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Modeling Of Thermophysical Properties Of Sour Cherry Juice

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ABSTRACT

The multiparameter model of some of the thermophysical properties of cherry juice as functions of temperature and concentration were developed. The experimental data of density and viscosity was used for the necessary approaches. By the aid of a microcomputer the models were modified and the graphs of them were drawn. The models suited to the experimental data satisfactorily.

ÖZET

VİŞNE SUYUNUN TERMOFİZİKSEL ÖZELLİKLERİNİN MODELLENMESİ

Vişne suyunun yoğunluk ve akışkanlığının sıcaklık ve derişime bağlı olarak değişimi modellenmiştir. Gerekli yaklaşımlar için deneysel veriler kullanılmıştır. Bilgisayar aracılığıyla bu modeller geliştirilmiş ve grafikleri çizilmiştir. Modeller, deneysel sonuçlara yeterli uyumu sağlamıştır.

INTRODUCTION

The operations of clarified fruit juice industry depend on many factors. The thermophysical properties such as density and viscosity are those of importance. Food plant operators and food engineers use these data to maintain a standard products quality level. These data should be available at any instant of the production. Experimental approach is not convenient in terms of time and cost. So the mathematical models seem to be practial.

The physical conditions such as the temperature and the concentration are parameters that can be rapidly obtained during any operation, so this data can easily be used to figure out the desired thermophysical property. This is possible with the utilization of the proper model for the required thermophysical property.

The curve fitting is one of the reliable method. Curves indicate very clearly how well the models have been derived for the necessary data. Today microcomputers are used to develop models and to fit these models as graphs to the data that is based on.

MATERIAL AND METHODS

The cherry juice used was a ready made, pasteurized product. The cherry juice was concentrated in a rotary evaporator, in which the evaporation chamber was rotating at a constant rotational speed in water bath at 40°C and soluble solids content were adjusted.

The viscosity and density values were measured at this Brix value within a temperadue to changing temperature. This theory were measured by a hand refractometer. The viscosity was measured in Ostwald - Cannon Fenkse viscometer. The concentration values at which data was taken were 13.8, 19.7, 22.8, 26.1°Brix., where the temperature values were 20, 30, 40, 50, 60 and 70°C. Pycnometer was used to determine the density of the cherry juice.

Experimental data is the subject of statistical analysis, where the model is the objective. B.M.D.P., a statistical software which allows the determination of the goodness of fit for multiparametric models and the significance of the regression was used to analyse the experimental data of viscosity and density (1).

Further improvements and definitions of the mathematical variations of the thermophysiscal properties of cherry juice as models were based on the preliminary statistical analysis.

Microcomputers are used for the related modifications and graphical representations.

RESULTS AND DISCUSSION

Some models have been suggested to correlate the density of sugar solutions and liquid foods (2, 3). The aim of the statistical software B.M.D.P. was to create this relation for clarified fruit juices. The present work has an objective of expressing the desired thermophysical property (primarily density and viscosity) as a function of temperature and concentration with a suitable multiparameter model. A microcomputer was used for the development and for the modification of the models.

The following model satisfactorily represented the density variation of sour cherry juice;

$\rho = 0.79 + 0.35 \exp(0.0108X) - 5.41 * 10^{-4}$.
where ρ is density (g/cc), X is concentration (°Brix) and T is temperature (K).

Variation of density of cherry juice with temperature and concentration is given in Figure 1.

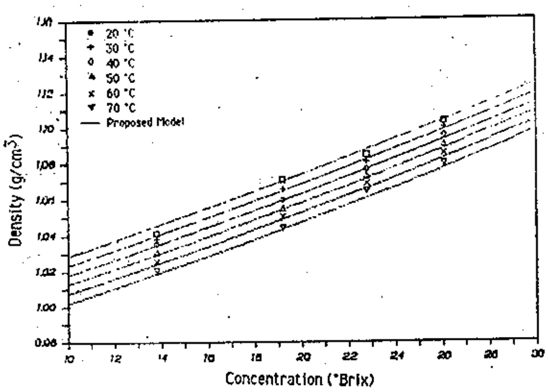

Figure 1: Variation of Density of Cherry Juice With Temperature and Concentration.

Viscosity is directly proportional to concentration and inversely proportional to temperature. The theory of viscosity also involves intermolecular activity. Increase in the sugar concentration will result the increase of hydrogen bonds by hydroxyl groups which leads to the increase of viscosity. The intermolecular distances which is also a factor that affects the viscosity is inversely proportional to it due to changins temperature. This theory mostly explains the reasons of temperature and concentration dependancy with molecular point of view.

Temperature effects on viscosity are expressed by Arrhenius Equation;

$\mu = \mu o \exp(Ea/R\ T)$
where μ is viscosity (cP), Ea is activation energy (kcal/gmol) and R is universal gas constant (kcal/gmol K).

It is reported that the effect of concentration on viscosities of fruit juices at constant temperature can be represented by an exponential or by a power type relationship (4, 5).

The concentration effects on the viscosity, when introduced into the Arrhenius Equation resulted in complex mathematical expressions. So another approach was suggested.

$$\ln(\mu/\mu wo) = 2.5 * \emptyset / (1 - K\emptyset)$$

Where $\emptyset$ denotes the volume fraction of solids and K is a dimensionless coefficient which represents the interaction between the particles and uwo is the viscosity of water at the same temperature.

With further modifications, the following equation was found;

$$\ln(\mu/\mu wo) = A*X / (100 - B*X)$$
$$A = -0.3 + (920/T)$$
$$B = 1.83 - 3.55 * 10^{-3} * T$$

Variation of viscosity of cherry juice with temperature and concentration is given in Figure 2.

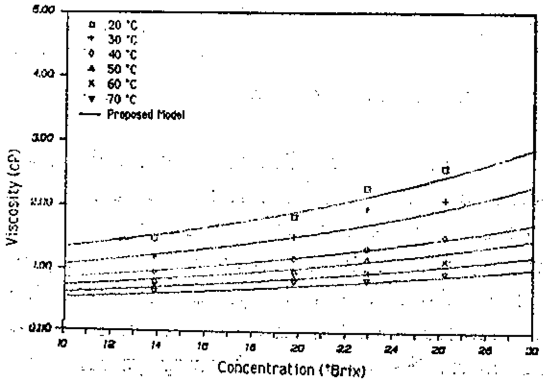

Figure 2: Variation of Viscosity of Cherry Juice With Temperature and Concentration.

Model Development and Curve Fitting :

The modeling and curve fitting are constructed of the following main steps; preliminary model building as a skeleton, statistical determination of the coefficients and by graphical approach fitting the rough model to the experimental data.

The software GWBASIC was used to determine the coefficients of the model. These coefficients were figured out by using basic loops within suitable ranges. The coefficients at each 'point' were determined so that by the help of coefficients available for that significant model, accurate results were obtained. Every single combination of the temperature and concentration conditions if defined by a 'point'. Although the accuracy of coefficients for each single point were satisfactory, when the means of these coefficients were taken into consideration for a unique model, an error range which was 0.01 - 0.1 % arised but was tolerable.

The graphical representation of these multiparameter models for the viscosity and density of cherry juice were done by another software LOTUS 123 with a single parameter treatment. The two dimensional graph of the model was drawn while one parameter was held constant. Several graphs were obtained, as much as the number of values assigned to the parameter that was held constant.

The softwares are under preparation for further modification of these models and for fitting them to data obtained from all clarified fruit juices.

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