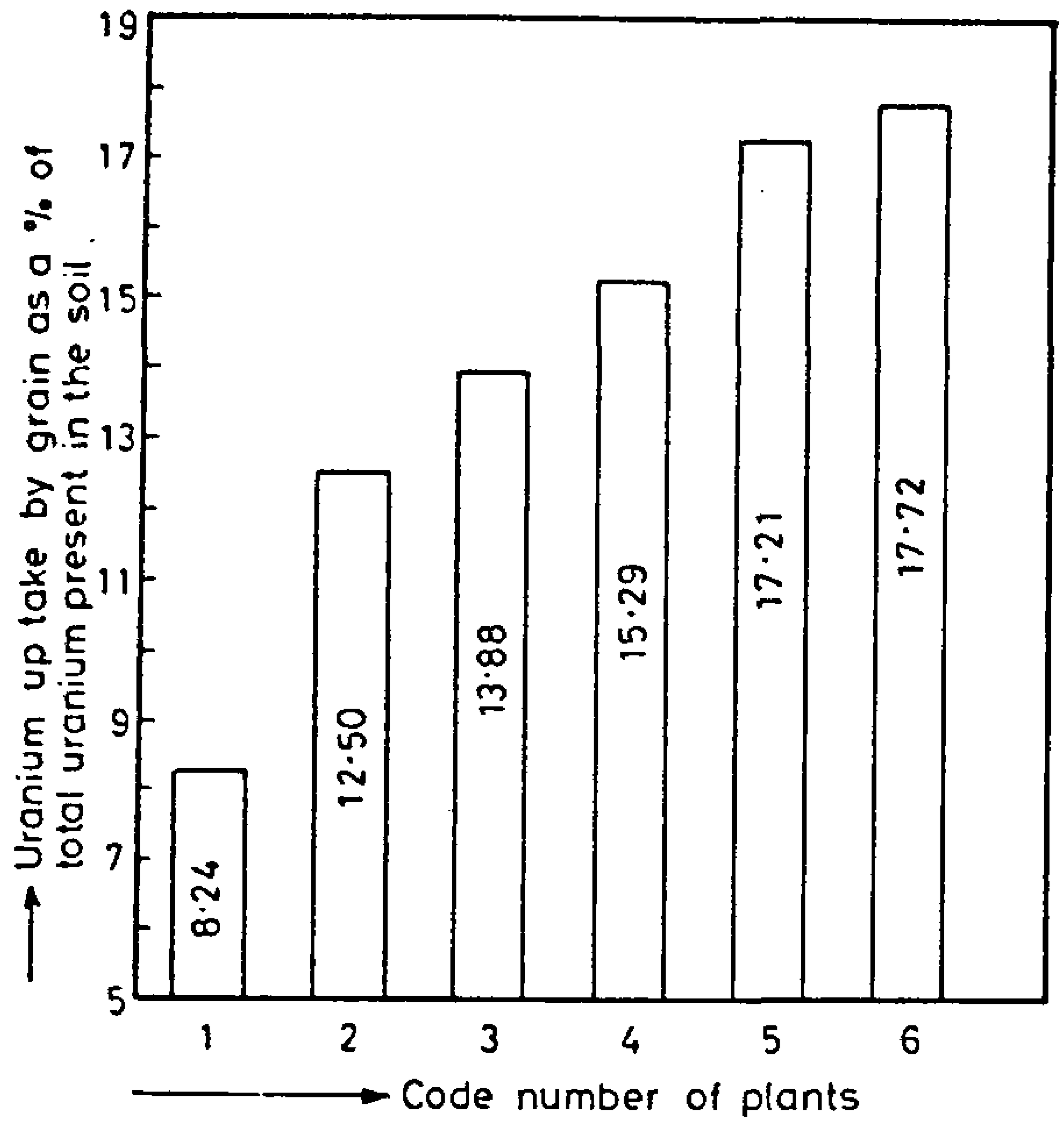

Figure 3. Bar diagram showing uranium uptake by grains as a percentage of total uranium present in the soil in some plants. 1, Wheat; 2, Rice; 3, Chick-pea; 4, Lentil; 5, Maize; 6, Black gram.

$$\text{U-uptake by grain} = \frac{\text{U-content in the grain (ppm)}}{\text{Initial U-content in soil (ppm)}} \times 100.$$

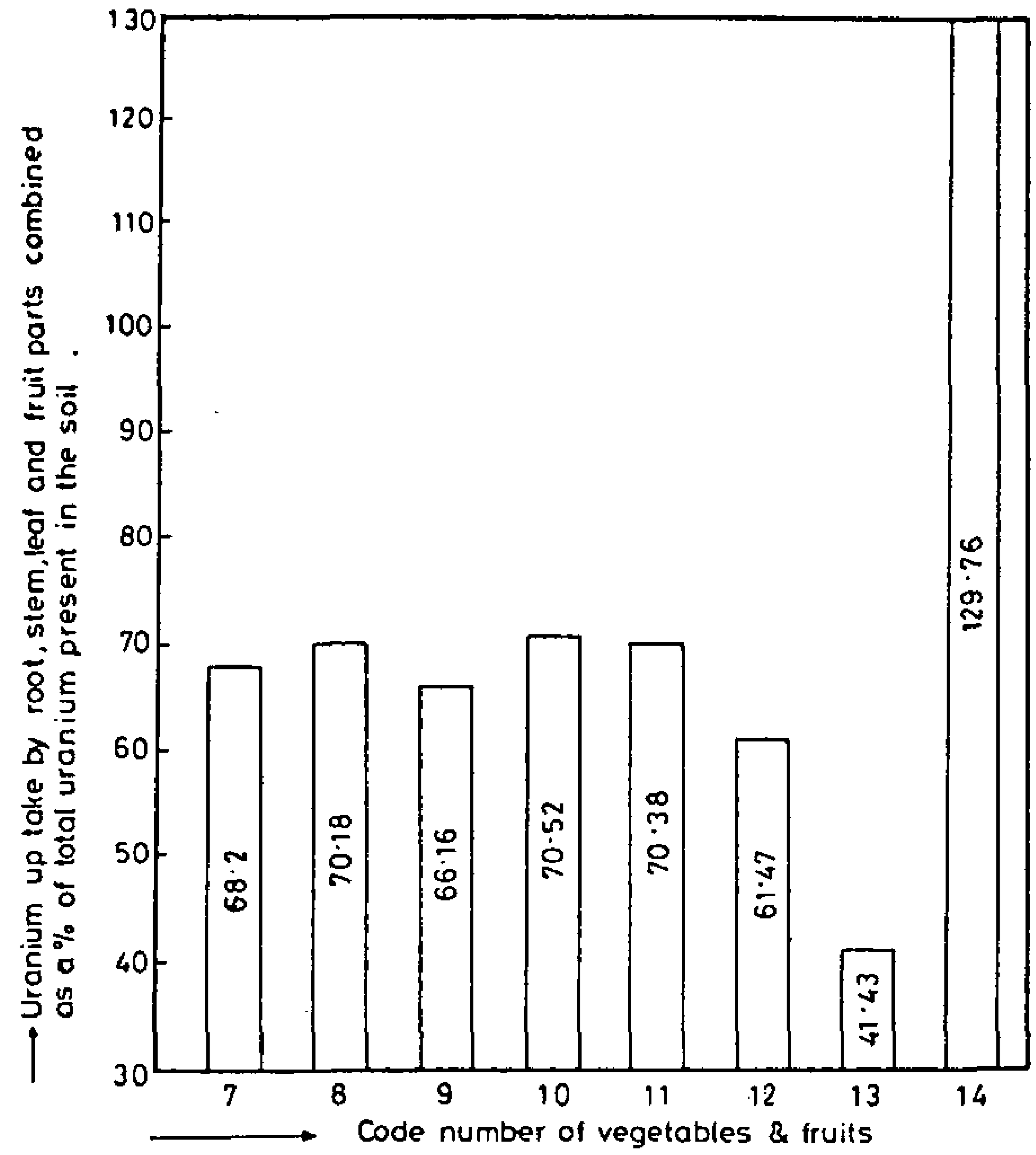

Figure 4. Bar diagram showing uranium uptake by some vegetables and fruits. 7, Spinach; 8, Carrot; 9, Radish; 10, Brinjal; 11, Tomato; 12, Banana; 13, Beet; 14, Arecanut.

$$\text{U-uptake by plant} = \frac{\text{U-content in (root + stem + leaf) ppm}}{\text{Initial U-content in the soil ppm}} \times 100.$$

Figure 5 shows the uranium uptake by root, stem, leaf and fruit parts of selected plants as a percentage of total uranium transported to various parts of the same plant. In the case of spinach, carrot, radish, brinjal and beet, uranium content is maximum in the leafy parts. But, in the case of tomato and banana, the stem portion contains the maximum percentage of uranium present in the soil. In the case of arecanut, both the leafy and fruit portion share the uranium content equally. It is also important to note that in the case of vegetables and fruits, stem portion shares the minimum percentage of uranium present in the soil.

Figure 6 shows uranium uptake by edible parts of some vegetables, and fruits as a percentage of total uranium present in the soil. It is important to note that the leafy portion of spinach shares the maximum percentage of uranium, while the fruit portion of arecanut shares the maximum percentage of uranium.

Uranium uptake in arecanut and betel plants grown in two different soils is highlighted through the following illustrations. Soil samples (M_1 and M_2) from Meghalaya contain more uranium than that from Assam (A_1 and A_2). Higher uranium content in the soil enhanced the uranium uptake in all the parts of arecanut, and betel plants. Soil sample (M_1) from Meghalaya contains 21.43% more uranium than that from Assam (A_1).

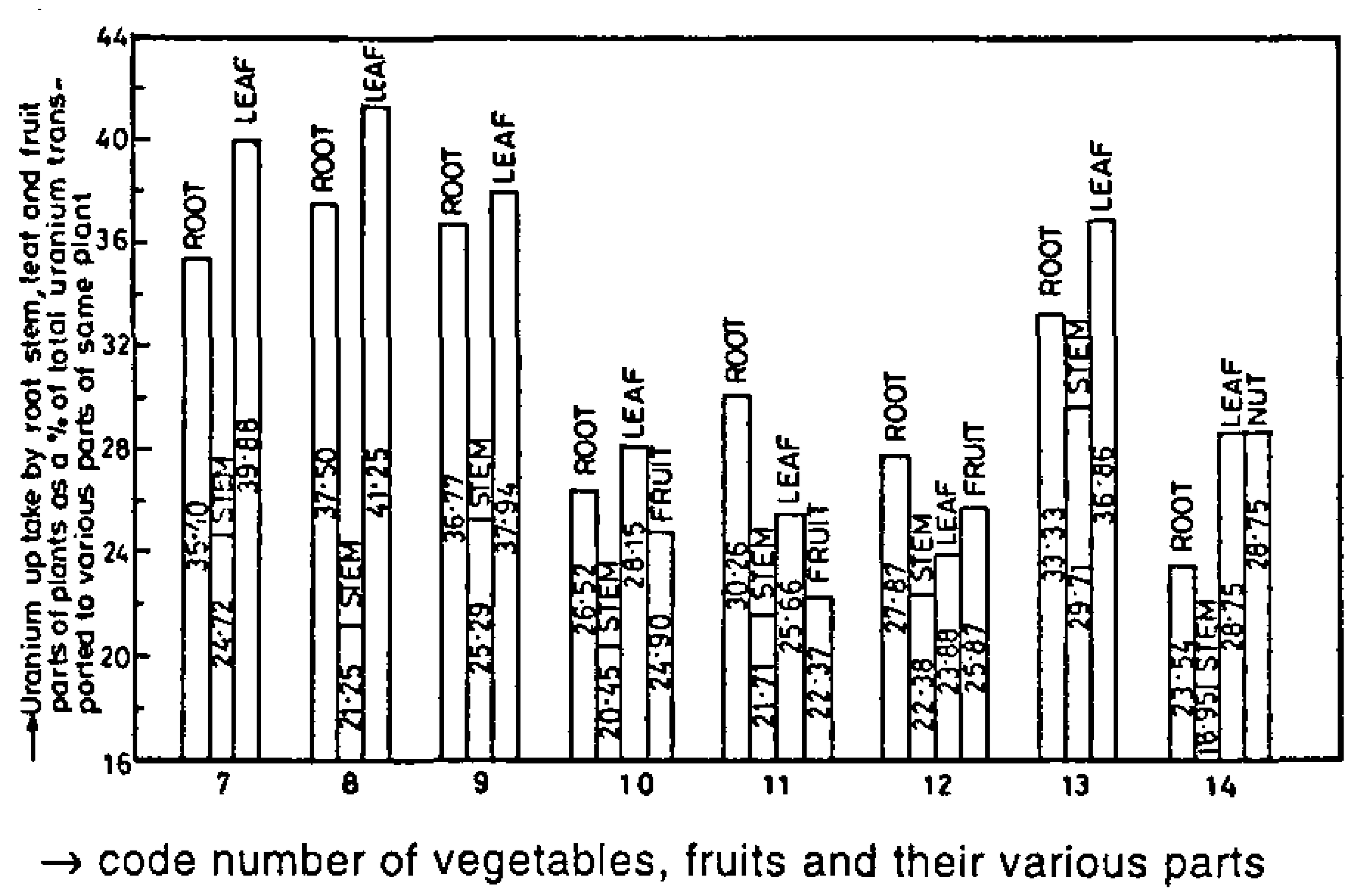

Figure 5. Bar diagram showing uranium uptake by various parts of some vegetables. 7, Spinach; 8, Carrot; 9, Radish; 10, Brinjal; 11, Tomato; 12, Banana; 13, Beet; 14; Arecanut. U-uptake by leaf

$$= \frac{\text{U-content in leaf (ppm)}}{\text{Accumulated U-content in various parts of the plant (ppm)}} \times 100.$$

Higher uranium content in the soil enhanced the uranium uptake in all the parts of arecanut plant, with an enhancement factor ranging from 1.88 to 4.15. Similarly, the increase in 6.9% of uranium from soil sample A_2 to M_2 caused an increase in the uranium transport in vari-

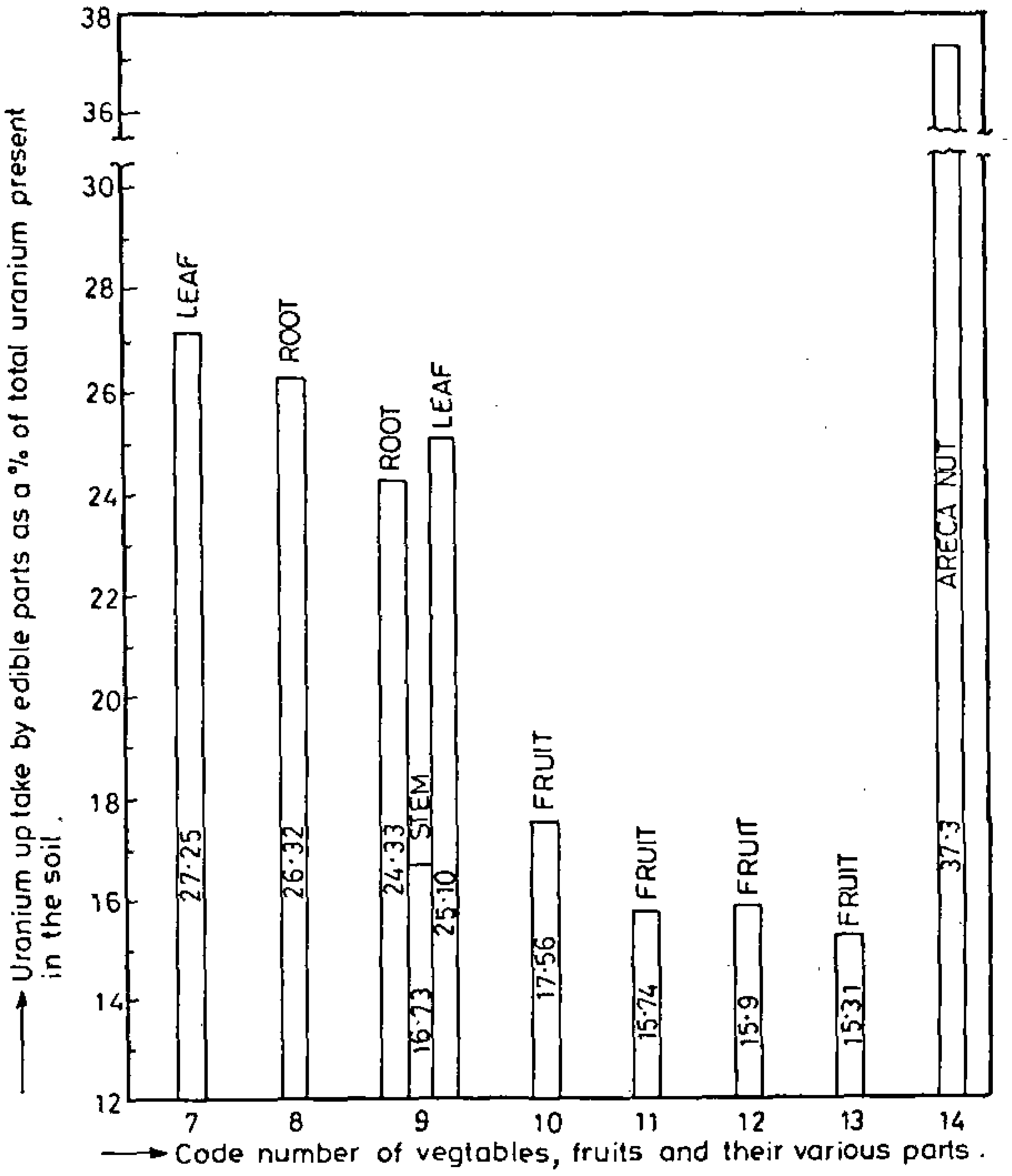

Figure 6. Bar diagram showing uranium uptake by edible parts of some vegetables and fruits. 7, Spinach; 8, Carrot; 9, Radish; 10; Brinjal; 11, Tomato; 12, Banana; 13, Beet; 14, Arecanut.

$$\text{U-uptake by fruit} = \frac{\text{U-content in fruit part of plant (ppm)}}{\text{Initial U-content in the soil (ppm)}} \times 100.$$

ous parts of betel plant with an enhancement factor ranging from 1.27 to 2.38.

It appears from these studies that in the case of vegetables, the chances of uranium transport to the related organs of human systems may be more by consuming the leafy portions of spinach. In the case of radish, root and leaf both are edible, which together account for about 75% uranium taken by the plant. In view of this, a greater risk of uranium transport is possible by consuming a large quantity of radish, grown in the soil containing high percentage of uranium. At the same time, care and sincere effort must be taken to reduce the uranium content of the soil to the minimum level.

The ecosystem is very important when considering the food chain, which is in effect a transfer of energy from plants through a series of organisms including human being.

At a certain fixed level of uranium content in the soil, the uptake of uranium is the highest in the edible parts of maize (in case of cereals), black gram (in case of pulses), spinach (in case of leafy vegetables) and radish (in case of underground vegetables).

This study further suggests that the critical zone population around nuclear installations should be monitored for uranium content in the lungs, blood, urine periodically. The uranium contents in the rain water, well water, river water, soil, air, edible and medicinal plants from critical zone should also be examined periodically with an objective to generate a scientific data bank for the future.

It is important to note that no technology is perfectly safe. Therefore, careful engineering design and engineered safety features are among the important safety approaches required to be adopted. Every attempt should be made to achieve the aim of zero release of uranium to the environment.

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