Optimization of the Processing Conditions and Quality Characteristics of Water Melon Jams Using Response Surface Methodology

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Abstract
Water melon (Citrullus vugaris) is a fruit grown for its thirst quenching property rather than for nutritional value. It consists of 92% water and 8% sugar, so it is aptly named. Its high water content makes it impracticable to use this fruit for jam, but because it is seasonal, processing the fruit into jam is a means of keeping this out of season produce available throughout the year. This study sought to investigate the effect of sugar concentration and pH balance on the chemical, physiochemical and physical properties of watermelon jams. Through the response surface methodology (RSM), the effect of refractive index, soluble solids, pH, total acidity, moisture, ash, total carbohydrate, hardness and colour with respect to sugar concentration and pH were determined. Response surface models were generated using regression analysis and used to plot graphs for each of the indices studied. The results revealed that inclusion of 60% sugar improved the soluble solids content, texture, colour and gel set of the jam. Inclusion of sugar concentration above 60% did not increase soluble solids content of the jam and resulted in jams of sticky consistency which is unacceptable from the standpoint of the consumer. The low sugar jams failed to set and had unacceptable texture, colour and soluble solids content. Sugar significantly contributes to the quality of the jam but above 60% sugar concentration, the quality of the jam is not improved. Acid had significant effect on the gel set, texture, total acidity and pH of the finished jam. All the pH levels studied resulted in jams of acceptable pH when analyzed. The optimal conditions required achieving the optimum soluble solids; pH and all other indices studied on the watermelon jam were sugar concentration of 60%, pH 3.0 and 3.5 with pectin concentration of 0.5%.

Keywords: Modeling tools for design, understanding, predicting and control

Introduction
Jam is one of the most effective and tasty ways of preserving fruits (Griswold, 1962). In Ghana, watermelon is purchased mostly for its thirst quenching properties, but its availability on the market all year round is not reliable. When in season from March to October, not all the fruits harvested are used which results in uncontrollable post harvest losses. To minimize these losses, it was necessary to find alternative-processing techniques to utilize the excess fruits harvested during the period. To achieve this, knowledge of ingredient balancing with respect to jam making was necessary to ensure uniformity and high quality of the jam. The objective of this study was to optimize the effect of ingredient balancing on the quality characteristics of watermelon jams.

Materials and Methods
The ingredients used in the processing of the watermelon jams were: watermelon fruit; sugar (sucrose); lemon and pectin (from apple peel; H_2O<10 %, ash~6 %, degree of esterification: 70-75 %, Hydroscopic). The jams were prepared by required quantities of sugar and pectin boiling the blended fruit pulp for 40mins

Experimental design for response surface methodology
A Central Composite Rotatable Design of the experiment was with K = 2 using for acid and sugar concentrations as independent variables. The dependent variables studied included total soluble, water insoluble solids, pH, and total acidity according to Egan et al., (1985). Moisture, ash, total carbohydrate (AOAC, 1990) and colour were determined. ANOVA was conducted at (p≤ 0.05).
Results and Discussion
The results showed that above 60% sugar concentration, the soluble solids content of the jams did not change appreciably (Fig.1). The total acidity decreased with increasing sugar concentration. Figure 2 shows that sugar concentration of 60 % resulted in a pH of 3.0. There was a gradual decrease in the moisture content of the jam with increasing sugar concentration. There was a gradual increase in the total carbohydrate content of the jam with increasing sugar concentration, however, there was an initial increase in the total carbohydrate content of the jam and then a slight decrease as pH level increased. From fig 3, it was observed that, the total carbohydrate content of the jam at 60 % sugar concentration and 100 % sugar concentration did not change significantly. The hardness of the jams increased gradually with increasing sugar concentration from 0% to 100%. Figure 4 shows that above 60 % sugar concentration the darkness of the jams did not change significantly implying that 60 % sugar concentration is sufficient to produce jams that are not too bright or too dark which would meet quality requirements.

Figures 1-4: Response Surface Plots
Fig.1: Soluble Solids

![Fig.1: Soluble Solids](image1)

Fig.2: pH

![Fig.2: pH](image2)

Fig.3: Total carbohydrates

![Fig.3: Total carbohydrates](image3)

Fig.4: L Value

![Fig.4: L Value](image4)

Conclusion
From the study, it was observed that the optimal processing conditions required to achieve the optimum quality of watermelon jam were sugar concentration of 60 %, pH range of 3.0 to 3.5 with a pectin concentration of 0.5 %. These levels gave the best quality watermelon jams with acceptable quality characteristics.

References