Effect of Anthocyanin Preparations as Colorants on Hygroscopicity of Dry-Pack Foods

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ABSTRACT

The equilibrium relative humidity isotherm of a cherry beverage base and a strawberry gelatin dessert mix colored with anthocyanins from grape skins, cranberries and roselle was evaluated versus a Red No. 2 control. As well, the water vapor transmission rate of the packaging material was evaluated to estimate probable shelf-life. Results indicated that physical parameters, such as hygroscopicity, must be considered in estimating effects of the use of natural colorants in foods as well as the color and chemical stability normally investigated.

One of the most important factors involved in preventing degradation of dry-pack powdered foods is the package. It must act as a barrier to moisture to prevent physical, as well as chemical changes from occurring.

The importance of packaging becomes more acute when consideration is given to use of natural pigments as food colorants due to their greater inherent chemical and physical instability as compared to synthetic colorants.

Chemical instability of anthocyanins in wet-pack products has been well documented and has been discussed in recent reviews (1,6). Carotenoids in the natural form also have stability problems (1) which are lessened to some extent when synthesized (7). Von Elbe (14) has pointed out that the stability of betalaines in a gelatin dessert powder can be increased by packing in aluminum pouches or storing at a low relative humidity to reduce the water activity. Furthermore, Pasch and von Elbe (12) have shown that a four-fold increase in stability of betalaine may be attained when the water activity is reduced from 1.0 to 0.37. They postulate that this may be due to reduced mobility of reactants or limited oxygen solubility. In a study of physical stability of natural pigments, Soukup and Maing (13) noted that colors derived from dried aqueous extracts or juices are typically hygroscopic since other water-soluble materials are present. They qualitatively evaluated dried beet juice, dried grape skin and turmeric versus synthetic dyes for stability as measured by several physical parameters, one of which was hygroscopicity.

With beet juice and grape skin extracts, hygroscopicity was rated as high and extreme, respectively, versus synthetic dyes rated as none while turmeric was rated as moderate (13). Thus it may be seen that hygroscopicity is a serious problem with natural pigments and in particular with anthocyanins from grape-skin extracts.

Until recently, little work has been done on evaluation of anthocyanins in dry-pack systems. However, several recent studies (2-4) evaluated the chemical stability of grape, cranberry and roselle anthocyanins in a cherry beverage base and a strawberry gelatin dessert. During these studies it was noted visually that hygroscopicity was a serious problem which would decrease the shelf-life of such products. Thus in estimating the product's shelf-life, the degree of hygroscopic activity and the rate of water vapor transmission through the packaging material are of great interest.

Therefore, this study was initiated to evaluate quantitatively the equilibrium relative humidity isotherm (ERHI) of cherry beverage base and strawberry gelatin dessert mix colored with anthocyanins from grape skins, cranberries and roselle, respectively, versus a Red No. 2 control. It was also necessary to calculate the water vapor transmission rate (WVTR) of the packaging material used in each instance to estimate the probable shelf-life of such materials. Such data provide further information on the potential of natural colorants in foods which must be evaluated not only on the basis of chemical or color stability but also on the basis of important physical parameters such as hygroscopicity.

MATERIALS AND METHODS

The sources of anthocyanin pigment used in this study were cranberry pomace (Ocean Spray Cranberries, Inc., Hanson, MA), Concord grape filter trim (tartrate sludge, Welch Foods, Inc., Westfield, NY), and an extract of the calyces of roselle (Hibiscus sabdariffa L.) which was obtained as a liquid concentrate from Trinidad (5). The first two were

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extracted with a mixture of 95% ethanol and 0.01% citric acid while the third was obtained as a liquid extract. All three were concentrated (10:1) in a vacuum pan and chilled before filtering. A carbohydrate carrier (Morrex 1918) was added to obtain a 30% total solids mixture and the product was spray dried according to procedures established by Main et al. (10).

Amounts of spray dried powder required to color the dry-pack products to approximate the desired color achieved with Red No. 2 were established by visual panels (2-4).

The pigment powders were blended with colorless bases obtained from a supplier in the following proportions: (a) cherry beverage mix: 4.93 g of grape powder/100 g, 16.6 g of cranberry powder/100 g, 14.81 g of roselle powder/100 g and (b) strawberry gelatin dessert: 2.54 g of grape powder/100 g, 9.51 g of cranberry powder/100 g, 8.46 g of roselle powder/100 g.

The blended mixes were then packaged. The cherry beverage mix contained 12.00 g per cherry beverage pouch which produced 118 ml of final product. Packages were filled with foil (0.285 mil) pouch paper laminates. The strawberry gelatin dessert mix contained 21.25 g/pouch which also produced 118 ml of final product. Packages were used with pouch paper laminated with 1.5 mil polyethylene (Reynolds Metals Co., Richmond, VA). The packaging material was selected to simulate commercial packaging of dry beverage mixes and gelatin dessert mixes (2-4).

**Equilibrium moisture isotherms**

Relative humidity (E.R.H.) data were obtained by use of the simplified E.R.H. apparatus described by Levine and Fagenson (9) as follows: (a) five-gram samples of dry powder were dried in the vacuum oven at 70 °C and weighed; (b) dried samples were placed in glass jars of selected atmospheres of saturated salt solutions at increasing relative humidities as follows: 11.1%, 20.4%, 31.9%, 43.4%, 50.0%, 66.8%, 75.1%, and 91.1%; (c) jar's lids were tightly closed and wrapped with tape; (d) they were placed in a constant temperature storage cabinet at 100 °F and weighed every day until a constant weight was reached; (e) gain in weight was calculated as percent moisture pick-up; and (f) the E.R.H. absorption isotherm was plotted as percent moisture content vs. relative humidity; and (g) initial moisture content and the critical moisture content (C.M.C.) (where the product is unsaleable) were noted for shelf life calculations (11).

**Moisture determination**

Five- and 10-gram samples were placed in aluminum weighing dishes and their weights recorded. The dishes were placed in a vacuum oven at 70 °C for 4 h. They were then removed and placed in a desiccator and allowed to attain room temperature after which they were weighed. From the change in weight, the moisture content was calculated as follows:

\[ \text{% moisture content} = \frac{\text{weight change (water)}}{\text{weight of sample}} \times 100 \]

**Water vapor transmission rate (W.V.T.R.)**

Because many packages have weak seals and may be folded or tightly creased, it is desirable to determine the (W.V.T.R.) by using the entire package (9). For determination of the W.V.T.R. the following procedure was used (9): (a) Foil and pouch paper packages used in the storage study were both tested. A quantity of desiccant was placed in the packages and heat-sealed in the same manner as the storage packs. At the same time, packages were filled with the product colored with powdered spray-dried anthocyanin and also sealed. (b) Packs were weighed and then placed into a controlled chamber set at 90% relative humidity and 100 °F and were weighed for the first time in no later than 24 h. (c) Weighings were continued on a day-by-day basis until there was no change in the rate of gain. (d) The weight gain in water was then plotted against time and from the slope the W.V.T.R. was determined. From both the moisture equilibrium data and the W.V.T.R. rates, an estimation for shelf-life was calculated.

**RESULTS AND DISCUSSION**

E.R.H. isotherms were plotted as shown in Fig. 1 and 2. These studies indicated that the natural colors increased the hygroscopic behavior of the food products and that a shortened shelf-life can be expected unless packaging is improved to compensate for the change. The Critical Moisture Content (CMC) for strawberry gelatin with Red #2 was 3% moisture, whereas with natural colors the CMC was 1.5-2% moisture. With cherry beverage mix the CMC for the Red #2 control was 2% moisture and 1.1-1.5% moisture for the anthocyanin colors. All critical moisture contents were calculated at the point where products caked up, which was not related to chemical changes. Caking occurred in all dry gelatin products colored with natural anthocyanin powders at 31.9% relative humidity at 100 °F and in the cherry beverage mixes caking occurred at 20.4% relative humidity at 100 °F.

Water vapor transmission rates (W.V.T.R.) were calculated as shown in Fig. 3 and 4, by plotting weight gain (H₂O) versus time (days) for the two packages and their respective products. The amount of water absorbed...
per day can be calculated (8), once the E.R.H. isotherm, critical moisture content (Fig. 1 and 2) and W.V.T.R. (Fig. 3 and 4) have been calculated, as follows:

\[
E = \frac{P A t}{W} \quad \text{E} = \text{weight of water absorbed}
\]
\[
P = \text{permeability of package to water vapor (W.V.T.R.)}
\]
\[
A = \text{area of package}
\]
\[
t = \text{time}
\]

These calculations showed the estimated shelf-life of the natural colored cherry beverage to be 200 days, and that of the natural colored strawberry gelatin to be 56 days. The amount of water absorbed by the product through the package (Fig. 3 and 4) is controlled by the W.V.T.R. (Fig. 3 and 4) of the particular package. The shelf-life is determined by this rate, and by obtaining the difference in moisture between the original moisture content, and the C.M.C. This figure divided by the daily uptake rate (Fig. 1 and 2) provides an estimated shelf-life for a particular package and product under the conditions used. As storage temperature and humidity are lowered, shelf-life would be extended. Or by using a package with a lower W.V.T.R., shelf life of natural colored products could be increased. This is shown by the difference in the estimated shelf life of the two test products where package construction resulted in different rates of water adsorption.

Results of this study indicate that physical parameters such as hygroscopicity must be considered in estimating effects of the use of natural colorants in formulation as well as the color and chemical stability normally investigated.

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