Predictive modelling of microbial growth and development of its application software on low-salt, low-sugar candied frui

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ABSTRACT

This research investigated the effect of processing conditions, such asconcentration of salt and sugar, amount of preservatives, storagetemperature and oxygen permeability of the packaging material (PE bag, KOP/CPP bag, zipper bag)on the safety and quality of candied fruits. Suitabledatabases and mathematically predictive models were built from the datacollected. Computer programming language such as Microsoft Visual Basic 5was then used to shift the mathematically predictive models into applicationsoftware, that is user friendly to the manufacturer and non-researchers ofcandied fruits, to help them speed up the development of a better version oflow-salt-low-sugar candied fruits and to ensure sanitation and safety of theproducts. The first step proceeded with curve fitting and statistical analysis ofthe microbial quality database collected from candied kumquat processing (the data points for total plate count and yeast and mould count are 27x9x11,respectively)with Gompertz function. However, the regression result of suchcurve fitting was not encouraging (R^2 mostly lesser than 0.2). It meansthat Gompertz function may be only suitable for short-term fit of fastgrowing and non-deceasing cells in liquid medium, but not suitable for thelong-term storage fit of life-and-death cycling of microbes in solid medium.The reason may be the fact that microbes response differently in variousliving conditions. Due to the fact that Gompertz function doesn''t accurately describe themicrobial growth status of candied fruits, the total viable plate count inthe microbial quality database of kumquat was directly fitted to the processand storage conditions using quadratic polynomial regression. The regressionequations of total plate count to sugar concentration, sorbic acidconcentration, water activity, storage temperature, and storage time wereobtained for candied kumquat packed in single and all packaging materials.The regression results as of R2 were also very low, meaning that the fittingresults of the models were still not good enough. Finally, the research thus proceeded with quadratic polynomialregression of total viable cell count to process and storage conditionsindirectly via growth parameters. The three stages of typical microbialgrowth curve include lag phase, log phase and stationary phase. Initially,the research proceeded with linear regression of total viable cell countunder fixed process condition to storage time to obtain the parameters oflag phase time (t1)against, specific growth rate or deceasing rate (μ or α), time reaching stationary phase (t2), and pseudo initial cell count (Y0).The relative regression coefficient was defined as R1^2.Then, thequadratic polynomial regression analysis was used to correlate theprocessing conditions with growth parameters which had R1^2 value greaterthan 0.7 to build a more accurately predictive modeling on microbial growth.The relative regression coefficent in such case was defined as R2^2.R1^2is the fitness of growth kinetics parameters (t1、t2、 μ、 α and Y0)toprocess conditions. The accuracy of any model is determined by the readingof R^2 and the fitness gets higher when R^2 reading gets closer to 1. Thefinal equation obtained from (R1^2 ＋ R2^2)max was chosen as the mostsuitable model, because both R1^2 & R2^2 are equally important. The fitnessof the model is 85~95 % accurate in log phase, proving to be a good choicefor the description of microbial growth in candied fruits. For the moment, operation systems that are available in the market suchas Microsoft Windows 95 and the pending version of Microsoft Windows 98 areall very user-friendly interfaces. The application software, developed inthis research for the prediction of microbial quality of candied fruits, isa single software written by Microsoft Visual Basic 5, and is compatible toMicrosoft Windows 95 without the need of other software. In addition topossessing the capability of predicting the shelf life of candied fruitsprocessed and stored under fixed conditions and the capability of predictingthe value of single process or storage parameter under specified shelf life,the software also supports graphics function, which enables user to foreseethe microbial growth in a short period of time.

Keywords : 低鹽低糖蜜餞 ; 多項式迴歸分析 ; 數學模式 ; 預測微生物學

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