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Stability of Tomato Powder at Intermediate Moisture Levels

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Abstract: Water sorption properties of tomato powder at intermediate moisture range (0.11 to 0.88 A_w) was characterized and its storage stability evaluated at 40°C by following changes in carotenoid contents, browning and pH. The sorption isotherm produced was of the sigmoid shape with safe moisture level of 12 percent which confirmed to 0.67A_w. The rate of carotenoid breakdown decreased from 7.6 x1 0^{-2} to 0.48 x10^{-2} mg/g per hr with the increase in water activity from 0.51 to 0.67 A_w and then it intensified sharply on further rise in water activity. Whereas, the rate for browning and pH increased continuously with gain in water activity. Since appearance of dense brown colour is more deterrent to quality of the product, the stock required for prolonged storage at 40°C may be maintained at a compromised lower water activity levels close to 0.67 A_w so as to retain the desired quality characteristics of the product at an acceptable levels.

Key words: Dehydrated tomato powder, Sorption isotherm, Carotenoid breakdown, Non-enzymic browning, pH

Introduction

Tomato (*Lycopersicon esculentum*) is one of the most popular and important vegetables abundantly grown in tropical regions of the world including Pakistan. A large area exceeding 4460 hectares of North West Frontier Province of the country is under tomato cultivation with a total production of about 41105 tones (Anonymous, 1989). The harvesting of tomatoes is at peak during summer. The losses of the fruits are significant at this time due to their perishable nature. Post harvest losses further aggravate on subsequent loading/unloading, transportation and fresh marketing. Such losses inflict heavily on the economy of growers, and their economic position is further weakened by low price return due to market glutting. Information regarding water sorption characteristics and the stability of tomato products on storage are limited (Silva *at al.,* 1975; Tripathi and Nirankar, 1989; Baloch *et al.,* 1997). The core purpose of this study was to relate changes in quality of tomato powder with water activity in intermediate moisture levels. The data generated are likely to provide guidelines for extending the shelf life of the product which should withstand adverse storage conditions usually prevailing during summer.

Materials and Methods

Mature oval type Roma variety of tomatoes were purchased from local market and washed well to remove dust, dirt, residual insecticides and microbial load from the fruit surface. The tomatoes were then cut into 4 mm slices with a stainless steel knife and subjected to blanching by dipping in boiling water for 2 min so as to inactivate the enzymes and to improve appearance and flavour. The slices were freeze-dried and ground to pass through a 25-mesh sieve.

Water activity adjustment: Samples (10 g) were taken in glass dishes and placed inside airtight desiccators containing saturated salt solution of known water activity. Saturated solutions from various salts corresponding to water activity level in the range of 0.11 to 0.88 A_w were prepared according to Rockland (1960). Water activity was verified using digital probe humidity meter, Model HN-K Chino Corporation, Japan. The desiccators were then placed in an incubator maintained at 40°C, and the samples were allowed to equilibrate in dark for one week period. During the period of conditioning of samples respective dry salt or distilled water was added to the solutions in order to maintained them saturated. The period for water activity adjustment was established by recording gain or loss in initial weight of the samples until constant weight was achieved. Equilibrium moisture contents of each sample were then determined. Absorption isotherm was constructed by plotting equilibrium moisture contents (dry basis) against water activities of the samples, Safe moisture level was determined according to Caurie (1970) after plotting Ln (100-% E.M.C./% E.M.C.) against water activity.

Storage studies: The dehydrated powder was divided into five lots (40 g) and subjected to water activity adjustment with 0.51 to 0.75 A_w, at already established conditions. The equilibrated sample housed in desiccator was placed in dark inside incubator maintained at 40°C for 35 days. The material was taken out weekly to measure total carotenoid contents expressed as I3-carotenes, moisture content, browning and pH. Moisture content and pH were determined as per methods of AOAC (1984). Total carotenoid pigments and non-enzymic browning were measured spectrophotometrically (Baloch *at al.,* 1997). The rate of quality change for each parameter was calculated by determining overall quantity change per hour from the estimated median value after 35 days of storage. A duplicate set of samples was pooled out for each determinant and the average value was recorded.

Results and Discussion

Characterization of Sorption isotherm: The equilibrium moisture contents of samples increased from 2.9 to 42.2 percent on increasing water activity of the equilibrating solutions from 0.11 to 0.88 A_w. The relationship is represented in the form of sorption isotherm in Fig. 1. It can be seen that the isotherm was a typical sigmoid shape normally exhibited by most food products containing a fair amount of hygroscopic components. The curve was apparently comprised on three moisture level ranges without having sharp demarcation as a result of moisture overlaps. The initial portion of the isotherm covered about 2 to 4 percent moisture levels with 0.11 A_w, whereas the second one extended with gradual rise in moisture content to about 10 percent matching to 0.6 A_w. The last portion beyond that level, was much enlarged with high moisture contents, displaying a steep rise in moisture per unit increment in water activity. In this region with the moisture in capillary form, the product exhibited high affinity to moisture exerting a significant influence on stability of the product during storage. The typical pattern of the isotherm suggested that a dissimilar molecular interaction existed between the attached water molecules and tomato components along several isothermal stages. Such variable character expectedly supported diversified stability on storage at different water activity levels.

Carotenoid breakdown: Irrespective of the water activity at which the samples were stored there appeared a gradual loss in total carotenoid through out the storage (Fig. 2). The loss increased rapidly at the beginning and then it leveled down on subsequent storage. The rate of carotenoid breakdown however, was greatly influenced by the level of water activity. The carotenoid loss during 35 days of storage decreased from 89.5 to 32.8 percent on increasing water activity of the samples from 0.51 to 0.67 A_w giving about 15 time reduced rate. On further rise in water activity to 0.75 A_w, however, the carotenoid breakdown intensified till the end of 35 days of storage inflicting 67.2 percent loss. A significant influence of water to protect carotenoid colour in foods has been shown by Von Elbe (1987). Silva *et al.* (1975) reported that the main cause of colour fading in tomato powder was due to oxidation of lycopene pigment. Using model system studies Baloch *et al.* (1977) reported that there was an optimum A_w at which the stability of β-carotene becomes maximum. It was comprehended that a moisture content of foods near monolayer coverage protected carotenoid by making barrier against atmospheric oxygen to food carotenoids, whereas higher moisture levels encouraged metallic ions and other radicals to damage carotenoids readily.

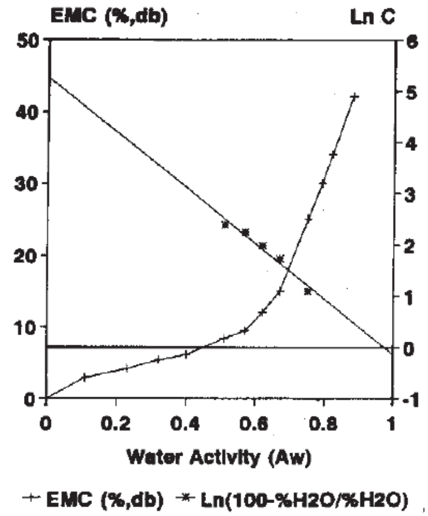

Fig. 1: Sorption isotherm of tomato powder at 40°C

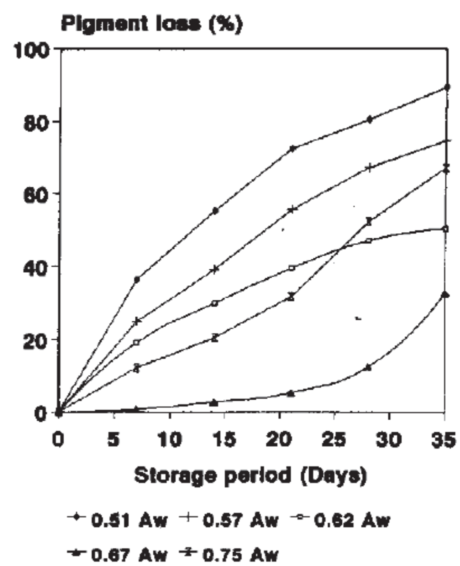

Fig. 2: Effect of Aw on carotenoid breakdown during storage at 40°C

Non-enzymic browning: Non-enzymic browning increased throughout the storage (Fig. 3). The absorption as A_{420} of the brown colour prior to storage of the samples ranged 0.049 to 0.069 units. However, it intensified on storage for 35 days approaching 0.079 to 0.193 units. The browning was more pronounced in samples stored at higher water activity levels and the rate of colour development of 8.0×10^{-5} appeared to be the highest at 0.75 A_w. On the other hand, the samples stored at lower water activity levels were more stable and deteriorated slowly (at 2.3×10^{-5} at 0.51 A_w) resulting relatively stable product. However, no optimum level of water activity emerged in the range

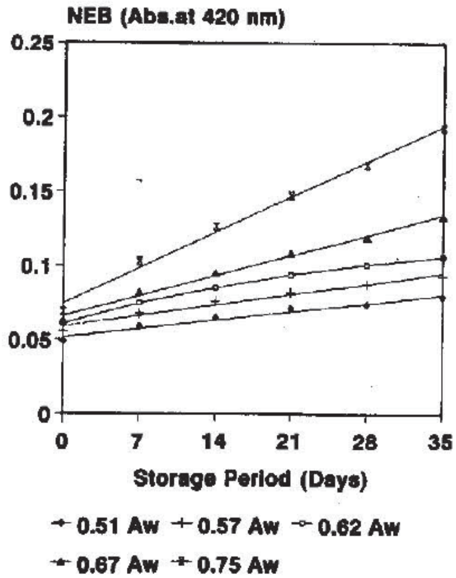

Fig. 3: Effect of water activity on NEB changes during storage at 40°C

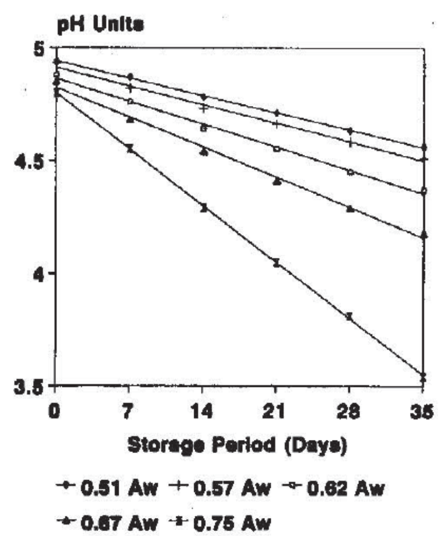

Fig. 4: Effect of water activity on pH during storage at 40°C

studied. The results are in agreement with those reported by many workers (Karel, 1975; Labuza and Saltmarch, 1981; Jayaprakasha *et al.,* 1997) who had indicated lower levels of water activity to control NEB significantly. In order to increase storage life and to maintain desirable colour it is suggested to store tomato powder at lowest permissible water activity level.

pH changes: A gradual decline in pH was shown in all the samples during the entire period of the storage and the change in the pH was highly influenced with the level of

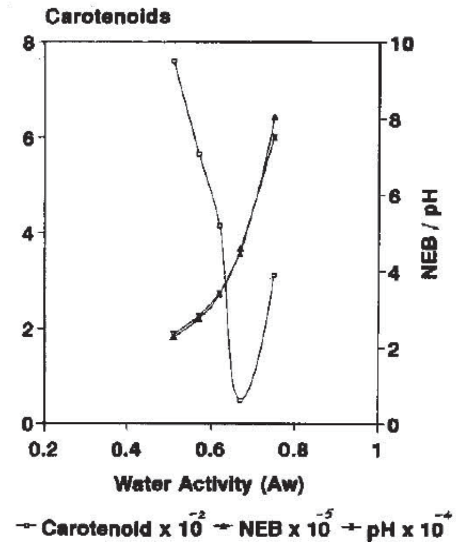

Fig. 5: Effect of water activity on rate of deteriorative changes during storage at 40°C

water activity and pH drop was highest in a sample with the highest level of water activity used (Fig. 4). The pH of the sample stored at 0.51 A_w decreased from 4.94 to 4.56 with a pH drop of 0.38 units, whereas it dropped from 4.80 to 3.54 giving a decrease of 1.26 units for the sample adjusted at 0.75 A_w while both the samples were held under similar conditions.

Changes in pH corresponded well with the browning development. Decline in pH was greater in samples inflicted greater damage by browning possibly through Maillard type reactions taking place in foods as suggested by Hodge (1953). On plotting the rates of quality deterioration of sample against respective water activity levels, it appeared that the rate of carotenoid breakdown declined on raising water activity from 0.51 to 0.67A_w however, on further rise in water activity the rate increased displaying a minimum rate of 0.482×10^{-2} for the sample equilibrated at 0.67 A_w. Whereas the rate for non-enzymatic browning and other associated deteriorative changes increased steadily exhibiting a sharp rise in the rates beyond 0.67 A_w. Since the graph related to changes in non-enzymic browning coincided well with that of the pH, it implies that the reactions leading to non-enzymic browning were the main source of acids formation and responsible for pH changes (Fig. 5). Water activity of 0.67 A_w appeared to occur within an intermediate moisture range and this might probably favour browning and various other associated deteriorative reactions. It was manifested that the rate of adverse changes for the parameters studied are not as alarming upto 0.67 A_w but shot up abruptly beyond that water activity level. On plotting logarithm of moisture free solids against water activity employed for the storage trials (Fig. 1), an equilibrium moisture content of about 12 percent was found, which according to Caurie (1970) represented a safe moisture level, and corresponded to water activity of about 0.62.

For keeping deteriorative changes associated with carotenoid breakdown and browning to lower ebb, maintenance of water activity in the range of 0.62 to 0.67 A_w is needed for extended storage of tomato powder. The samples at the stated water activity range are expected to yield a better quality product possessing maximum chemical stability and possibly quite safe microbiologically. There is a close agreement with the views of Karel (1975) that there is an optimum water activity level for each food at which it gives relatively increased storage life. However, the water activity of 0.67 falls at the junction of the isothermal segments where some of the moisture is likely to exist in liquid and vapour phases and is thus critical for influencing the stability of the powder (Fig. 1).

References

AOAC., 1984. Official Methods of Analysis. 14th Edn., Association of Official Agricultural Chemists, Washington, DC., USA.

Anonymous, 1989. Agriculture statistics of Pakistan. Ministry of Food, Agriculture and Co-operative (Planning Unit), Govt. of Pakistan, Islamabad.

Baloch, A.K., K.A. Buckle and R.A. Edwards, 1977. Stability of β-carotene in model systems containing sulphite. Int. J. Food Sci. Technol., 12: 309-316.

Baloch, W.A., S. Khan and A.K. Baloch, 1997. Influence of chemical additives on the stability of dried tomato powder. Int. J. Food Sci. Technol., 32: 117-120.

Caurie, M., 1970. A new model equation for predicting safe storage moisture levels for optimum stability of dehydrated foods. Int. J. Food Sci. Technol., 5: 301-307.

Hodge, J.E., 1953. Dehydrated foods, chemistry of browning reactions in model systems. J. Agric. Food Chem., 1: 928-943.

Jayaprakasha, H.M., K.J. Rao and W.A.L. Kumar, 1997. Studies on the influence of water activity (a_w) on the stability of foods: A critical appraisal. J. Food Sci. Technol., 34: 273-285.

Karel, M., 1975. Heat and Mass Transfer in Freeze Drying. In: Freeze Drying and Advanced Food Technology, Goldblith, S.A., L. Rey and W.W. Rothmayr (Eds.). Academic Press, London, UK., ISBN-13: 9780122884504, pp: 177-202.

Labuza, T.P. and M. Saltmarch, 1981. The Nonenzymatic Browning Reaction as Affected by Water in Foods. In: Water Activity: Influences on Food Quality, Rockland, L.B. and G.F. Stewart (Eds.). Academic Press, New York, USA., ISBN: 978-0-12-591350-8, pp: 605-650.

Rockland, L.B., 1960. Saturated salt solutions for static control of relative humidity between 5° and 40°C. Anal. Chem., 32: 1375-1376.

Silva, S.D., M.F.F. Leitos, I. Chirose, I. Belazari and R.B. de Campae, 1975. Physico-chemical and microbiological evaluation of commercial samples of tomato paste. Food Sci. Technol., 8: 910-918.

Tripathi, R.N. and N. Nirankar, 1989. Effect of starch dipping on quality of dehydrated tomato slices. J. Food Sci. Technol., 26: 137-141.

Von Elbe, J.H., 1987. Influence of Water Activity on Pigment Stability in Food Products. In: Water Activity: Theory and Applications to Food, Rockland, L.B. and L.R. Beuchat (Eds.). Chapter 3, Marcel Dekker Inc., New York, USA., ISBN-13: 9780824777593, pp: 55-74.