



Cairo University

FLOW BEHAVIOR OF SOME FRUIT JUICES

By

Mariam Mohamed Adel Mohamed Zaki El-Menawy

A Thesis Submitted to the
Faculty of Engineering at Cairo University
In Partial Fulfillment of the
Requirements for the Degree
MASTER OF SCIENCE
In
Chemical Engineering

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2018

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute

I further declare that I have appropriately acknowledged all sources used and I have cited them in the references section

Name: Mariam Mohamed Adel Mohamed Zaki El-Menawy

Date: 3rd November 2018

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Dedication

To my dad, may your soul rest in peace. I wish you were among us to witness it

To my mother and my super hero. I wouldn't have gone that far without you

To my backbone and blessing, my sister & brother (Sarah & Sherif) for their endless support

To my husband (Youssef) who continuously motivated me, supported me & kept pushing me whenever I stopped working

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Table of Contents

List of Figures.....	VI
List of Tables	VIII
Nomenclature	X
Abstract.....	XI
Chapter 1: Introduction	1
Chapter 2: Literature Review.....	5
2.1 Introduction to Rheology	5
2.2 Fluid types	6
2.2.1 Time Independent Fluids	6
2.2.2 Time dependent Fluids	11
2.3 Production Schemes of fruit juice	13
2.3.1 Introduction	13
2.3.2 Production scheme of juice from raw fruit by Pasteurization [23].....	13
2.3.3 Production scheme of juice from raw fruit through Belt Press / Decanter [24]	15
2.3.4 Typical Processing Plant	18
2.4 Rheological studies of some fruit juices	21
2.4.1 Orange juice.....	21
2.4.2 Other citrus juices	21
2.4.3 Tomato juice	22
2.4.4 Apple juice.....	22
2.4.5 Mango juice	23
2.4.6 Guava juice	23
Chapter 3: Materials and Methods	24
3.1 Starting materials.....	24
3.1.1 Mango juice	24
3.1.2 Guava juice	25
3.2 Rheology Measurements	27
Chapter 4: Results and Discussion	29
PART I: Mango Juice.....	29
4.1 Mixing step of Mango Juice.....	29
4.1.1 Shear rate – shear stress diagrams of mixed mango juice	29
4.1.2 Apparent viscosity of mango juice after mixing	30
4.2 Homogenizing step of mango juice.....	30
4.2.1 Shear rate – shear stress diagrams of homogenized mango juice.....	30

4.2.2 Apparent viscosity of mango juice following homogenizing.....	33
4.2.3 Sensitivity of viscosity variations for homogenized mango juice	34
4.2.4 Evidence of thixotropy of mango juice on homogenizing	36
4.3 Cooling step of mango juice.....	36
4.3.1 Shear rate – shear stress diagrams of cooled mango juice	36
4.3.2 Apparent viscosity after cooling mango juice	38
4.3.3 Sensitivity of viscosity variations for cooled mango juice.....	39
4.3.4 Evidence of thixotropy of mango juice on cooling	41
PART II: Guava juice.....	42
4.4 Mixing step of guava juice	42
4.4.1 Shear rate – shear stress diagrams of mixed guava juice	42
4.4.2 Apparent viscosity of guava juice after mixing	43
4.5 Homogenizing step of guava juice	43
4.5.1 Shear rate – shear stress diagrams of homogenized guava juice	43
4.5.2 Apparent viscosity of guava juice following homogenizing	44
4.5.3 Sensitivity of viscosity variation for homogenized mango juice	46
4.5.4 Evidence of thixotropy of guava juice on homogenizing.....	46
4.6 Cooling step of guava juice.....	47
4.6.1 Shear rate – shear stress diagrams of cooled guava juice.....	47
4.6.2 Apparent viscosity after cooling guava juice	49
4.6.3 Sensitivity of viscosity variation for homogenized mango juice	50
4.6.4 Evidence of thixotropy of cooled guava juice	51
Chapter 5: Conclusion and Recommendations	52
5.1 Conclusion.....	52
5.2 Recommendations	53
References.....	54
Appendix.....	58

List of Figures

Figure 1-1 Juice Consumption Rate across EU in accordance with U.S	1
Figure 1-2 Juice Variants consumption in U.S	2
Figure 1-3 Percentage distribution of the actual annual consumption of the household	3
Figure 1-4 Worldwide Consumption Per Capita in Kg in 2013	3
Figure 1-5 juice market sorted by fruit content from 2010 - 2013	4
Figure 2-1 Fluid Types Hierarchy.....	6
Figure 2-2 Force required to move the plate.....	6
Figure 2-3 Stress axis display	7
Figure 2-4 Shear Stress VS shear Rate & Viscosity VS Shear Rate for Newtonian Fluids	8
Figure 2-5 Shear stress VS shear rate for various types of fluids	9
Figure 2-6 Viscosity VS shear rate for different fluid types.....	11
Figure 2-7 Thixotropy increasing & decreasing shear stress & shear rate after time t.....	12
Figure 2-8 Rheopectic & Thixotropic viscosity VS shear rate	12
Figure 2-9 Process Flow Diagram for juice production from raw juice	14
Figure 2-10 Flottweg Decanter	15
Figure 2-11 Juice production from raw fruit through decanter.....	15
Figure 2-12 Flottweg belt press	16
Figure 2-13 Juice production from raw fruit through belt press	16
Figure 2-14 juice from raw fruit through belt press & decanter	17
Figure 2-15 Typical Juice Processing Flow Diagram.....	18
Figure 2-16 Homogenization technique.....	20
Figure 2-17 Homogenizer working technique	20
Figure 3-1 Brookfield Rheometer.....	28
Figure 4-1 Shear stress – shear rate diagram of mango juice after mixing.....	29
Figure 4-2 Apparent viscosity – shear rate diagram of mango juice after mixing	30
Figure 4-3 Shear stress – shear rate diagram of mango juice after homogenizing	31
Figure 4-4 Variation of constant k in equation (4.3) with temperature	32
Figure 4-5 Apparent viscosity – shear rate diagrams of mango juice following homogenizing	33
Figure 4-6 Arrhenius plots for mango juice following homogenizing	34
Figure 4-7 Sensitivity of viscosity of homogenized mango juice	35
Figure 4-8 Thixotropic character of mango juice following homogenizing.....	36
Figure 4-9 Shear stress – shear rate diagram of mango juice following cooling.....	37
Figure 4-10 Variation of yield stress with temperature	37
Figure 4-11 Variation of consistency index with temperature.....	38
Figure 4-12 Apparent viscosity – shear rate diagrams of mango juice after cooling	38
Figure 4-13 Arrhenius plots for mango juice following cooling	39
Figure 4-14 Sensitivity of viscosity of cooled mango juice	40
Figure 4-15 Thixotropy of cooled mango juice samples	41
Figure 4-16 Shear stress – shear rate diagram of guava juice after mixing	42
Figure 4-17 Apparent viscosity – shear rate diagram of guava juice after mixing.....	43
Figure 4-18 Shear stress – shear rate diagram of guava juice following homogenizing	44
Figure 4-19 Apparent viscosity – shear rate diagram of guava juice following homogenizing	45
Figure 4-20 Arrhenius plots for guava juice following homogenizing.....	45

Figure 4-21 Sensitivity of viscosity of homogenized guava juice	46
Figure 4-22 Limited thixotropy of guava juice samples following homogenizing	47
Figure 4-23 Shear stress – shear rate diagram of guava juice following cooling	48
Figure 4-24 temperature dependence of consistency index of cooled guava juice.....	48
Figure 4-25 Apparent viscosity – shear rate diagram of guava juice following cooling	49
Figure 4-26 Arrhenius plots for cooled guava juice	50
Figure 4-27 Sensitivity of viscosity variation for cooled guava juice	51
Figure 4-28 Thixotropy of cooled guava juice samples.....	51

List of Tables

Table 2-1 Juice types	13
Table 3-1 Analysis results for Juice after mixing	24
Table 3-2 Analysis results for Juice after Homogenization.....	24
Table 3-3 Analysis results for Juice after heat exchanger	25
Table 3-4 Finished products specification	25
Table 3-5 Analysis results for Juice after mixing	26
Table 3-6 Analysis results for Juice after homogenization.....	26
Table 3-7 Analysis results for Juice after heat exchanger	26
Table 3-8 Finished product specification.....	27
Table 4-1 Shear thinning parameters for mango juice following homogenizing	31
Table 4-2 Activation energy for mango juice following homogenizing.....	33
Table 4-3 Values of coefficients in equation (4.6) for homogenized mango juice.....	35
Table 4-4 Activation energy for mango juice following cooling	39
Table 4-5 Values of coefficients in equation (4.6) for homogenized mango juice.....	40
Table 4-6 Bingham fluid parameters for guava juice following homogenizing.....	43
Table 4-7 Activation energy for guava juice following homogenizing	44
Table 4-8 Bingham fluid parameters for guava juice following cooling	47
Table 4-9 Activation energy for cooled guava juice.....	49
Table 4-10 Values of coefficients in equation (4.6) for cooled guava juice.....	50
Table 0-1 Mango Juice Readings at Different Temperatures After Mixing	58
Table 0-2 Shear Stress VS Shear Rate for Mango Juice at Different Temperatures After Homogenization.....	59
Table 0-3 Viscosity VS Shear Rate for Mango Juice at Different Temperatures After Homogenization.....	60
Table 0-4 Shear Stress VS Shear Rate for Mango Juice at Different Temperatures After Cooling.....	61
Table 0-5 Viscosity VS Shear Rate for Mango Juice at Different Temperatures After Cooling	61
Table 0-6 Thixotropic Calculation for Mango After Homogenization at Temperature 65°C with spindle rpm from 10-100	63
Table 0-7 Thixotropic Calculation for Mango After Homogenization at Temperature 65°C with spindle rpm from 100-10 after 20 mins	64
Table 0-8 Thixotropic Calculation for Mango After Cooling at Temperature 65°C with spindle rpm from 10-100.....	65
Table 0-9 Thixotropic Calculation for Mango After Cooling at Temperature 65°C with spindle rpm from 100-10 after 20 mins	66
Table 0-10 Guava Juice Readings at Different Temperatures After Mixing	67
Table 0-11 Shear Stress VS Shear Rate for Guava Juice at Different Temperatures After Homogenization.....	68
Table 0-12 Viscosity VS Shear Rate for Guava Juice at Different Temperatures After Homogenization.....	69
Table 0-13 Shear Stress VS Shear Rate for Guava Juice at Different Temperatures After Cooling.....	70

Table 0-14 Viscosity VS Shear Rate for Guava Juice at Different Temperatures After Cooling	71
Table 0-15 Thixotropic Calculation for Guava After Homogenization at Temperature 65°C with spindle rpm from 10-100	72
Table 0-16 Thixotropic Calculation for Guava After Homogenization at Temperature 65°C with spindle rpm from 100-10 after 20 mins	73
Table 0-17 Thixotropic Calculation for Guava After Cooling at Temperature 65°C with spindle rpm from 10-100	74
Table 0-18 Thixotropic Calculation for Guava After Cooling at Temperature 65°C with spindle rpm from 100-10 after 20 mins	75

Nomenclature

τ	Shear Stress, Pa
$\dot{\gamma}$	Shear Rate, sec ⁻¹
μ_{app}	Apparent Viscosity, Pa.Sec
τ_0	Yield Stress, Pa
k	Consistency Factor
n	Flow Behavior index
T	Temperature, °C
E	Activation Energy
a_0	Empirical Constant
a_1	Empirical Constant
a_2	Empirical Constant

Abstract

Juice production is known to be one of the important and critical industries as it involves products that are delivered and consumed by people. Strict parameters should be maintained in order to deliver safe product from raw materials delivery and semi-finished product processing to end product handling. The demand for juice in Egypt has increased widely to call for new product innovations and concepts since it is a country with high potentials of market growth.

Upon processing juice, identifying the juice type whether it's high on fruit content, artificial fruit drink or juice mix is mandatory as it strongly assists in identifying the optimum processing parameters. Juice production schemes can differ depending on whether the starting point is production from juice concentrate or juice fruit.

The fluid behavior in each processing step starting from ingredients mixing up to heat treatment should be known as it serves in the ideal handling for the juice and maintaining the product quality. This results in providing premium juice for end consumer and can be studied through Rheology. Rheology is the study of flow behavior and deformation of fluid upon applying certain force and analyzing the flow behavior in response to time, temperature change and deformation

The purpose of this thesis is to study the fluid behavior of both Mango and Guava juice in preliminary mixing, product homogenization and final heat treatment. For both juices, the rheological study was conducted from range 10-105 °C using Brookfield Rheometer with speed of spindle ranging from 10-100 rpm.

For Mango Juice, fruit content was constant at 15%. After mixing at both temperature 10 & 18 °C the fluid behavior follows a Bingham fluid. the increase in temperature from 10 to 18 °C has had for effect to decrease the yield stress and the limiting viscosity. After homogenizing at temperature range (50-103 °C), temperatures a shear thinning behavior was observed approaching a zero viscosity at infinite shear rate. A thixotropic behavior can be observed as evidenced by the presence of a hysteresis loop. Finally, the cooling step for mango juice at temperature range (65-20°C) gave the straight lines indicating prevalence of Bingham behavior with a decrease in the consistency index (Limiting viscosity). While also observing a thixotropic behavior as evidenced by the presence of a hysteresis loop.

For Guava Juice, fruit content was constant at 25%. After mixing at both temperature 10 & 18 °C the fluid behavior follows a Shear Thinning behavior. After homogenization At temperature range (50-80 °C), The best fits of data showed then displaying Bingham fluids behavior approaching limiting viscosities at infinite shear rate. A thixotropic behavior can be observed as evidenced by the presence of a hysteresis loop. Finally, the cooling step at temperature range (65-20°C) gave the straight lines indicating prevalence of Bingham behavior with general decrease in yield stress. While also observing a thixotropic behavior as evidenced by the presence of a hysteresis loop.

Chapter 1: Introduction

Juice production is known to be one of the important and critical industries as it involves products that are delivered and consumed by people. Strict parameters should be maintained in order to deliver safe product from raw materials delivery and semi-finished product processing to end product handling.

Currently, diverse trends for juice mixes are available such as: juice and milk mix, fruit and vegetable mix, culture drinks and healthy drinks. Some producers also advertise 100% natural juice that is not made from concentrate. For example, Cawtson Press juice range claims that it consists of pressed original fruits and vegetable blends with no added sugar, no sweeteners, no coloring and no preservatives. Likewise, healthy people range claims for its mango and acerola super fruit that it is a main source of antioxidants as it includes both vitamin C and vitamin E.

In 2012 -2013, Germany scored the highest in juice consumption worldwide and maintained almost the same consumption rate across EU region in 2016 according to Statista EU per capita consumptions in litres. [1] (Fig 1.1)

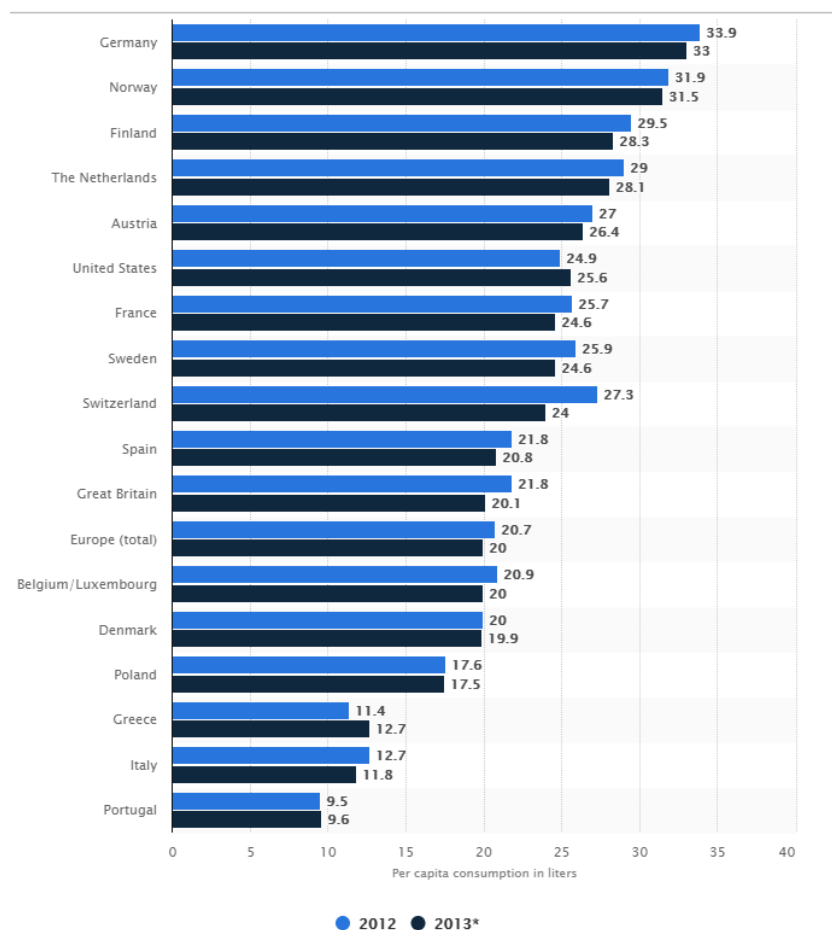


Figure 1-1 Juice Consumption Rate across EU in accordance with U.S