

I. INTRODUCTION

Despite the extensive studies reported in the literature on vitamin C little is known of factors that affect requirement for it. There have been indications recently that activity, i.e., more than moderate physical exercise, may be an influencing factor. Hamel (1937) stated that strenuous activity increased the adult requirement for vitamin C by at least 20 mg. daily. Ratsimamanga (1937) reported greater concentrations of blood lactic acid after exercise in guinea pigs receiving a scorbutic diet than in normal controls. Smith (1938) suggests that various conditions of increased metabolic activity may affect requirement for vitamin C as, for example, manual labor and violent exercise. Belser et al. (1939) in an experiment designed to study tissue saturation of ascorbic acid made incidental observations on the effect of exercise on the urinary excretion of ascorbic acid. One of their subjects played baseball frequently during an experimental period, and there was a significant drop in vitamin excretion as compared with other periods of the experiment. These authors suggested a possible relationship between the loss or increased use of ascorbic acid and the physical energy expended. Unpublished experimental work from the Nutrition Laboratory at Oklahoma Agricultural and Mechanical College¹

1. Courtesy of Dr. Williamina Armstrong Himwich.

during the summer of 1942 indicated that controlled rope jumping each day markedly affected plasma concentrations of vitamin C in two subjects.

A practical, if unwarranted, application of these observations is being made today in industrial organizations. Employers, after giving workers added crystalline ascorbic acid, have believed that there was significant improvement in efficiency, decreased fatigue and lessened absenteeism (Holmes, 1942). Beneficial results of C therapy have been reported in cases of heat shock, industrial poisoning, allergy and insomnia. However, similar effects have been noted when supplementary food was given to employees during rest periods and when nutrients other than vitamin C were made available (Haggard et al., 1939). Hence, it is debatable whether the improvement in work production was specific for vitamin C.

The reputed influence of vitamin preparations in preventing or modifying fatigue and in promoting general well-being has created a tremendous market for them. To allow for the increased demand for vitamin C alone, the United States in 1940 manufactured 17 tons of synthetic vitamin C and expected to reach an output of 100 tons (Holmes, 1942).

Nutritionists have felt that promiscuous vitamin therapy is ill advised until more information is secured as to the extent that dietary supplementation can improve the nutritional status of an individual under conditions of physical and nervous stress (Howe, 1943). The war has further

emphasized the need for such information because of the unusual physical demands of military campaigns and the stepped-up civilian program. Soldiers and war workers alike require an allowance of nutrients that will not only supply normal body needs but will overcome the effects of extremes of temperature, fatigue, infection, and nervous tension.

It would seem therefore that a more critical research into the factors that affect requirement for ascorbic acid is indicated. It also would seem necessary to establish the relationship, if any, between an increased program of activity and an individual's requirement for vitamin C. If longer working hours and a more strenuous schedule demand a higher allowance of vitamin C to maintain physiologic integrity, then present standards need to be qualified.

A revision of standards for vitamin C requirement would be applicable not only to the war worker and to individuals serving in the armed forces but to men and women on our college campuses. These students are attending classes today under conditions which impose a greatly accelerated program, geared to a full-time, year-round schedule. One wonders if the allowance of 70 mg. of ascorbic acid per day as recommended for them by the National Research Council (1941) is adequate under the present circumstances which involve sustained as well as increased activity. Might their efficiency be improved by increasing the daily allowance of vitamin C to

provide for a possible cumulative deficit due to increased energy expenditure?

Certainly the question seems worthy of investigation, and the present study was undertaken to determine the effect of controlled exercise on urinary and plasma concentrations of vitamin C in college women.

II. REVIEW OF LITERATURE

A. Chemistry of Vitamin C

King in 1932 (King, 1938) demonstrated that the hexuronic acid obtained from the adrenal glands by Svirbely and Szent-Gyorgyi and the hexuronic acid isolated from lemons by Waugh and King were identical. The compound with the general formula $C_6H_8O_6$ was not named according to its relationship to compounds as d-glucose and l-sorbose but was designated as ascorbic acid by Haworth and Szent-Gyorgyi to denote its anti-scorbutic properties. Although ascorbic acid has become the official chemical name, the compound is known both as ascorbic acid and as vitamin C, which it was originally named.

The synthetic form of vitamin C was first produced from l-xylose; today synthesis is accomplished commercially from the reduction of d-glucose to sorbitol with a subsequent selective fermentation to l-sorbose.

The antiscorbutic properties of ascorbic acid are dependent on the d- and l-configurations of carbons four and five (figure 1).

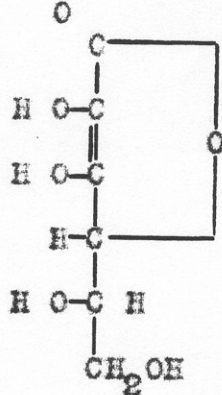


Fig. 1. Ascorbic Acid

The chemical characteristics of ascorbic acid most pertinent to this paper are those of oxidation-reduction. King (1938) states that the vitamin is reversibly oxidized by organic compounds as methylene blue, quinones, indophenol dyes and by inorganic substances as Cu^{++} , Fe^{+++} , Hg^{++} , Ag^+ , Mn^{+++} , $\text{Fe}(\text{CN})_6^{--}$, NO_3^- , H_2O_2 , and I_2 . He quotes Barron et al. as saying that, in aqueous solutions below pH 7.6, ascorbic acid will not be oxidized in the presence of air unless a catalyst such as copper is present. The dehydro form of ascorbic acid is comparatively stable in aqueous solutions below pH 4.

B. Occurrence and Functions of Vitamin C

Vitamin C is found in body fluids as plasma, sweat and gastric juices (Abt and Farmer, 1938). Bessey and King (1933) have stated that the concentration in the adrenals is high, 1.4 to 2.3 mg. per gm. of tissue, with lesser amounts in

brain, liver, and the reproductive organs, muscle tissue and blood having the least amount. Younger animals have a higher concentration in body tissue than do older animals according to these same workers. They believe that its plentiful occurrence in green leaves and in association with carotenoid pigments indicates a role in the oxidation-reduction processes of photosynthesis in plant tissue and in respiratory processes in animal tissue.

Abt and Farmer (1938) have defined the chief function of vitamin C to be the formation of intercellular colloids with a possible role as respiratory catalyst through transportation of hydrogen. The relation of vitamin C to the formation of intercellular substances was first shown in experimental animals by Wolback and Howe (1926). Crandon and Lund (1940) have said that it probably is due to lack of intercellular constituents in C avitaminosis that the capillaries are singularly fragile and subject to hemorrhage. One of the earliest criteria for detection of subclinical vitamin deficiency was a lowered capillary strength (Smith, 1938).

Dalldorf (1938) proposes that, since hydrogen ion concentration is of critical importance to a colloidal system, it might follow that vitamin C, acting as a hydrogen carrier, directly affects the physical character of intercellular fluids.

According to Bessey and King (1933) it is probable that ascorbic acid functions identically in various body

tissues and that its function is related to respiratory and metabolic processes in general. There is some indication that vitamin C may be a regulatory substance in the cellular oxidation of carbohydrates and in total carbohydrate metabolism (Owens et al., 1941).

C. Mechanism of Absorption of Vitamin C

Vitamin C is selectively absorbed from the gastrointestinal tract and particularly from the small intestine (Abt and Farmer, 1938). Since the vitamin is soluble in water, absorption is almost quantitative and little is lost through the stool. Chinn and Farmer (1939) state that the quantity of vitamin C excreted into the feces is small, being about 4.92 mg. in 24 hours on a normal mixed diet. This average fecal excretion of vitamin C is but slightly affected by intake.

After absorption vitamin C appears in increased amounts in blood plasma by which it is transported to body tissues. (Abt and Farmer, 1938)

D. Mechanism of Excretion of Vitamin C

Ralli et al. (1938) carried out simultaneous vitamin C and inulin clearances and demonstrated that the amount of vitamin which appears in urine is the composite result of filtration and active tubular reabsorption. The mechanism of