for 25 min, and the unreacted diene was isolated by preparative GLC. IR analysis (9) showed 107% *trans*. Ozonolysis indicated that 44% of the first double bond moved equally in both directions. Aldehydes containing 5, 6 and 7 carbon atoms were present. Apparently during alkali-isomerization, a small amount of diene isomerizes to a nonconjugatable type of diene.

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Thickening Action of Hydroxystearates in Peanut Butter

ABSTRACT

When 0.5-1% of 12-hydroxystearic acid or the corresponding triglyceride is incorporated into unhardened peanut butter, the resulting product has stiff creamy consistency, and no oil separation takes place upon standing. Sensory evaluation of this peanut butter indicated that it was indistinguishable from typical commercial material in flavor and texture.

We wish to report that when either 12-hydroxystearic acid or tri-12-hydroxystearin (both derived from hydrogenated castor oil) is added at the level of 0.5-1.0% to unhardened peanut butter, the resulting product is indistinguishable from commercial, hardened peanut butter. Hydroxystearates increase the viscosity of hot aqueous starch and flour pastes (1), and it was of interest to examine a largely lipid-containing system for comparison. Thus we tested a number of derivatives of 12-hydroxystearic acid including the triglyceride, monoglyceride and the ethylene and propylene glycol monoesters. Thickening activity paralleled the melting point of the additivies, and this factor was confirmed by the ineffectiveness of the closely related ricinoleic (12-hydroxyoleic) acid, its triglyceride (castor oil) and monoglyceride, the first and second of which are liquid at room temperature with the third being a low melting solid. However these ricinoleates all behave much like the hydroxystearates in the aqueous starch systems mentioned above. Also examined were monostearin, stearic acid and tripalmitin. At the levels employed (0.5-1%) hardening action was minimal and oil separation occurred upon standing.

The solubility characteristics of the test compounds in vegetable oil were examined by dissolving the substances (1%) in hot oil and then permitting the mixtures to stand overnight at room temperature. The hydroxystearates formed gelatinous crystalline matrixes, in contrast to the nonhydroxy derivatives which either formed no crystals at all or the crystals of which were not held in suspension. The behavior of 9,10-dihydroxystearic acid and of 12-ketostearic acid was also examined in oil at the same concentration. Crystals which formed from these materials did not produce significant thickening, but rather settled out. Formation of satisfactory gels is restricted to the hydroxystearates, the most effective of which is the free acid.

Peanut butter samples for sensory evaluation were prepared from a brand of unhardened peanut butter containing salt only. Glucose, 1.5%, was added in finely powdered form to adjust the sweetness to that of the commercial hardened variety chosen for comparison.. The appropriate amount of 12-hydroxystearic acid or tri-12-hydroxystearin was added, and the mixture was warmed to ca. 90 C and blended with a household cycloidal mixer at ca. 50 cycles per minute for 5 min. The samples were stored overnight at 5 C before being warmed to room temperature and submitted to the evaluation panel. Experimental samples were compared against the commercial peanut butter as control, using the duo-trio test and a panel of 15 untrained judges who replicated each comparison twice giving a total of 30 judgements per comparison. The tests were conducted in a room with individual booths under subdued lighting to eliminate possible color differences between samples. Each judge received ca. 15 g of each sample for tasting as is. The results are shown in Table I.

TABLE I

Peanut Butter Test Results

Comparison	Judgments		
	Total	Correct	Preferring control
0.5% 12-Hydroxystearic acid vs. control	30	16	12
1.0% Tri-12-hydroxystearin vs. control	30	15	17

[a]Twenty correct judgments needed for significance at P = 0.05.

From this test it is clear that the judges were unable to discriminate between peanut butter containing additive and the standard commercial control. This indicates that the additive did not cause significant alterations in flavor or texture of the product, at the level tested.

The hydroxystearates are nontoxic (2), as was demonstrated by Binder and coworkers in a series of rat-feeding studies. No adverse effects were noted, except for somewhat reduced growth in rats fed 10% of hydrogenated castor oil. Lower digestibility of this diet rather than chemical growth inhibition was cited as the cause of the lesser growth. No laxative activity is observed with derivatives of hydroxystearic acid (3). Castor oil itself has been used as a frying oil in China and also in India as an adulterant of various edible oils (4). Foods that contain other hydroxy fatty acids include milk (5) as well as such items as apples and pears (6). These facts suggest that 12-hydroxystearic acid and derivatives thereof should be

acceptable for food use, provided FDA approval is granted.

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