SEARCH FOR IMPROVING BULGUR PRODUCTION TECHNIQUES

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By
Mustafa BAYRAM
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Approval of the Graduate School of Natural and Applied Sciences

Assoc. Prof. Dr. Ali Rıza TEKİN

Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Prof. Dr. Mehmet D. ÖNER

Chairman of the Department

We certify that we have read this thesis and in our opinions it is fully adequate, in scope and quality, as thesis for the degree of Master of Science.

Assoc. Prof. Dr. Sami EREN Prof. Dr. Mehmet D. ÖNER

Supervisors

Examining Committee in Charge:

Assoc. Prof. Dr. Ali Rıza TEKİN(Chairman) .....

Prof. Dr. Mehmet D. ÖNER .....

Assist. Prof. Dr. Ahmet KAYA .....

ABSTRACT

SEARCH FOR IMPROVING BULGUR PRODUCTION TECHNIQUES

BAYRAM, Mustafa

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Supervisors:

Prof. Dr. Mehmet D. ÖNER

Assoc. Prof. Dr. Sami EREN

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In this study, bulgur production processes were searched. In bulgur production, cooking and drying are two critical operations. Cooking was made as atmospheric cooking at 87, 92 and 97 °C and pressure cooking. Before pressure cooking, soaking was made at different temperatures (40, 50, 60, 70 and 80 °C) and the best soaking, based on minimum soaking time to reach 40% moisture content, was obtained at 80 °C. Pressure cooking was carried out at 10, 15 and 18 psig for 2, 4 and 6 minutes. The best result, based on color, processing shorter time and extent of gelatinization, was obtained at 18 psig for 6 minutes and used for preparation of wheat before drying operations. Dimensions, volume, density, moisture content, starch gelatinization, starch extraction, color of wheat were determined during these operations. Drying systems with different working principles were used (convectional, conductional, infrared and microwave). Fluidized Bed, Tray, Conductional, Infrared and Microwave dryers were used to dry wheat at 70, 80 and 90 °C except microwave while drying with

microwave, 30%, 50% and 100% power levels were used. Color and moisture content were determined during drying operations.

Key words: Bulgur, atmospheric cooking, soaking, pressure cooking, fluidized bed dryer, tray drying, conductional drying, infrared drying, microwave drying

ÖZET

BULGUR ÜRETİM TEKNOLOJİLERİNİN GELİŞTİRİLMESİ ÜZERİNE ARAŞTIRMA

BAYRAM, Mustafa

Yüksek Lisans Tezi, Gıda Mühendisliği Bölümü

Tez Yöneticileri:

Prof. Dr. Mehmet D. ÖNER

Doç. Dr. Sami EREN

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Bu çalışmada bulgur üretim sistemleri araştırılmıştır. Bulgur üretiminde pişirme ve kurutma kritik işlemlerdir. Pişirme işlemi atmosferik pişirme, 87, 92, 97°C sıcaklıklarda ve basınçlı pişirme olarak yapılmıştır. Basınçlı pişirmeden önce buğdaylara ıslatma işlemi beş ayrı sıcaklıkta gerçekleştirilmiştir (40, 50, 60, 70 ve 80 °C) ve en iyi sonuç, nemin %40'a ulaşması için gerekli minimum ıslatma süresi baz alınarak, 80 °C de elde edilmiştir. Basınçla pişirme işlemi 10, 15 ve 18 psig'de 2, 4, ve 6 dakikada yapılmıştır. En iyi sonuç, renk, proses süresi ve jelatinleşme oranı baz alınarak, 18 psig'de 6 dakika olarak bulunmuş ve kurutma işleminden önce buğdayın hazırlanmasında kullanılmıştır. Bu işlemler esnasında, buğdayın boyutları, hacmi, yoğunluğu, nem miktarı, nişastanın jelatinleşmesi, nişastanın suya geçmesi ve renk değişimi ölçülmüştür. Kurutma işleminde farklı sistemlerle çalışan (kondüksiyonel, konveksiyonel, kızılötesi ve mikrodalga) kurutucular kullanılmıştır. Bu işlem için, Akışkan Yataklı, Tepsili,

Kondüksiyonel, Kızılötesi ve Mikrodalga kurutucuları kullanılmıştır. Kurutma işlemleri, mikrodalgalı kurutma hariç, 70, 80 ve 90 °C'de yapılmıştır. Mikrodalga ile kurutmada %30, %50 ve %100 güç kaynağı seviyeleri kullanılmıştır. Kurutma işlemleri esnasında, nem ve renk değişimi ölçülmüştür.

Anahtar Kelimeler: Bulgur, atmosferik pişirme, ıslatma, basınçlı pişirme, akışkan yataklı kurutma, tepsili kurutma, kondüksiyonel kurutma, kızılötesi kurutma, mikrodalga kurutma

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ABBREVIATIONS

ai	:Initial length of wheat kernel, cm
af	:Final length of wheat kernel, cm
bi	:Initial width of wheat kernel, cm
bf	:Final width of wheat kernel, cm
ci	:Initial width of wheat kernel, cm
cf	:Final width of wheat kernel, cm
Wi	:Initial weight of wheat kernel, g
Wf	:Final weight of wheat kernel, g
Vi	:Initial volume of wheat kernel, cm^3
Vf	:Final volume of wheat kernel, cm^3
ρi	:Initial density of wheat kernel, g/cm^3
ρf	:Final density of wheat kernel, g/cm^3
m.c.	:Moisture content, %, (w.b.)
%Gelatinization	:Percent gelatinization of starch
%Starch	:Percent starch in water
R	:Red
Y	:Yellow
B	:Blue
V_{TS}	:Total volume of sample in starch determination, mL
a_p	:Polarization value in starch determination
L_p	:Length of polarization tube in starch determination, dm
α^{20}_D	:Conversion factor (specific rotation) of Ewers's method for starch in starch determination [182.7 /(dm x g/L)]
W_s	:Weight of sample in starch determination, g
X_t	:Moisture content (d.b.), kg water/kg dry solid
W	:Weight of sample, g

W_s	:Weight of dry solid, g
X	:Free moisture content, kg water/kg dry solid
X^*	:Equilibrium moisture content, kg water/kg dry solid
Ls	:Dry solid, kg
A	:Drying area, m^2
t	:Drying time, hour
R	:Drying rate, kg/m^2 .hour
X_{ave}	:Average free moisture content of X_n and X_{n+1} kg water/kg dry solid
X_n	:Free moisture content at n^{th} time, kg water/kg dry solid
X_{n+1}	:Free moisture content at next from n^{th} time, kg water/kg dry solid

CHAPTER I

INTRODUCTION

1.1. Definition of Bulgur

Bulgur is cleaned, cooked, dried and pulverized hard (durum) wheat [1, 2]. Referred to as "Arisah "in the old Testament, this ancient food is variously known as bulgur, bulgor, boulgur, burgul, burghul, burghoul [3]. Bulgur (in North America) or burghul (in the Middle East and North Africa) are names given to one of the oldest cereal-based food, which has been consumed for centuries in Turkey, Syria, Jordan, Lebanon, Egypt and East Europen countries and history of the bulgur goes back to 4000 years ago in these countries [4, 5, 6].

Bulgur is rapidly coming into commercial prominence in the United States to evaluate America's wheat and large amounts are being shipped overseas under government assistance programs, and its availability in domestic food channels is growing. Because, it is a relatively unrefined product, its nutritional values have been regarded as similar to those of whole wheat [2, 7]. Migration from village to city, production of this type of food materials carried to factory and administration [8]. In Turkey, bulgur was produced at Karaman during First World War by Rıza Küçükoğlu for first time at the industrial base [9].

1.2. Properties of Bulgur:

Bulgur is an ideal food to meet the nutritional requirements of many people, because of its low cost, long shelf-life, ease of preparation, and high nutritional value. Additionally, starch is gelatinized and the wheat is almost cooked [10]. Also it is differently usable food material and resists attact by insects and mites. Also, it is important for human diet and trade. It is spread over the world with this properties [3, 8, 11, 12, 13, 14, 15].

Recently, in the USA, according to scientific researches, bulgur does not absorb radiation. That's why, bulgur is stored for military and human nutrition purpose in this country.

Bulgur is more stable than wheat at hot and humid environment [16]. Additionally, bulgur is more important than wheat with respect to physiological properties and cooked easily to eat immediately [12. Biological differences between wheat and bulgur are, wheat has respiration activity and enzymes are active in kernel. In bulgur, there are no biological and enzyme activity.

In Turkey, two types of bulgur are standardized, coarse type for pilaf "kernel dimensions 1.5-2.5 mm" and fine type for meat ball (köfte) "kernel dimensions 0.5-1.5 mm". But, most of the bulgur are produced by the producers practically. Acccording to the Turkish Standards, bulgur is explained with following properties: [2, 17, 18, 19, 20, 21, 22]

Types of bulgur:

Type I : Bulgur for pilaf (1.5 mm-2.5 mm)

Type II: Bulgur for meat balls (köftelik) (0.5 mm-1.5 mm)

Properties of bulgur:

Color	: should be natural
Taste	: should be natural
Flavor	: should be natural
Mold	: should not be found
Waste of insects (insect's egg etc.)	: should not be found
Chemical Food Additive	: should not be found
Moisture content(d.b.)	: should be less than 13 %
Ash content (dry basis)	: should be less than 1.75 %
Insoluble ash content in 10% of HCl	: should be less than 0.30 %

Tolerances:

Stone, soil, sand, straw	: should be less than 0.01 %
Foreign herb seed	: should be less than 0.1 %
Pelemir	: should be less than 0.2 %
Other cereal grains	: should be less than 1 %
Coarse wheat	: should be less than 1 %
White kernel	: should be less than 1 %
Lower screen	: should be less than 0.5 %

1.3. Preparation of Food From Bulgur:

Preparation of bulgur for consumption depends on the particle size of the product. Coarse bulgur is usually boiled or steamed in the presence of meats or vegetables similar to the manner in which rice or couscous are prepared. Its flavor and texture vary depending on the wheat and the processing method. Fine and very fine bulgur (called smesma) are used in several traditional dishes where coarse granulation is not required. Bulgur flour, which usually contains some foreign material, and the bran detained in bulgur production are usually fed to poultry [23].

Diners in restaurants that feature Middle Eastern Foods are often served a savory golden pilaf made from bulgur in Syria, Lebanon, Egypt, Turkey and other Middle Eastern countries, bulgur has been a mainstay of diet for many centuries [3]. An Eastern European dish consisting of wheat, meat. oil and herbs are cooked together [9]. In Turkey, there are more than 25 type of meals made from bulgur nowadays [14].

One brand of the whole grain product is called Rediwheat in the USA: the crushed is Cracked Bulgur [14]. Dry bulgur is easily prepared for serving by boiling for 15-20 min. It is often used as a meat accompaniment but can be served in many ways. Bulgur recipes for numerous dishes ranging from soups to desserts have been developed. Additionally, heat expanded dry bulgur is the main ingredient in a wafer developer [15]

1.4. Raw Material

The type of wheat is important factor for producing high quality bulgur. Common hard and even soft wheat can be used to produce bulgur. Generally, Triticum durum is selected which is a macaroni type hard wheat for the production of bulgur. Because, hard wheat has a good yellow color and it has more protein than other wheat types. Also, much nitrogenous compounds are found in hard wheat. If there is no enough durum wheat, sometimes soft wheat can be used at villages. But, in the Middle East, bulgur is traditionally made in homes from durum wheat, but commercial products used in the United States are made from both white and red wheats in either whole grain or cracked forms [1, 12, 24, 25.

26]. Color (fix yellow color), water absorption, texture and chewing characteristics of final product depend on raw material [1, 8, 11, 27]. In additional to physical properties, some characteristics such as, level of foreign materials, homogenity and seed of pelemir (it is not separated from wheat easily) are important [8].

Aydın et al. [24] examined the bulgur quality obtained from some durum wheat varieties. In this study, durum wheat varieties in Turkey (Kunduru 1149, Çakmak 79 and Kızıltan 91) grown at different locations (Haymana,. Kazan, Polatlı and Çiçekdağı) have been used. Physical and chemical characteristics and suitability of these varieties for bulgur production have been investigated. The effects of variety and environment on bulgur process were also studied. According to their results, water absorption and pigment content of bulgur have been found to be affected by variety, stickiness and firmness. Total organic matter of bulgur and pilaf quality have been found to be affected by the environment. Also, another research was made by Ercan and Bildik [28] and durum wheat varieties grown in Turkey have been studied for their milling ability and physicochemical characteristics.

Additionally, genetic relationships among 15 durum wheat cultivars of Turkey have been investigated by Zencirci et. al. [29]. Cultivars were close genetic makeup and this has revealed a narrower genetic base in Turkish durum wheat gene pool.

Sometimes, bulgur is produced from oats, corn and triticale instead of wheat. These types of bulgur production and consumption occur at very small amount [19, 30, 31]. Also, in Peru (South America), some cereals are processed like bulgur [19].

1.5. Bulgur Production From Different Raw Materials

1.5.1. Corn Bulgur

Corn bulgur have been investigated by Elgün et al. [30]. In this research, effects of the maturation stage (milk, yellow or ripe) and cooking form (on the cob or shelled) of Narman sweet corn on some selected parameters obtained in the bulgur-making process were studied. Physical and chemical properties of corn bulgur, were also investigated. The results obtained at statistically significant levels

(P less than 0.05) were as follows. During cooking at less than 95 °C for approximately 60 minutes, there was an increase in the dry matter content and color intensity of cooking wastewater. As the grain matured, the amount of material diffused into the cooking wastewater decreased. The yellow stage corn provided the hardest and most vitreous endosperm texture to the bulgur after drying and showed the highest resistance to grinding, whereas the milky stage corn bulgur showed the lowest resistance. On a raw material basis, the yields of pilaf bulgur (greater than 1.5 mm) and total bulgur (greater than 0.5 mm) increased sharply with grain maturation, especially in the ripe stage. In either total or yellow color intensity of the bulgur fractions, the yellow stage corn bulgur showed the highest values with amberlike yellowness and brightness. Increasing in particle size of the bulgur decreased with maturation, but fat content increased. In general, the finer the corn bulgur fraction contained the higher the ash, fiber, protein and fat contents. In conclusion, the best stages were, yellow corn for bulgur color, appearance and functionality; milky corn for nutritional value; and ripe corn for bulgur yield.

1.5.2. Triticale Bulgur

Bulgur at acceptable quality was prepared from 2 commercially available triticale by boiling 10 minutes and cooking for 3 minutes or 10 minutes at 15 lb/in^2 and 120 °C. Moisture contents of 32-41 % were needed to achieve a desirable level of gelatinization of starch. Compared to triticale whole meal, bulgur had almost similar amounts of protein, amino acids and gross energy but lower amounts of crude fat, thiamin, riboflavin, folic acid, Vitamin E, Ca, Fe, Cu, P, Mn, Zn, K, Na and Mg [31].

1.6. Processing and Production of Bulgur

For bulgur production, there are some different production processes over the world. These differences come from technological level of countries, habits of humans, etc. That's why, different types of processing are explained.

1.6.1. Cleaning of Raw Material

First step in production is cleaning. Generally, cleaning steps are nearly the same for all types of processes.

At this step, stem, straw and husk are separated by using the rotary or flat screen and aspirators. Stones, foreign materials and broken kernel are separated by using separators. Then, in washing unit, dust and dirty materials are removed. At industrial scale, to prevent the damage to the outside of kernel, washing is made by centrifuge. Additionally, in this unit light materials can be removed. Free bulk water are removed with separator and moisture content of wheat is increased upto 15% [1, 8, 12].

1.6.2. Traditional Production of Bulgur

As practiced traditionally, the processing of bulgur is deceptively simple. Conversion of the elementary operations of cooking, drying, debranning, cracking and sieving to large scale modern processing required extensive pilot plant study which is starting from traditional process before the automatic, continuous processing operations now used were successful[32]. Also, traditionally, bulgur has been made by boiling or simmering whole wheat in open pots for 1-3 hours, then drying the product in the sun or in simple tunnel dryers. To avoid leaching of soluble nutrients, minimum water is used. The loose outer bran is removed by hand rubbing or in mortars. The dried kernels are cracked and sieved to obtain a coarse, a medium and a fine granulation of product [27, 33].

The ancient method of producing bulgur calls for boiling whole wheat in open vessels until tender. The cooked wheat is spread in thin layers to be dried by the sun. The coarse outer layers of bran are removed and the grain is cracked. Bran is often removed by sprinkling the dried wheat with water and rubbing the moistened grain by hand. Stone or a crude mill is used to crack the now vitreous kernels [3].

1.6.3. Small Batch Type Production of Bulgur

In a small-scale batch operation, the wheat-water mixture is stirred while heating to allow light foreign material to float to the surface for removal. The cooked product is cooled, dried, moistened, peeled (optional), redried, cleaned by

winnowing, milled and sized. Peeling, when done, is to remove the bran. Milling reduces the particle size of the product, after which it can be purified or classified into up to four size-grades: coarse, fine, very fine and flour [8].

Bulgur is produced as follows; cleaned wheat is cooked in cooker for 1.5-2 hours. Amount of water added is very important in small batch type production of bulgur. If the large amount of water is added, loss of nutritional compounds will be occur because of decantation of water at the end of the cooking. If the small amount of water is added, gelatinization will not occur completely. Addition of water is regulated such that remaining water should not be found in cooker.That's why, water is added two times of the volume of wheat generally. This ratio is changed with respect to species of wheat. After cooking, wheat is dried. Drying process is made with vacuum dryer in modern plants[34].

In the another type of batch system, stone, straw, stem, foreign materials are separated by using hand screen. Then 1.5-2 times water is added into kettle then 1-1.5 hours boiled. At the end of cooking all of the water should be absorbed by kernel to prevent nutritional losses. Cooked bulgur is spread over clothes to dry under sun. Then, it is tempered and brans are removed by using the large mortar or wood type mortar and milling process is applied. Milled product is dried again and it is winnowed. Round grind is made into stone miller. Screened product is classified as coarse or fine bulgur [1, 8].

1.6.4. Large Scale, Industrial Type Production of Bulgur

In industry, different types of bulgur production systems are used. These systems are explained individually.

1. In this system, raw materials should be homogeneous and contain lesser amount of foreign materials. Also, type of wheat is very important criteria for processing condition. Steam jacketed screw cooker, belt in water type cooker, screw-silo combination systems and pressure-drum cookers can be used for cooking system [34]. First step is gelatinization of starch in wheat. For that reason, in Turkey and neighboor countries, hard wheat is cooked for 1 hour [35]. All of these systems are based on temperature, time, water absorption and gelatinization of starch. For drying, fluidized bed dryer is advised. The purpose is 45-50% of initial moisture of wheat should be removed and inhibition of caking [34].

According to Ünal [34], wheat is rested for 3-4 hours after drying. Then, peeling, grinding and sieving can be made. Wheat is peeled with mechanical dehuller (miller type) or mortar. Then, wheat is screened to remove bran. Then, 32% of moisture is obtained by addition of water. This process is called as tempering. After that, wheat is grinded then sieved again. Following processes are classification (with respect to their sizes) and packaging [27, 34].

2. In the second type system, washing is essential because the wheat should be throughly cleaned and all broken kernels should be removed .This also provides the first tempering stage after standing for about 4 hours. The wheat is moved through a battery of tanks with successive additions of warm water for 16 to 18 hours. Temperature is raised to 82 °C and moisture content is increased to 40%. Continuing to move, it passes into the pressure cooker where it remains 70 to 90 seconds under 30 pounds of pressure. This procedure insures complete gelatinization of starch without discoloration. Wheat enters a large conveying drum with a counter-flow of heated air. This flash heat removes surface moisture and prevents sticking. Drying must be gradual at comparatively low temperature and preferably with continuous movement or frequent turning. It is desirable to remove a small percentage of the rough outer bran. This is best accomplished by abrasion in some type of hulling or light grinding equipment immediately following a light spray of water. The wheat is then cracked to desired granulations, and the process is completed [3].

3. The third type system was explained by Parlayıcı [22], after dry and wet cleaning, precooking and cooking are made. In precooking step, wheat is soaked into certain amount of water to absorb water. During precooking, ratio of wheat to water is 5/4. 95-100°C of water is mixed with 15-20°C of wheat and wheat is precooked for 15-20 minutes. Then, wheat is transferred into pressure cooker and it is cooked at 130°C for 20-30 minutes under 1.5 atm. At the end of cooking, the amount of moisture is 55% and it is decreased to 45-50% by applying vacuum in the cooker.The control of cooking is made by cutting the kernel. If the amount of white spot in kernel is lower than 1%, is assumed to be completed. Drying is made with tower dryer for 6-8 hours by using hot air at 90°C until moisture of wheat

decreases under 13%. Dried wheat is peeled by mechanical devices. Peeling is arranged by controlling of ash content (below 1.70%). During peeling, cellulose compounds (bran) are removed from surface of wheat. Then peeled wheat is cutted to bulgur size.

4. Another type system have been explained by Smith et. al. [15] and preferred conditions for atmospheric-pressure process is given in Table 1.1. In this system, there are two soaking steps at different temperatures.

Table 1.1. Operation conditions for atmospheric cooking

Operation	Time(minutes)	Temperature (°C)
Soaking 1	30	57.2-68.3
Soaking 2	30	68.3-85
Tempering	30	76.7-85
Cooking	15-20	100
Total	105-110	

In continuous soaking (Soaking 1 and Soaking 2); wheat is soaked in a standard screw-conveyor. Soaking time is controlled by adjusting the rotation rate of the screw. Retention time is determined by timing the passage of dyed wheat kernels through the unit at steady-state operation and in continuous tempering; drained soaked wheat is tempered by holding it hot for various periods. to allow moisture concentrated in surface portions to diffuse into the kernels [15].

In continuous cooking; hot wheat from the tempering operation is cooked in steam at 100°C on wire-cloth trays in a small belt-type cooker. Completion of cooking is judged by making "white center counts". Drying; the cooked wheat is loaded onto wire-cloth trays and dried to near 10% moisture in a cabinet dryer, with air entering through the bottom of the tray and following up through the bed of wheat [15]. During peeling of bran, generally 7% of weight of dried wheat is decreased [36. 37].

5. In one method for the production of bulgur, pressure cooking is used at different soaking temperatures, which is described by Schafer [38]. Cleaned white or red soft wheat, preferably decorticated, is cooked by a multistage process in which the moisture content is gradually increased by spraying with water and temperature gradually raised. Eventually, when the moisture content is 40%, the

wheat is heated to 94 °C and then steamed for 1.5 minutes at 30 lb/in^2 (206.85 kN/m^2) pressure so that the cooked product is gummy and starchy. The starch is partially gelatinized. Wheat is dried and pearled (or cracked) finally.

6. In continuous system, straws, stems, stone, foreign matters and broken kernels are removed by mechanical sieve. Then, vertical washer machine is used for cleaning by using sprayed water and centrifugal force to remove excess water from kernel. Soaking is made to swell starch. After that, it is cooked by steam. Steam cooking time depends on steam temperature and pressure. At atmospheric pressure, cooking time with steam is 15-20 minutes. [15]. Cooked wheat is dried with dry air. After drying, wheat is resting in silos for 3-4 hours. Then, wheat is passed through emery machine or wear type miller to remove bran. This wheat is grinded then classified as pilaf, raw meat ball and animal feed [1, 8].

7. Another type simple, low-cost continuous process has been developed for making bulgur from either hard red winter or white club wheats. The process employs readily available, non-pressurized equipment that can be sized to use in plants of large or small capacity. The conventional procedure of making bulgur is, essentially, as follows; cleaned wheat is soaked in water, cooked to gelatinize the starch, dried, and partially debranned [15]. Similar modern processes for making bulgur are reviewed by Shetty and Amla [39] and Kent [10].

1.6.5. Some Different Type Processes in Different Countries

Bulgur production methods currently in use in the United States range from those similar to traditional batch procedures of the Near East to those making use of continuous pressure cookers. The former are used by small plants producing largely for limited local distribution. A modern, large-scale, and continuous version of the traditional open-pot method was developed [15]. Pressure used for cooking wheat for bulgur may be either quite low in batch operations or relatively high in continuous operations [7].

Different processes have been used for commercial production of bulgur in the United States: [15]

1. First one is the traditional batch method of soaking and cooking in externally fired open kettles. Cleaned size-graded wheat is used as starting

material, and the total time for soaking and cooking is about 1 hour. The cooked wheat contains about 50% moisture. It is dried to near 10% moisture in a rotary dryer or on screen trays in the sun. Dried product is partially debranned in an abrasive-type mill and cracked in a burr mill.

2. Another process involves soaking and pressure cooking of cleaned wheat in a batch-type rotary unit. The combined soaking and cooking time is about 2 hours. Cooked product is dried in a column-type grain dryer.

3. A continuous fully-mechanized process was developed and patented a few years ago and used for large-scale production. The wheat is progressively heated and soaked to about 45% moisture as it moves through three large tanks connected in series. Total soaking time is about 8 hours. The soaked grain is cooked in steam for about 1.5 minutes in a continuous pressurized cooker. Cooked wheat is passed through a small rotary dryer to remove surface moisture and then through column-type grain dryers to complete drying to 10-11% moisture.

4. In the U.S.A. , soft wheat is soaked until moisture content reaches to 40% (4-5 hours) then it is cooked at 12 atm for 1.5 minutes or at 4.8 atm for 10 minutes by using steam. Drying process is made below 60 °C into hot room [11]. Before 10 minutes of tempering, 3% of water is absorbed into dried wheat [3, 37].

Traditionally in Lebanon and Syria, bulgur is prepared as follows; the wheat is washed and conditioned, cooked in boiling water in open containers for 5-6 hours, drained, and air-dried. After the treatment, the wheat is crushed in a stone mortar with a wooden pestle to separate the bran. Before use, the dry bulgur is cooked in water or with steam for 15-20 minutes. [25].

The common method of making bulgur in the Middle East, whether it is small or large scale operation, is to soak the cleaned wheat and cook it to gelatinize the starch [23].

1.6.6. New Technology

Cleaning, soaking, cooking, drying, sieving, peeling, grinding, packaging and storage are used in new technology respectively. Cleaning is made by using the aspirator installed sieving machine. This stage removes dust, soil and foreign materials. Cleaning step is finished with washing. Then soaking is applied to wheat

until 40% of water is absorbed by the kernel for complete gelatinization of starch during cooking. The partially gelatinized starch adheres to the nitrogenous compound and it is not disturbed. During the cooking process, the determination of water content in the cooker is very difficult. So, wheat is soaked at 60 °C for 4 hours generally. Cooking is made in the pressure cooker for a short time. If there is no any white spot in the endosperm, cooking is finished. The cooked bulgur is dried in the tunnel dryer with the ventilation of hot air at 60°C until the moisture content decreases to 10-12%. If the temperature of air increases, color of wheat will be darken. Sieve is used for sorting of wheat according to their sizes. Wheat bran can be peeled easily which is made by using of Konoz (technical terms in Turkish language of this machine). During peeling, aleurone and endocarp layers should not be damaged. Because, aleurone layer is guard for endosperm. The peeled wheat is grinded with rollers miller. The processed bulgur is packaged into bag or sack and then stored [27].

In another type of new technology is; the clean wheat is soaked, tempered, and cooked in simple conveyor units. Soaking involves immersion of wheat in water for 60 minutes with temperature progressively increasing. The soaked grain is then drained and held hot for 30 minutes in another conveyor to promote equalization of moisture. This grain is fed to a wire-mesh conveyor belt on which it is cooked in steam at atmospheric pressure for 15-20 minutes. The cooked grain is dried, partially debranned, and cracked by conventional means. Bulgur has been a staple food for centuries in Near Eastern countries, but it has only recently been produced in large quantities in the United States by this type new technology [15].

1.6.7. Some Processing Parameters and Important points

During the bulgur production thermal conductivities of bulgur were given by Demir et al. [40] in Table 1.2. In this search thermal conductivity is explained with respect to moisture of bulgur.

$$k(W/mK)=0.1250+0.0033 \times (\text{moisture content \% at w.b.})$$

Table 1.2. Thermal Conductivity of Bulgur During Cooking Period.

Product-Process	Moisture Content (%)	k (W/mK)	Standard Deviation	Density (kg/m^3)
Wheat	9.50	0.164	0.00164	858
	10.85	0.172	0.00122	904
Soaking	12.85	0.180	0.00122	804
Cooking	55.00	0.318	0.00353	708
Drying	27.75	0.256	0.00147	659
	25.30	0.219	0.00148	665
	22.30	0.189	0.00192	675
	17.65	0.185	0.00043	717
	10.90	0.171	0.00122	770
	8.84	0.154	0.00111	736
	6.90	0.129	0.00071	772

Some other physical properties of bulgur during processing are shown in Table 1.3. [1]

Table 1.3. Physical Properties of Bulgur During Processing

	Moisture content (%) (w.b.)	Hectoliter	Density (g/cm^3)
Clean wheat	10	81.3	1.355
Washed wheat	15	65.8	1.165
Cooked wheat	51	68.5	1.062
Dried wheat	11	71.6	1.300

Industrially produced bulgur carries some problems, these are insufficient amount of homogeneous raw material, unsuitable technology and high cost of energy [8].

According to Ünal [34], disruption of wheat is advised during cooking. But, this is wrong because, disrupted wheat will collapse and nutritional compounds will be lost during process. When dispersion occurs, starch will leach out of kernel. Another factor to the dispersion, damage to kernel surface during washing. To prevent dispersion, arrangement of revolution and palettes of centrifuge should be made[8]. Also, during cooking and grinding, testa, periperm and aleuren layers are not separated. However, some parts of endocarp are peeled. As yield, 4% of bran and 4% of small bulgur are produced from 100 kg of wheat during bulgur production during these stages [11]. Additionally, production yield of cutting machine is more than grinding machines [1]. So, this type machine should

be used in factories. The product is sometimes used in whole kernel form, but is usually coarsely cracked, screened to remove very fine particles, and bagged for distribution. Soaking conditions must be controlled to obtain penetration of sufficient water into the kernel to allow gelatinization of the starch during cooking. Soaking and cooking conditions that minimize bursting of kernels and exudation of starch are required or the grain becomes too sticky for subsequent processing. Excessive darkening of the grain, development of undesirable flavors, and material loss of nutrients must also be avoided [15].

1.7. Cooking

The main requirement during cooking, moisture content should be larger than 40%. If the moisture content of kernel is less than this limit, white spots will occur in the kernel. This white spot shows the ungelatinized starch. The gelatinization of wheat starch start at 67.5°C. During gelatinization, shape of the wheat starch does not change but it swells [1, 8]. During cooking, temperature should be below 95°C to prevent denaturation of the nutritional compounds [1, 8, 11].

The basic objective when cooking cereals is to convert their starch content to a digestible form by gelatinization. However, commercial cooking processes purue additional aims: to change the cereal's properties, e.g. as in the case of parboiled rice or bulgur; to prepare the cereal for further processing, e.g. corn flakes or rice crispies; and to shorten subsequent preparation stages, e.g. for "instant groats" or "1 minute rice" in each case with only partial gelatinization of the starch and with minimum changes to product texture and consistency [41].

Cooking conditions must be selected to give complete gelatinization without darkening the product or making it so sticky as to interfere with subsequent drying. Conditions for the precook treatment and for the drying must be selected carefully to balance the costs of these treatment with the quality characteristics of the product [9].

Cooking equipment varies from atmospheric batch kettles to continuous pressure cookers [3]. In some factory, screw conveyer cooking system is applied. In batch system, 1.5-2 times water of wheat is added into kettle then 1-1.5 hours

boiled. At the end of cooking all of the water should be absorbed by kernel to prevent nutritional losses [1].

Industrially, water addition and cooking processes are made simultaneously with designed steam jacket helezonic conveyor. At each helezon temperature and water content are different. Helezons have slope. This slope supplies that, at half of helezon, wheat will be immersed into water and at other half part, will not be immersed into water during conveying [1, 8]. This design supplies that, wheat absorbs water during immersion, then at the other part; water will diffuse into wheat homogeneously. Temperature is 80 °C and 95 °C respectively in first and second conveyors [1, 8]. Temperatures are controlled by thermocouples and check valves. Addition of water is important for nutritional content. If water content is high, solubilized vitamin B will be decanted at the end of the cooking [1]. At Maktas Co., this process is used and capacity is 5 tones/day [1, 8]. At sufficient water addition, solubilized vitamin B will be diffused into kernel. That's why, nutritional value and color quality will be high. In addition, energy recovery will be increased. Total retention time in the helezons are 72 minutes [1].

Pressure parboiling technique developed for paddy is used for producing bulgur wheat. Wheat is cleaned by circulating water, steamed at 12.5 kg/cm^2 for 10 minutes in a specially developed vessel, then open steamed for 10-15 minutes with a constant pressure of 1.4 kg/cm^2 for 20-25 minutes. The wheat is then dried to 12.5-14.0% moisture, polished with 5% rice husk in a rice huller and milled. Maximum time for producing bulgur is 55-60 minutes. The bulgur wheat contained 10.70-13.60% moisture, 1.23-1.90% crude fiber and 11.62-12.52 % protein. A recently developed pressure parboiling process involves soaking paddy in water for a few minutes, followed by steamed at atmospheric pressure for 10-15 minutes and at 25 lb/in^2 (gauge) for 5 minutes. The process, which possesses several advantages in terms of operating costs and times and product quality, is becoming increasingly popular in India. Brief mention is also made of a pressure parboiling system for use in rural areas; such a system may be used for freshly harvested paddy and does not require a boiler. Pressure parboiling may also be successfully applied to bulgur wheat [42, 43].

In small batch system, cooking step is made in tank, firstly. Wheat absorbs water then gelatinizes. In this system labor and energy cost are high. But investment cost is less [8].

1.8. Drying

Drying is another the most important step in bulgur production. Successful drying is practiced varying from simple tunnel dryers to huge dryers [3]. Cooked bulgur is dried in tunnel dryer with ventilation of hot air at 60 °C until 10-12% of moisture [27]. For industrial drying, fluidized bed dryer and a cascade tower are used satisfactorily[44].

A fluidized bed dryer system is explained by Çömden [1]. In this system; moisture content of kernel is 52% after cooking which is decreased with fluidized bed dryer by using 80 °C of hot air. The shape of fluidized bed dryer is perpendicular with 4 sections. Three sections are used for drying and one is for cooling. Pressure drop is changed at each section because of moisture differences. Cooling section is used for decreasing the kernel temperature to 30-40°C at the end of drying. Because, if the hot kernel is stored in silos, kernel sticks to each other. Some part of used hot air is recycled in drying. Density of dried wheat is higher than cooked wheat because of shrinkage of wheat during drying. That's why, fluidized bed dryer is not suitable for drying. Yield of fluidized bed dryer at first section for mass transfer, is higher than second and third sections. That's why, for efficient heat transfer, fluidized bed dryer can be used until hardness of wheat surface increases. Then, belt type dryer may be used. Also, high ventilator force is needed, so consumption of electricity will be high because of high pressure drop in fluidized bed dryer. Also, tower dryer can be used to dry bulgur instead of this system [37].

With sun drying, vitamin B loss will be high [1]. Loss of riboflavin is 28% and 64% with dryer and sun drying respectively [35]. According to literature, industrially, drying can be made by fluidized bed, rotary dryer, sun drying, tower and tunnel.

1.9. Nutritional Importance of Bulgur

Some nutritional values were given by Baysal [45] in Table 1.4.

Table 1.4. Composition and Nutritional Value of Some Cereals

Cereals for 100 g	Calorie kcal	Carbo hydrate g	Protein g	Lipid g	Ca mg	Fe mg	Vit. A I.U.	Vit. B1 mg	Vit. B2 mg	Niacin mg	Vit. C mg
Wheat	354	69.3	11.5	2.2	36	3.1	0	0.57	0.12	4.3	0
Corn	351	72.0	9.4	4.2	9	2.5	200	0.43	0.10	1.9	0
Bulgur	350	69.8	12.5	1.5	40	3.5	0	0.40	0.04	4.3	0
Bread	247	53.1	7.2	1.1	20	1.3	-	0.25	0.06	2.1	0
Macaroni	367	76.3	11.0	1.1	16	1.0	0	0.13	0.04	1.1	0
Tarhana	329	58.8	14.4	3.9	78	1.8	-	-	0.07	4.1	0
Biscuit	341	-	8.1	10.5	217	0.5	-	-	0.08	0.4	0
Rice (w/o bran)	359	78.0	7.1	1.1	14	1.0	0	0.16	0.04	2.5	0
Rice (w/ bran)	360	68.9	9.7	1.9	50	4.0	15	0.38	0.20	7.2	0
Wheat flour (yield 85%)	350	74.3	11.7	1.5	24	2.4	0	0.32	0.07	1.7	0
Wheat flour (yield 72%)	364	75.5	10.9	1.5	16	1.0	0	0.13	0.04	4.3	0

Cereal grains are the major source of both protein and calories in the world. In this regard, bulgur is an ancient wheat food of Near Eastern origin. USDA engineers in the Agricultural Research Service have developed it as part of a national effort to increase the use of wheat domestically and in foreign lands under the Foods for Peace Program.

Intestinal activity and digestion system is stimulated by bulgur with its dietary fiber content. Vitamin B and Vitamin E are the most wellknown vitamins that found in wheat. These vitamins also found in other foods. But, in wheat; starch and thiamine act a big role in carbohydrate metabolism [29]. Nutritionally, complex carbohydrates are preferred instead of simple carbohydrates. Vitamin B's and cellulose materials are rich in bulgur. Additionally, people in developed countries prefer natural foods. Since, bulgur is a natural food product that's why, traditional and nutritional importance of bulgur increases [1, 11]. If the water supply limited, a high protein food is contraindicated in order to minimize renal activity. The proximate protein content of bulgur is relatively low 11.2%; presweeted bulgur with sugar is even lower 8.1% [46].

Some researches are studied on the nutritional value of modern produced bulgur and wheat. Their nutritional values are nearly same [7]. But according to some researchers, there are some nutritional losses during processing. For example, during cooking, proteins are denaturated because of the effect of temperature and starch is gelatinized and birefringence property of starch is lost. That's why, after drying, kernel is hard and translucent. This texture supply high resistance characteristic to bulgur. During, bulgur production, properties of protein is changed but there is no big loss in protein content [6, 47]. Also, during cooking period, electrophoretic properties of proteins change. For instance, relative color intensity of some protein band decreases, additionally, fast mobile protein band is losts. Nutritionally, raw cellulose is decreased to half of its original value after peeling operation [47].

Physiological differences between bulgur and wheat flour occurs because of remove of epidermis and epicarp layers from bulgur and adhering of aleurein layer over particle. During milling of wheat, this layer is separated together with bran [1, 11].

Saraçoğlu [48] has found 8.9-42.4% loss of thiamin. Additionally, by Shammas and Adolph [33], loss of niacin is found to be low but losses of thiamin and riboflavin are 38% and 73% respectively. When cooking time is increased, the loss of thiamin increases especially, but riboflavin losses were insignificant [49]. But, when autoclave is used, the loss of thiamin is higher than other cooking procedure [14].

The transfer of nutrients from bran and aleurone structures to endosperm during parboiling of cereals is well known. Opportunity for loss of nutrients during conditioning and initial cooking of wheat is not great, and bran removal from the dried, cooked wheat is only partial. A comparison of some of the nutrients in bulgur and in the type of wheat from which it was made shown in Table 1.5.[7].

Table 1.5 :Composition and Nutritional Value of Bulgur and Various Cereal Grains

Cereals (for 100 g)	Cal. cal.	Protein g	Fat g	Carbo hydrate Total g	Fiber g	Ash g	Ca mg	P mg	Fe mg	Vit.B1 mg	Vit.B2 mg	Niacin mg
Bulgur	362	8.5	1.2	78.2	1.3	1.3	64	267	2.8	0.35	0.10	3.0
White wheat	335	8.4	2.0	76.4	1.9	1.7	36	394	3.0	0.53	0.12	5.3
Milled White rice	362	7.6	0.3	79.4	0.2	0.4	24	136	0.8	0.07	0.03	1.6
Pearled Barley	349	8.2	1.0	78.8	0.5	0.9	16	189	2.0	0.12	0.08	3.1
Whole Ground Corn Meal	355	9.2	3.9	73.7	1.6	1.2	10	256	2.4	0.38	0.11	2.0

The differences in fat, fiber and ash are significant but moderate. The values for these factors in the bulgur are sufficiently larger than those normally found in flour or wheat endosperm to indicate that a fairly large part of the bran nutrients is retained in bulgur. The finished bulgur contains about two third as much thiamin, niacin and phosphorus as the wheat. Iron and riboflavin are retained well, more than 80% of the amounts found in wheat. Sun drying of bulgur, however, would be expected to cause lower values for riboflavin. The substantially higher amount of calcium in bulgur probably stems from the inward transfer of nutrients during parboiling and could be significantly influenced by the mineral composition of the water used for parboiling. Nutritionally, the wheat products are somewhat superior to the other cereals shown in this table [1].

Thiamin losses, related to successive steps in processing, are reported in Table 1.6. Washing is the only stage in which excess water is used and discarded. Moisture is increased to approximately 40% in three conditioning stages. During this time, 18 hours, the temperature is gradually raised to about 82.2 ^{o}C. The wheat passes through the pressure cooker in 70 to 90 seconds and is then slowly dried at relatively low temperatures. Thiamin losses are surprisingly low. High readings for pearlings, which are mostly bran, and low values for endosperm fines, incident to cracking, appear to balance each other without greatly affecting the finished bulgur [7].

Current commercial processing methods for converting wheat to bulgur cause losses, in varying degree, of soluble and heat labile nutrients as a results of application of moisture and heat, partial debranning, grinding and sieving. In laboratory tests of 5-8 samples of bulgur, losses of thiamin averaged, 15%;

riboflavin, 12 %; niacin, 7 %; folic acid, 25%; pantothenic acid, 24%; and vitamin B_6, 2%. Losses were essentially the same in atmospheric and pressure cooking of the pre-soaked wheat. Removal of part of the outer bran from cooked and dried wheats and subsequent cracking and size-grading led to 15-25% decrease in crude fiber, but losses were less in total ash, ether extract, iron, calcium and phosphorus. Values for iron and calcium were occasionally greater in bulgur than in the wheat, presumably because of pick-up from processing waters and vessels. Phosphorus values generally decreased slightly during processing. Exposure of whole-kernel bulgur to high-velocity hot air to create a crisp, expanded structure suitable for quick-cooking products caused additional losses of approximately 53% for thiamin, 12% for pantothenic acid, and 19% for Vitamin B_6 (60,33% and 19% on the basis of the starting wheat). Losses for the other B-vitamins studied were less than 10%. Partially, debranned raw wheat canned under vacuum at 55% moisture and retorted for sterilization, lost 72% of its original thiamin and 30% of its riboflavin. Steaming of moistened dry bulgur to prepare it for table use caused negligible loss of thiamin and approximately 10 % loss of riboflavin. Additional detailed informations are given by Özkaya et al.[6].

Table 1.6. Loss in Thiamin Due to processing

Product	**Processing stage**	**Thiamin (mg/lb)**
Wheat, soft and white	to washer	2.08
Wheat	to conditioner	1.66
Wheat	from conditioner	1.63
Wheat	from cooker	1.50
Wheat	from dryer	1.56
Pearled wheat	from pearler	1.40
Pearlings	from pearler	2.92
Fines	from cracker	1.12
Bulgur-ala	from packer	1.44

Production of bulgur is the application of parboiling operation to wheat, preferably hard varieties. During this process, the wheat starch is gelatinized and the kernel is more cooked. Absorption of 60-100 g water per 100 g wheat takes place [8], and as this water diffuses through the hull and the bran, most of the water soluble nutrients in these parts of the kernel are transported into the endosperm.

Therefore the nutritive value of bulgur is very little less than that of whole wheat and better in many ways than that of rice-bulgur contains roughly 1.5 times as much protein, 2 times as much each of thiamin, riboflavin and niacin compared to rice [1, 8, 44]. All nutritional compounds in bulgur is richer than rice except carbohydrate. Additional properties which increases the importance of bulgur are longer shelf life, easy cooking, price [1]. Composition of wheat is changed with respect to place, conditions, climate etc. [50].

According to some researchers [9, 37, 51] protein content, fat, carbohydrate, cellulose and vitamin B_1 are found as 13.4-12.4%, 1.74-1.96%, 61.9-64.8%, 1.47-1.89% and 0.30-0.190 mg respectively.

During bulgur production, bran and flour of bulgur are separated that's why, Vitamin B and mineral content are decreased. According to Pence et. al. [7], amounts of Fe and Ca of bulgur are higher than original wheat, but amount of P of bulgur is nearly same with original wheat. But, according to Özkaya and Kahveci [52], Mn, Zn and P contents of bulgur are lower than wheat.

Additionally, mineral losses occur during removing of bran and bulgur flour. Namely, boiling and drying do not effect the mineral content [6].

According to Saraçoğlu and İbiş [35], 32.7% of thiamin, 30% of riboflavin and 15.6% niacin loss occur during bulgur production from wheat. During bulgur production, vitamins on the outer layer of wheat should be diffused into wheat during cooking also aleoren layer should not be damaged [1, 34]. Amount of Vitamin B is changed in bulgur with respect to type of applied processing. Also loss of thiamin of various type wheats are given by Saraçoğlu and İbiş [35] during processing. Effect of processing on nutritional value of wheat is explained by Çömden [1] and Tahsin [11]. According to Tahsin [11], vitamin B_1 losses by 13%. Hectoliter decreases additionally, farinograph and extensograph values change; but, not big change occurs for nitrogenous compounds.

During boiling of bulgur, vitamins and nutritional compounds diffuse into kernel. So, nutritional value of bulgur increases. From these properties we can say that bulgur is highly nutritional, cheap, easily maintained and easily storable food material [1, 11, 36].

The loss of riboflavin are 28% and 68% with dryer and sun dryer respectively. Small amount of vitamin is lost during drying, but loss of riboflavin is high during sun drying [33, 35, 52]. According to Özkaya et. al. [6]; during drying and cooking processes, ash content of the wheat is not changed, but, ash content of bulgur is lower than wheat because of remove of bran. Protein content is not also changed during bulgur processing. A little losses of thiamin and riboflavin occur during removing of bran and bulgur flour from boiled and dried wheat [1].

Shammas and Adolph [33] found that approximately 38% of the thiamine and 73 % of the riboflavin were lost during traditional production of bulgur. The large loss of riboflavin was attributed to sun-drying. In more intensive studies with bulgurs made by traditional methods, Saraçoğlu [48] found that loss of thiamin for 28 Turkish wheats average 27.3% (range 8.9-42.4 %). The boiling step accounted for nearly all of the loss of thiamine. Sabry and Tannous [49] later showed that thiamine losses increased steadily with time of boiling, but that riboflavin was affected only slightly. Niacin, however, increased slightly as boiling time was lengthened. presumably because of increased transfer from bran tissues to endosperm. Wheat boiled 1 hour lost roughly 20% of its thiamine and riboflavin. Sun-drying, however, increased the riboflavin loss to 76%. Haley and Pence [3] indicated that washed wheat loses slightly more than 13% of its thiamine when made into bulgur by a modern process using pressure cooking. The washing step to clean the original wheat, however, removed nearly 20% of the thiamine before the subsequent processing was applied. Results obtained in the Pence et al. [7] suggest that modern processing methods can minimize losses of B-vitamins and minerals in converting wheat to bulgur and indicate that commercial bulgurs provide good food sources of these vitamins and the major mineral nutrients of whole wheat.

Recently, bulgur was examined by Mathew and Pellett [53]. In this research, in order to evaluate the actual protein value of some recommended weaning food mixtures, a series of biological determinations of protein quality have been completed on fourteen different home made weaning mixtures. The individual foods were cooked, dried and then mixed in recommended proportions resembling the original meals.

There are few systematized storage studies available which relate sensory testing with storage life to this product. The aim of this study, sponsored by the Defense Civil Preparedness Agency, was to perform this task using as products a 100% bulgur wheat cereal and an 85% bulgur, 15% soy grits, defatted, toasted blend. These were air and nitrogen packaged in 401x411 cans, stored for 0, 1, 3, 6, 9, 12, 18 and 24 months at 38 °C, withdrawn, and evaluated at these designated times. Studies indicate that these products are very stable, even when stored in air packs. In a presoaked, uncooked bulgur cereal served at 21 °C sweetening with a minimum of 6% sugar raised its acceptance significantly to a more desirable level, nearly comparable to its cooked counterpart. Other product data are discussed including a low cost presweetened bulgur wheat product formulation [54].

To enrichment of bulgur, beer malt can be used [35], additionally nutritional fortification are explained by another researchers [55, 56, 57].

1.10. Aims of Study

Bulgur is a critical food material for Turkish people because of its economical and nutritional value. In Turkey, the number of bulgur plants are nearly 500 and 856.000 tones of bulgur were produced in 1989. Seventeen thousand tones of bulgur were exported in the same year. Additionally, bulgur is consumed as 12 kg per person.

In home and small plants, bulgur is cooked with atmospheric cooking and drying is made over clothes under sun. But, there is no feasible cooking and drying operation yet which used in factories and there are some problems in used cooking and drying operations during bulgur production [17, 18, 58]. Contamination of aflatoxin is one of the most critical problem during sun drying because of enviromental condition effect [59, 60, 61].

In this bulgur processing study, effort was concentrated on the soaking, cooking and drying steps because the remaining steps are efficiently completed by conventional means. The new process resulting from this work is essentially a modernization and mechanization of the traditional open-kettle method and drying operation under sun. It presents a means of producing bulgur at reduced cost, since it avoids use of prolonged soaking, cooking and drying, and manually performed

batch operations. For that reasons, atmospheric and pressure cooking, soaking and five different drying operations were performed to solve cooking and drying problems and to help the next new researches.

CHAPTER II

MATERIALS AND METHODS

2.1. Materials

2.1.1. Wheat

Wheat was received from Gaziantep Bulgur Producers which was Triticum Durum Cultivar. Moisture content of wheat was 9.13% (w/w wet basis).

2.1.2. Reagents

To measure percent starch which leaches into cooking and soaking water, HCl (Merck, Germany) and Phosphore-Wolfram acid "Phosphotungstic acid, $2H_3PO_4.24WO_3.nH_2O$" (Carlo Erba, Italy) were used.

2.1.3. Instrumentations

Soaker/cooker was manufactured in Gaziantep. Soaking and cooking were made in a special design of soaker/cooker (Figure 2.1). In this instrument, temperature, pressure and rotational speed of mixer could be controlled. Heat was supplied with electricity by using resistance which was installed into jacket of soaker/cooker. Cooling coils were used to prevent over heating by circulation of water. In soaker/cooker, a mixer was installed to obtain homogeneous system.

Pressure cooker (Armfield Ltd. Portable Ref no:7777, England) was used for pressure cooking. Also, Fluidized Bed Dryer (Gateshead Sherwood Sci Co., MK II, England), Tray Dryer (Armfield Ltd., UOP 8-A, England), Conductional Dryer (OHAUS, MB200, England), Infrared Dryer (Sartorius, Thermocontrol YTC 01L, Germany) and Microwave Dryer (Arçelik, ARMD 580, Turkey) were used for drying. During drying operation, anemometer (Airflow Inst., LCA6000, England) was used to measure flow rate and velocity of air. Relative humidity, dry bulb and dew-point temperature was measured with Digital thermometer (Testo Limited, Testo 610, Germany).

Color of wheat was measured with Lovibond Tintometer (The Tintometer Ltd., E4260, England).

Polarimeter (Carl-Zeiss Jena, Dr 21949, Germany) was used in Ewers's method. Micrometer(Mutitoyo, No=505-633, Japan) was used for measuring of dimensions.

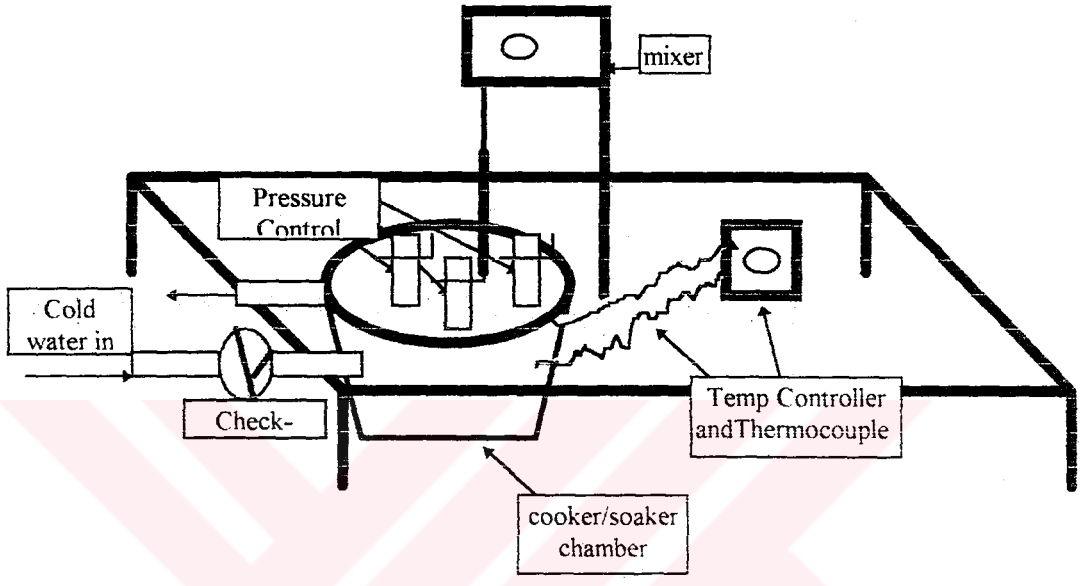

Figure 2.1. Figure of cooker/soaker

2.1.4. Statistical Operations

All of the experimental data were examined statistically at α=0.05 by using the ANOVA and Multiple Range Analysis.

2.2. Methods

2.2.1. Measurement of Dimension, Weight, Volume and Density of wheat

Grain kernel shapes were simulated to ellipsoids to obtain their dimensions and the three axes were measured as a, b and c by using a micrometer. In Figure 2.2., the shape and abbreviations of grain dimensions were given.

Before soaking and cooking, some wheats were selected and marked, then their weights and dimensions (length and two widths) were noted. Measurement of weight of each wheat kernel was made with an analytical balance.

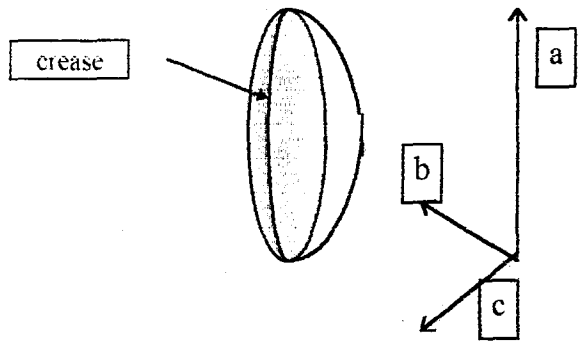

Figure 2.2. Simulated ellipsoid shape of wheat

During cooking and soaking, one of the marked wheats were taken at 10 minutes interval and their weights and dimensions were measured. Dimensions of wheat were used to calculate volume of grains by using Equation 2.1. To find the density of one kernel, weight of kernel was divided to its volume.

$$V=(\pi.a.b.c)/6 \qquad (2.1)$$

These measurements were made only for soaking and cooking. It was impossible for drying, especially for fluidized bed dryer.

2.2.2. Determination of Moisture Content

Moisture determinations were carried out with 3-4 g of sample which was dried in a oven at 105 °C until reached the constant weight (3-5 hours).

2.2.3 Determination of Gelatinization of Starch

Determination of gelatinization of starch was based on essentially the procedure used by Smith et. al. [15] and Singh et. al. [31] where 100 dried cooked kernels were cut with a razor blade and the endosperms examined for opaque white centers. The gelatinized endosperm was essentially translucent but the ungelatinized starch appears as central white spots. The number of kernels

containing white centers was designated as the "white center count" with percentage. Uniform gelatinization of starch throughout the kernel endosperm was required.

2.2.4. Measurement of Color

Color of wheat was measured with Lovibond Tintometer. Color was determined with respect to yellow, red and blue scales.

2.2.4.1. Measurement of Color for Soaking and Cooking

To prevent color differences with respect to wheat differences during sample collection, at the start of the soaking and cooking, certain amount of sample was installed into cell of tintometer. Back cover of cell was replaced with tulle for water diffusion easily. At 10 minutes intervals, this cell was taken and introduced to cell holder of the Lovibond Tintometer. Then, color was measured. After that, cell was immediately put into soaker/cooker again.

2.2.4.2. Measurement of Color for Drying

At the start and end of drying process, color of selected wheats were measured by using tintometer.

2.2.5. Determination of Starch in Soaking and Cooking Water (Ewers's method)

In this method, starch was hydrolysed with HCL then amount of starch was measured with polarimeter. At 10 minutes intervals, during cooking and soaking processes, 10 mL of water was taken and stored into refrigerator until starch content was measured.

1.25 g of sample were treated with 12.5 mL of 1% HCL in a 25 mL flask and shaked. The mixture was kept for 15 minutes in water bath at 95-100 °C. During heating period, mixture was shaken continuously. Then, 7.5 mL of distilled water was added and cooled to the room temperature. In order to obtain a precipitate of free nitrogenous matter, 2.5 mL of 4% phosphore-wolfram acid was added and solution was diluted to 25 mL. After filtering, the filtrate was poured into 2 dm of polarization tube and polarization value was determined by using the polarimeter. Percent starch was calculated by using the following formula, [62]

$$\%Starch=[(V_{TS}*a_p)/(\alpha^{20}{}_D * L_p * W_s]*100 \quad (2.2)$$

where:

V_{TS} :Total volume of sample, mL

a_p : Polarization value

L_p : Length of polarization tube, dm

$\alpha^{20}{}_D$: Conversion factor (specific rotation) of Ewers's method for starch [182.7 /(dm x g/mL)]

W_s :Weight of sample, g

2.2.6. Dry Cleaning

Dust, foreign materials, broken and small kernels were seperated by using 3.2 mm sieve.

2.2.7. Wet Cleaning

To remove adhesive type materials and to obtain clean raw material, wheats were washed in water by mixing with bagette for 1 minute.

2.2.8. Cooking

Two types of cooking processes were used in this study. These were atmospheric and pressure cooking. The atmospheric cooking was made in specially designed cooker which was explained previously. The pressure cooking was made by using Armfield Pressure Cooker.

2.2.8.1. Atmospheric Cooking

Before cooking, a definite quantity of wheat was numerically marked. Dimensions and weights of these kernels were determined to observe change of dimensions. volumes, weights and densities of grains during cooking. 500 mL of water (at about 20 °C) and 200 g of cleaned wheat were mixed into the cooker chamber. For cooking initially cold water was used because of good effect on quality of bulgur [5]. Additionally, certain amounts of wheat were installed into Tintometer cell and the initial color was measured. Then, this cell with wheat was also put into the cooker. Atmospheric cooking was made at 87, 92 and 97°C. Temperature of cooker was set to applied temperature with thermocouple. When

temperature reached to the setting temperature, samples were taken at 10 minutes intervals from chamber. At every sampling wheat grains, cooking water, tintometer's cell and marked wheat kernel were taken. The wheat grains were used to determine the percent moisture content and gelatinization ratio. The cooking water was used to measure starch extraction. Marked wheats were used to determine change in dimension, volume, weight and density. Change in color was measured with prepared tintometer cell which was put back into the cooker immediately after each measurements.

2.2.8.2. Pressure Cooking

2.2.8.2.1. Soaking

Before pressure cooking, wheat was soaked at 40, 50, 60, 70 and 80 °C. Wheat was added into the soaker at these temperatures and waited for 1 hour. During the soaking, wheat grains, soaking water, tintometer's cell and marked wheat kernel were taken at 10 minutes intervals. The wheat grains were used for measurement of moisture content. The soaking water was used to determine starch content. Tintometer cell was used to measure color of wheat. Marked wheat kernel was also used to determine dimension, volume, weight and density of grain. After optimization, temperature and time were selected and pressure cooking was continued with this soaking parameter.

2.2.8.2.2. Pressure Cooking

Pressure cooking was made at 10, 15 and 18 psig for 2, 4 and 6 minutes. During pressure cooking, wheat was not contacted with water to prevent increasing of moisture content which was important for bulgur production to supply quality and economy. At the start of pressure cooking, color of wheat (firstly, wheat was introduced into cell of tintometer), dimensions of marked wheat were measured. Tintometer cell and marked wheats were introduced into the pressure cooker. After 2, 4 and 6 minutes at 10, 15 and 18 psig; color, gelatinization, moisture content, density, dimensions, volume, weight of grains were measured.

2.2.9. Drying of Cooked Wheat

Drying of cooked wheat was made by using different type dryers. These drying systems were explained below.

2.2.9.1. Fluidized Bed Drying of Cooked Wheat

500 g of cooked wheat was installed into column of fluidized bed dryer. Drying was made at 70, 80 and 90 °C at 22.71 mL/s of volumetric flow rate (2.75 m/s of air velocity) until wheat reaches the constant weight. Optimum fluidization velocity was determined with trial and error [63].

From the start of drying process, column of fluidized bed was weighed which was made for first 10 minutes at 1 minute intervals, for second 10 minutes at 2 minutes intervals and until reaches the constant weight at 5 minutes intervals.

2.2.9.2. Tray Drying of Cooked Wheat

500 g of cooked wheat was installed into two trays of dryer. Drying was made at 70, 80 and 90 °C and at 0.5 m/s of air velocity. Dimension of tray was 18.5X27.5 cm and two trays were used. Depth of sample was 0.5 cm in the tray.

From the start of drying process, weight of sample was recorded. This was made for first 10 minutes at 0.5 minute intervals, for second 10 minutes at 2 minutes intervals and until reaches the equilibrium moisture content at 5 minutes intervals.

2.2.9.3. Conductional Drying of Cooked Wheat

24 g of cooked wheat was installed into disc of dryer. Drying was made at 70, 80 and 90 °C until wheat reaches the constant weight. During infrared drying, hot air circulation was not applied. Diameter of disc was 12 cm. Depth of sample was 0.5 cm in the disc.

From the start of drying process, weight of sample was recorded. This was made for first 10 minutes at 1 minute intervals, for second 10 minutes at 2 minutes intervals and until reaches the equilibrium moisture content at 5 minutes intervals.

2.2.9.4. Infrared Drying of Cooked Wheat

24 g of cooked wheat was installed into disc of dryer. Drying was made at 70, 80 and 90 °C until wheat reaches the equilibrium moisture content. During

infrared drying, hot air circulation was not applied. Diameter of disc was 12 cm. Thickness of sample was 0.5 cm in the disc.

From the start of drying process, weight of sample was recorded. This was made for first 10 minutes at 0.5 minute intervals, for second 10 minutes at 2 minutes intervals and until reaches the equilibrium moisture content at 5 minutes intervals.

2.2.9.5. Microwave Drying of Cooked Wheat

500 g of cooked wheat was installed into tray of dryer. Drying was made at 30%, 50% and 100% power level. Diameter of tray was 30 cm. Depth of sample was 0.5 cm.

From the start of drying process, weight of sample was recorded. This was made for first 10 minutes at 1 minute intervals and until reaches the equilibrium moisture content at 2 minutes intervals.

2.2.10. Preparation of Drying Curve

Drying curve was prepared for each drying system individually. Moisture content was calculated by using Equation 2.3.

$$X_t=(W-W_s)/W_s \qquad (2.3)$$

where:

X_t :Moisture content (d.b.), kg water kg dry solid

W :Weight of sample, g

W_s :Weight of dry solid, g

Free moisture content (X) was calculated with Equation (2.4) by using of moisture content (X_t):

$$X=X_t-X^* \qquad (2.4)$$

where:

X :Free moisture content, kg water/kg dry solid

X^* :Equilibrium moisture content, kg water/kg dry solid

Equation 2.5. was used to determine rate of drying.

$$R=(-Ls/A)(dX/dt) \quad (2.5)$$

where:

Ls =Dry solid, kg

A =Drying area, m^2

X =Free Moisture content, (d.b.), kg water/kg dry solid

t =Time, hour

R =Drying Rate, kg/m^2 .hour

Drying rate graph was drawn as R vs. X_{ave} and X_{ave} was calculated by using Equation 2.6.:

$$X_{ave}=X_n+X_{n+1} \quad (2.6.)$$

where:

X_n : Free moisture content at n^{th} time, kg water/kg dry solid

X_{n+1} : Free moisture content at next from n^{th} time, kg water/kg dry solid

CHAPTER III

RESULTS AND DISCUSSION

3.1. Atmospheric Cooking:

Atmospheric cooking was made to see the effect of pressure on bulgur production operation. Wheat was cooked at atmospheric pressure at 87, 92 and 97 °C for 140 minutes. Dimensions, volume, density, moisture content, gelatinization, color and percent starch extraction were measured. In traditional method, wheat is added when water reaches boiling temperature, but according to Fisher [5], if the water used is heated before being mixed with the wheat, results are less good and the final product has a darker color. From this point, in this work, wheat was mixed with water before heating. Wheat starch for bulgur production gelatinizes at 87 °C [5]. That's why, cooking temperature was increased with 5 °C intervals until reaching boiling point (97 °C).

In Table A.1., lengths of grains were given for three different temperature cooking process (Results were replicated twice). Differences and percent increase in length were calculated, average results were also given at last columns of the same table. Change (as percentage) in "a", average of Treatment I and II, of grains during atmospheric cooking was given in Figure A.1. At 97 °C, cooking couldn't be continued to 140 minutes because of overcooking of the grains.

The lengths of grains did not regularly increase or decrease during cooking period at 87, 92 and 97 °C. These results were expected. During cooking operation, grain absorbed water and swollen and big differences occured in "b" and "c" (Table A.2. and Table A.3.). Percent increase in "b" was greater than "c" because of seperation of the crease of grain with water absorption. The percent change values were increasing gradually in "b" and "c" (Figure A.2. and Figure A.3.). Since, widths (b, c) of grains increased significantly, percent change in length (%a) was negative because of shrinkage.

All of the initial grain sizes were not exactly same. So, some fluctuations were observed in the figures.

Partical density of wheat grain was calculated from measured weigths and calculated volumes of the grains. The weigths of grains were given in Table A.4. and Figure A.4. Wheat grain was assumed to be ellipsoid in shape, then volume was calculated and given in Table A.5. and Figure A.5. There was gradual increase in weigths and volumes because of water absorption. Percent volume change was greater than percent weight change in turn slight decrease in density were observed (Table A.6. and Figure A.6.).

Moisture content of wheats samples were given in Table A.7. and Figure 3.1. According to literatures [1, 3, 8, 27, 34, 35], moisture content of cooked wheat is generally 40-50% at the end of cooking (1.5-2 hours). Final moisture content reached to 60-70% in our study. So, high amount of energy should be needed to remove this excess moisture during drying. This could have been caused due to type of wheat, ratio of water and wheat (in cooker), mixing and type of cooker. But, it should be noted that, generally during experimental studies, bulk water was removed before moisture content were determined. But, industrially cooked wheat is sended into dryer directly. For that reason, during our experiment, surface water of wheat and adhesive bulk water were not removed.

In Table A.8. and Figure 3.2., average percent gelatinization was given. From these results, during cooking period, gelatinization degree of starch reached a maximum point but after a certain time, grains were disrupted and inside of grains opened like pop-corn and these types of wheat grains were not accounted. Also, there were these type damaged grains in randomly selected 100 grains. That's why gelatinization degree decreased and over cooking occured. As a result gelatinization degree of starch was critical parameter to control cooking time.

Gelatinization was determined by knife-cutting method. The criteria to decide the gelatinization was not to find any ungelatinized part in grain (zero tolerance).

Red, yellow and blue color scales were given in Table A.9. and Figure 3.3. During color measurement same wheat kernels were used in the cell of tintometer.

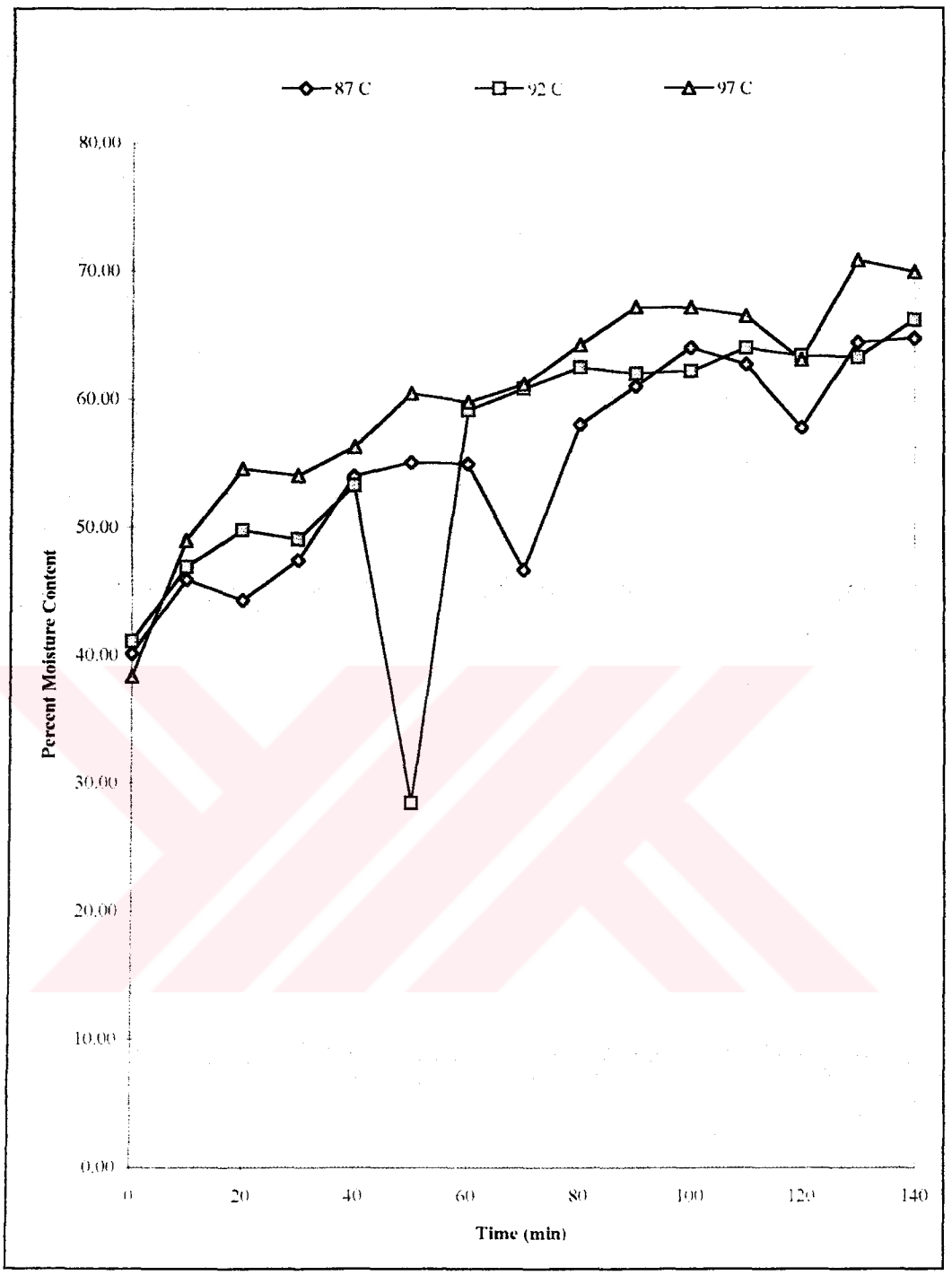

Figure 3.1. Percent Moisture Content, average of Treatment I and II, of grains during Atmospheric Cooking

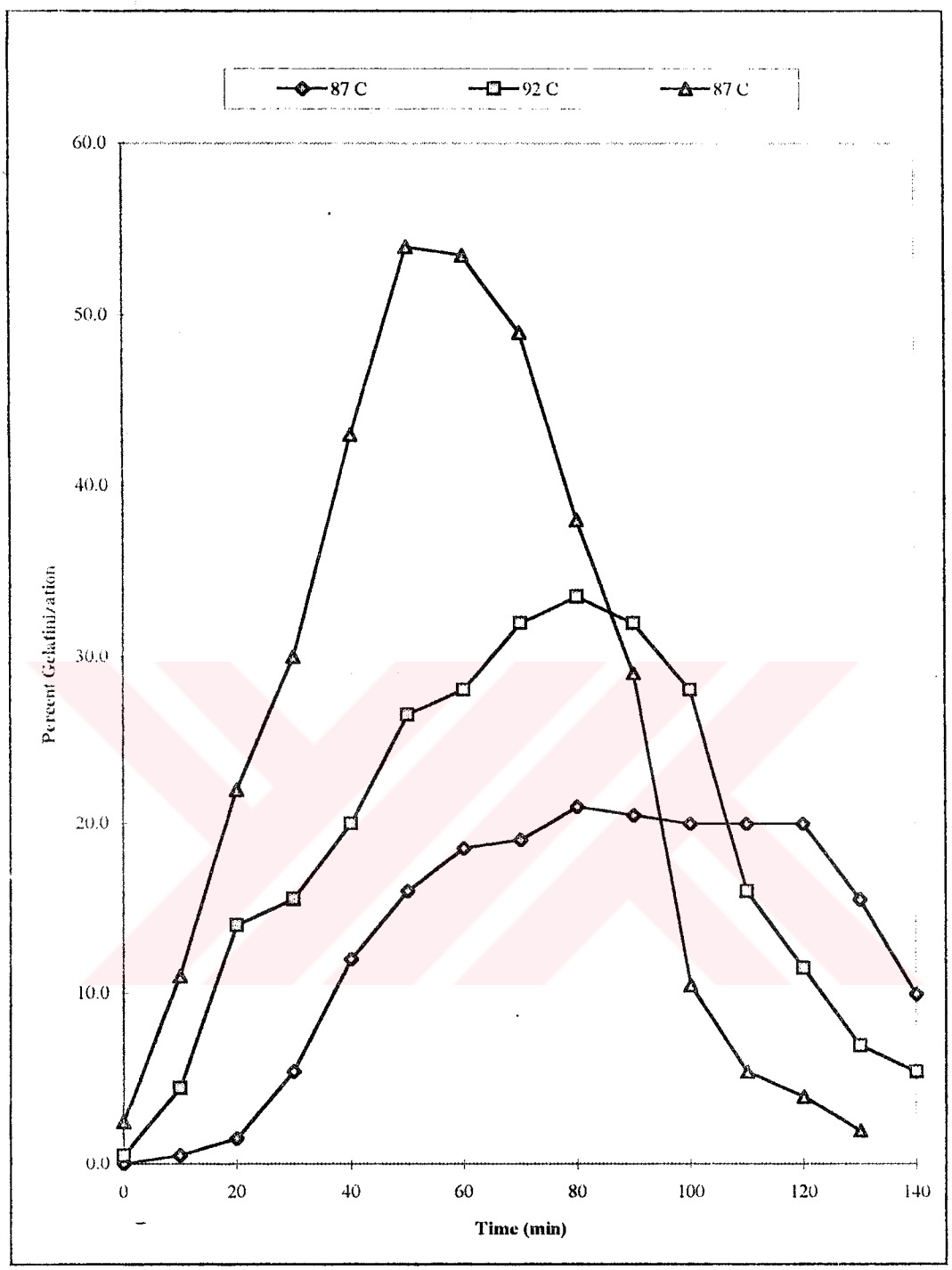

Figure 3.2. Percent Gelatinization, average of Treatment I and II, of grains during Atmospheric Cooking

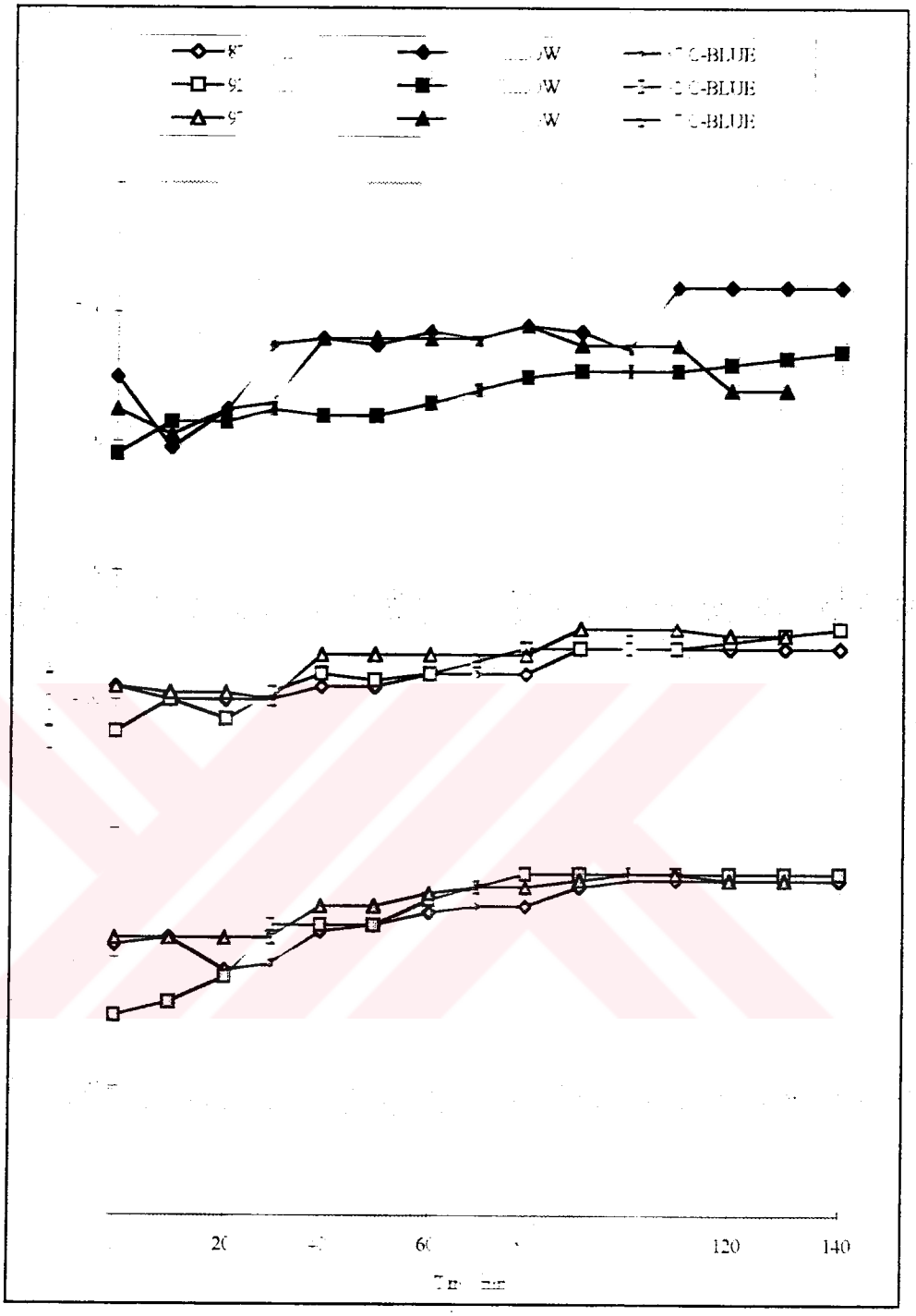

Figure 3.3. C[illegible] Values, avera[illegible] Treatment I a[illegible] of grains [illegible] Atmospheric Cooking

Color changed only during first cooking periods. After a certain time, color values were constant.

Starch extraction into cooking water were also important because of carbohydrate loss from wheat. That's why, starch in cooking water was measured during cooking period (Table A.10. and Figure 3.4.).

Statistical summary data were extracted from statistical analysis and given on Table 3.1, Table 3.2 and Table 3.3.

Statistically, as shown in Table 3.1., temperature did not effect the (af-ai), %a, %b, (ρf-ρi), %ρ and blue scales. But, temperature effected the % mc, % gelation, color and % starch in cooking water. This means that, temperature was critical parameter. Additionally, time was also effective. But, time and temperature interaction occurs at (af-ai), %a, %W, (Vf-Vi), % gelatinization and % starch in cooking water. As a result, time and temperature were effective and especially, they were effective on parameters (%mc, % gelatinization and % starch in cooking water).

Table 3.2. shown that, parameters measured at 87 and 97 °C were different from each other. Additionally, at boiling point, most of properties changed. From Table 3.3., time was not effective after 60 minutes on measured parameters except % gelatinization and % starch in cooking water.

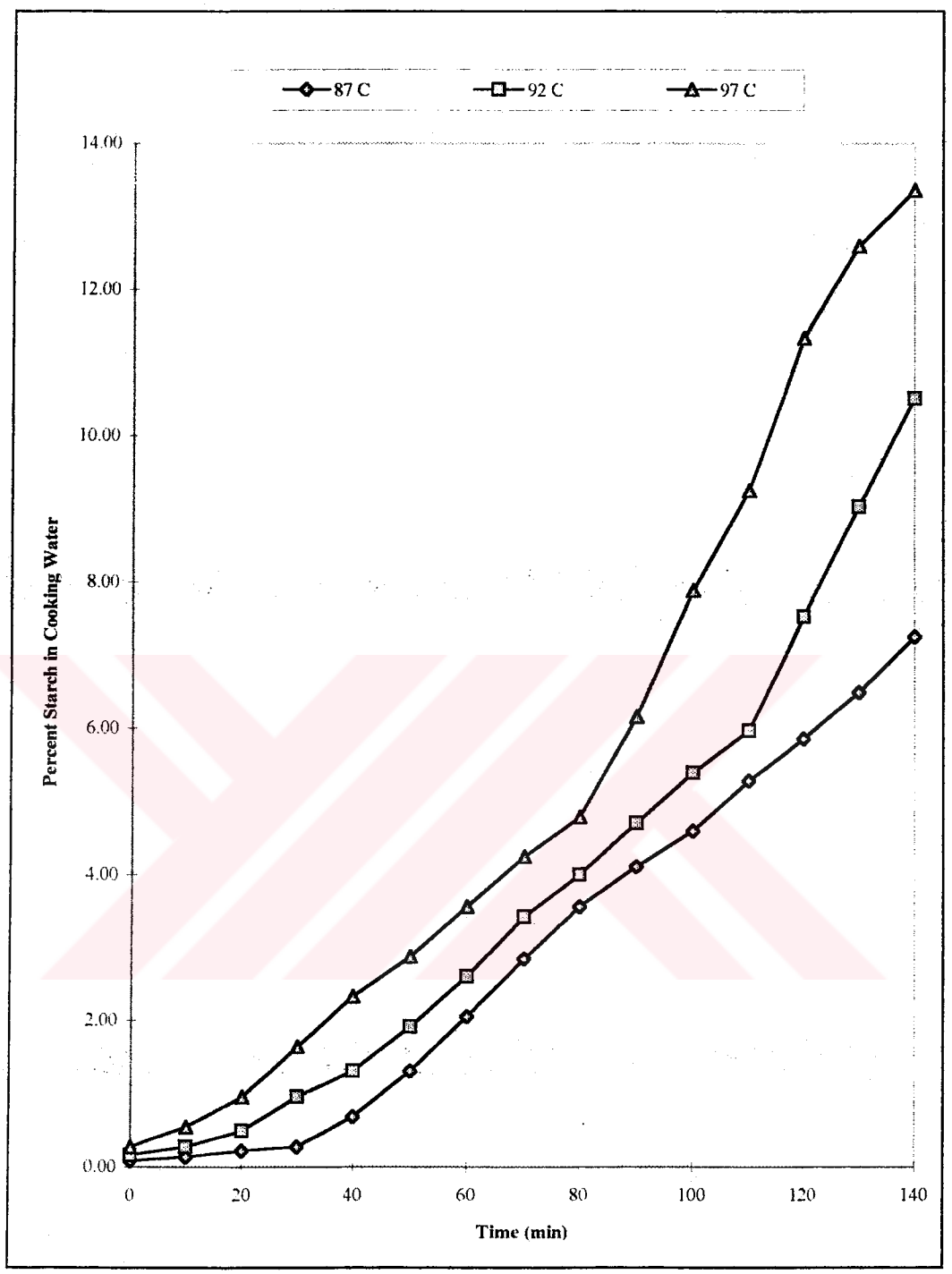

Figure 3.4. Percent Starch in Cooking Water, average of Treatment I and II, of grains during Atmospheric Cooking

Table 3.1. Summary Table of Analysis of Variance (ANOVA) for Atmospheric Cooking

Variations	(af-ai)	%a	(bf-bi)	%b	(cf-ci)	%c	(Wf-Wi)	%W	(Vf-Vi)	%V	(ρf-ρi)	%ρ	%mc	%Gelation	RED	YELLOW	BLUE	%Starch
Temperature			*		*	*	*	*	*	*			*	*	*	*		*
Time	*	*	*	*	*	*	*	*	*	*			*	*	*		*	*
INTERACTIONS																		
TempXTime	*	*						*	*					*				*

* : denotes a statistically significant difference

Table 3.2. Summary Table of Multiple Range Analysis of Temperature for Atmospheric Cooking

Temperature	(af-ai)	%a	(bf-bi)	%b	(cf-ci)	%c	(Wf-Wi)	%W	(Vf-Vi)	%V	(ρf-ρi)	%ρ	%mc	%Gelation	RED	YELLOW	BLUE	%Starch
87 C	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a
92 C	a	a	b	a	a	a	b	b	b	a	a	a	a	b	a	b	a	b
97 C	a	a	b	a	b	b	c	c	c	b	a	a	b	c	b	a/b	b	c

Same letters show the homogenous groups

Table 3.3. Summary Table of Multiple Range Analysis of Time for Atmospheric Cooking

Time	(ai-ai-1)	(ai-1-ai-2)	(bi-bi-1)	%b	(ci-ci-1)	%c	(Wi-Wi-1)	%W	(Vi-Vi-1)	%V	(ρi-ρi-1)	%ρ	%mc	%Gelation	RED	YELLOW	BLUE	%Starch
0	a/b/c	a	a	a	a	a	a	a	a	a	a	a	a	a	a/b	a/b	a	a
10	b	a	a/b	a/b	a/b	a/b	b	b	a/b	a/b	a	a	a/b	b	a/b/c	a	a	a/b
20	b/c	a	b/c	b/c	a/b/c	a/b/c	b	b	b/c	b/c	a	a	b/c	d	a	a/b	a	a/b
30	a/b/c	a	c/d	c/d	b/c/d	a/b/c/d	b	b	b/c	b/c	a	a	b/c	e	a/b/c	a/b	a/b	b/c
40	a/b/c	a	d/e	d/e/f	b/c/d/e	b/c/d	c	c	c/d	c/d	a	a	b/c/d	g	c/d	a/b	b/c	c/d
50	a/b/c	a/b	d/e	d/e	c/d/e/f	c/d/e	c/d	c/d	c/d/e	c/d	a	a	a/b	h/i	b/c/d	a/b	b/c	d
60	a	c/d	e/f	e/f/g	c/d/e	b/c/d	e	c/d	e	c/d	a	a	c/d	i	d/e	a/b	c/d	e
70	a/c	d/e	f/g	e/f/g/h	e/f/g	d/e/f	d/e	d/e	d/e/f	d/e	a	a	b/c/d	i	d/e	a/b	c/d	f
80	a/b/c	b/c	f/g	g/h	d/e/f/g	c/d/e/f	d/e	e/f	e/f	d/e	a	a	d	h	d/e	b	d	f
90	a	b/c	f/g	f/g/h	g	e/f	e	f/g/h	f	d/e/f	a	a	d	g	e	b	d	g
100	a/b/c	d/e	g	h	g	f	e	e/f/g	f	e/f	a	a	d	f	e	a/b	d	h
110	a	b/g	g	h	f/g	e/f	e	h	d/e/f	e/f	a	a	d	d	e	b	d	i
120	a/b/c	a/b	g	g/h	g	e/f	d/e	e/f/g/h	f	e/f	a	a	d	d	e	b	d	j
130	a	g	g	h	h	g	e	g/h	f	f	a	a	e	e	e	b	d	k
Contrast																		
0-10							*	*						*				
0-20			*	*			*	*	*	*			*	*				
0-30			*	*	*		*	*	*	*			*	*				*
0-40			*	*	*	*	*	*	*	*			*	*	*		*	*
0-50			*	*	*	*	*	*	*	*				*			*	*
0-60			*	*	*	*	*	*	*	*			*	*	*		*	*
0-70			*	*	*	*	*	*	*	*			*	*	*		*	*
0-80			*	*	*	*	*	*	*	*			*	*	*		*	*
0-90			*	*	*	*	*	*	*	*			*	*	*		*	*
0-100			*	*	*	*	*	*	*	*			*	*	*		*	*
0-110			*	*	*	*	*	*	*	*			*	*	*		*	*
0-120			*	*	*	*	*	*	*	*			*	*	*		*	*
0-130			*	*	*	*	*	*	*	*			*	*	*		*	*
10-20								*						*				

* : denotes a statistically significant difference
Same letters show the homogenous groups

Table 3.3. (cont'd)

10-30			*	*										*				
10-40			*	*			*		*	*				*			*	*
10-50			*	*	*	*	*	*	*	*				*			*	*
10-60	*	*	*	*	*		*	*	*	*			*	*	*		*	*
10-70	*	*	*	*	*	*	*	*	*	*				*	*		*	*
10-80			*	*	*	*	*	*	*	*			*	*	*	*	*	*
10-90	*	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*
10-100			*	*	*	*	*	*	*	*			*	*	*		*	*
10-110	*	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*
10-120			*	*	*	*	*	*	*	*			*	*	*	*	*	*
10-130	*	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*
20-30														*				
20-40			*	*			*	*						*	*		*	*
20-50			*	*			*	*						*	*		*	*
20-60	*	*	*	*			*	*						*	*		*	*
20-70			*	*	*	*	*	*	*	*				*	*		*	*
20-80			*	*	*		*	*	*	*			*	*	*		*	*
20-90	*	*	*	*	*	*	*	*	*	*			*	*	*		*	*
20-100			*	*	*	*	*	*	*	*			*	*	*		*	*
20-110	*	*	*	*	*	*	*	*	*	*			*		*		*	*
20-120			*	*	*	*	*	*	*	*			*		*		*	*
20-130	*	*	*	*	*	*	*	*	*	*			*	*	*		*	*
30-40							*	*						*				
30-50							*	*						*				*
30-60			*	*			*	*						*	*		*	*
30-70			*	*	*		*	*	*	*				*	*		*	*
30-80			*	*			*	*	*	*			*	*	*		*	*
30-90			*	*	*	*	*	*	*	*			*	*	*		*	*
30-100			*	*	*	*	*	*	*	*			*	*	*		*	*
30-110			*	*	*	*	*	*	*	*			*	*	*		*	*
30-120			*	*	*	*	*	*	*	*			*	*	*		*	*
30-130			*	*	*	*	*	*	*	*			*	*	*		*	*
40-50														*				
40-60														*				*
40-70			*				*	*						*				*
40-80			*	*			*	*	*					*			*	*
40-90			*		*	*	*	*	*						*		*	*
40-100			*	*	*	*	*	*	*	*				*	*		*	*
40-110			*	*	*	*	*	*		*				*	*		*	*
40-120			*	*	*	*	*	*	*	*				*	*		*	*
40-130			*	*	*	*	*	*	*	*			*	*	*		*	*

Table 3.3. (cont'd)

50-60													*					*
50-70			*						*									*
50-80			*	*				*	*				*				*	*
50-90			*	*	*		*	*	*				*	*	*		*	*
50-100			*	*	*	*	*	*	*	*			*	*	*		*	*
50-110			*	*			*	*	*	*			*	*	*		*	*
50-120,			*	*	*	*		*	*	*			*	*	*		*	*
50-130			*	*	*	*	*	*	*	*			*	*	*		*	*
60-70							*		*									*
60-80			*				*	*	*					*				*
60-90					*	*	*	*	*					*				*
60-100			*	*	*	*	*	*	*	*				*				*
60-110			*	*	*	*	*	*	*	*				*				*
60-120			*		*	*	*	*	*	*				*				*
60-130			*	*	*	*	*	*	*	*				*				*
70-80														*				
70-90								*						*				*
70-100														*				*
70-110								*						*				*
70-120														*				*
70-130					*	*		*		*				*				*
80-90														*				*
80-100														*				*
80-110								*						*				*
80-120														*				*
80-130					*	*		*		*				*				*
90-100														*				*
90-110														*				*
90-120														*				*
90-130					*	*								*				*
100-110								*						*				*
100-120														*				*
100-130					*	*								*				*
110-120																		*
110-130					*	*								*				*
120-130					*	*								*				*

3.2. Soaking

Before pressure cooking, soaking operation was made to absorb enough amount of water (%40 of moisture). For that reason, wheats were soaked into water at different temperatures (40, 50, 60, 70 and 80 °C) for 60 minutes. During soaking periods same parameters also measured except percent gelatinization. Table B.1. shows the length of wheat kernel during soaking. These values were also shown in Figure B.1. Significant change occured during soaking in length and maximum change occured at 80 °C of soaking. In Table B.2. and B.3. show the value of "b" and "c". Both of them increased during soaking like atmospheric cooking. Here, their maximum percent increase were 27% and 18% respectively (Figures B.2. and Figure B.3.). Additionally, weight of grains were increased (Table B.4.) and at 80 °C of soaking shown the biggest water absorption for 60 minutes. Figure B.4. shows the graphs of these changes.

All dimensions, during soaking, changed in turn volume was changed. Maximum volume change was 68% at 80 °C (Table B.5.) and Figures B.5. shows the volume changes during soaking.

Volume changes were found to be more significant than weight changes. (Table B.6.). So, some negative values for density changes were observed (Figure B.6.).

For soaking, the most important parameter was the amount of water absorbed in turn final moisture content of the grain. During 60 minutes of soaking, moisture content reached to 40 % only at 70 °C and 80 °C. This 60 minutes was upper limit for overall processing time. Moisture content reached 40% at 40 minutes and 20 minutes for 70 and 80 °C respectively (Table B.7. and Figure 3.5.) for the lower temperature soakings, moisture content did not reach 40% in 60 minutes. So, 70 and 80 °C soaking temperatures were used later for pressure cooking.

During soaking, yellow color scale increased initially, then stayed constant at the same value. In red and blue scale, there were not any significant changes (Table B.8. and Figure 3.6.).

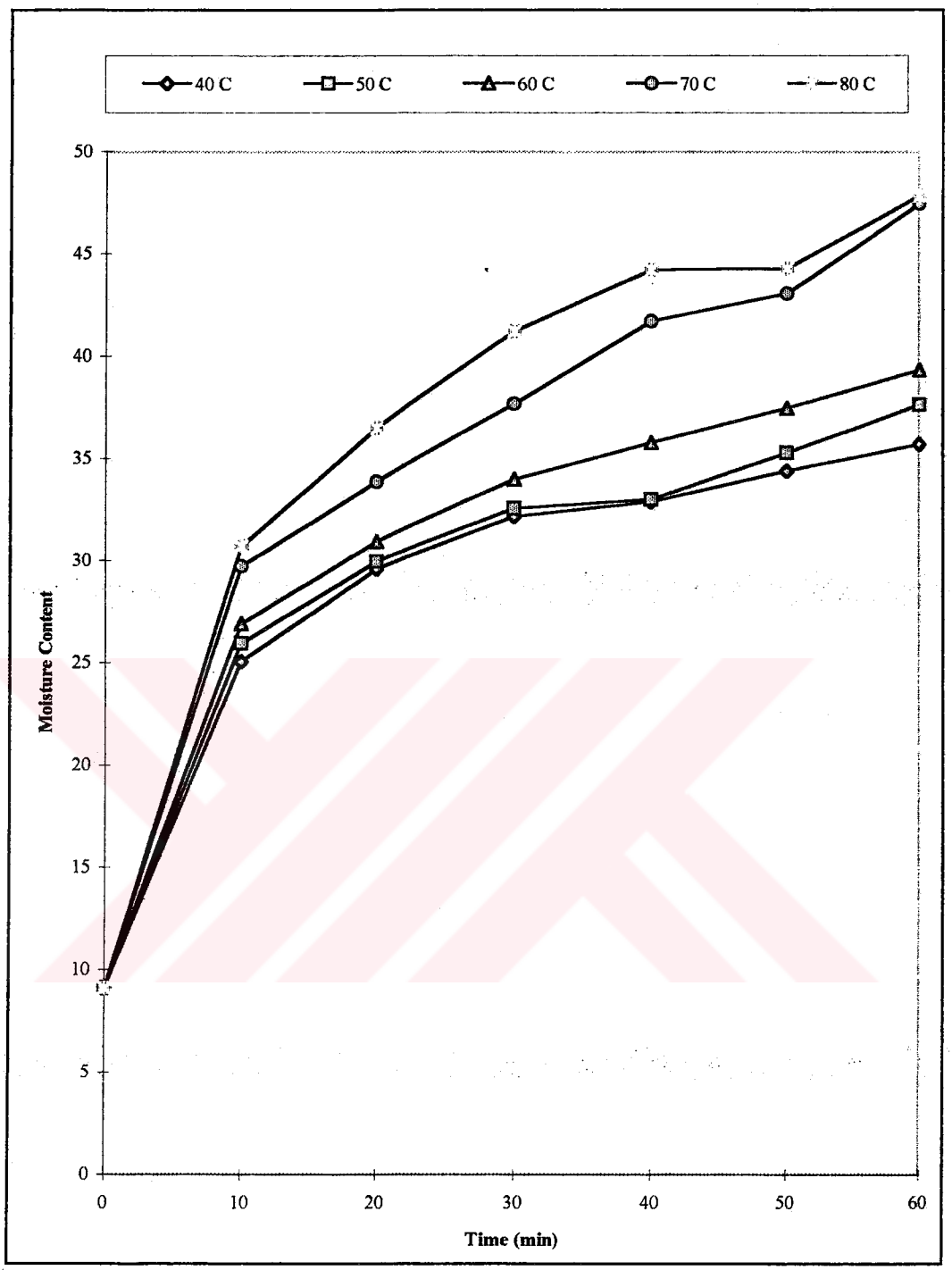

Figure 3.5. Percent Moisture Content, average of Treatment I and II, of grains during Soaking

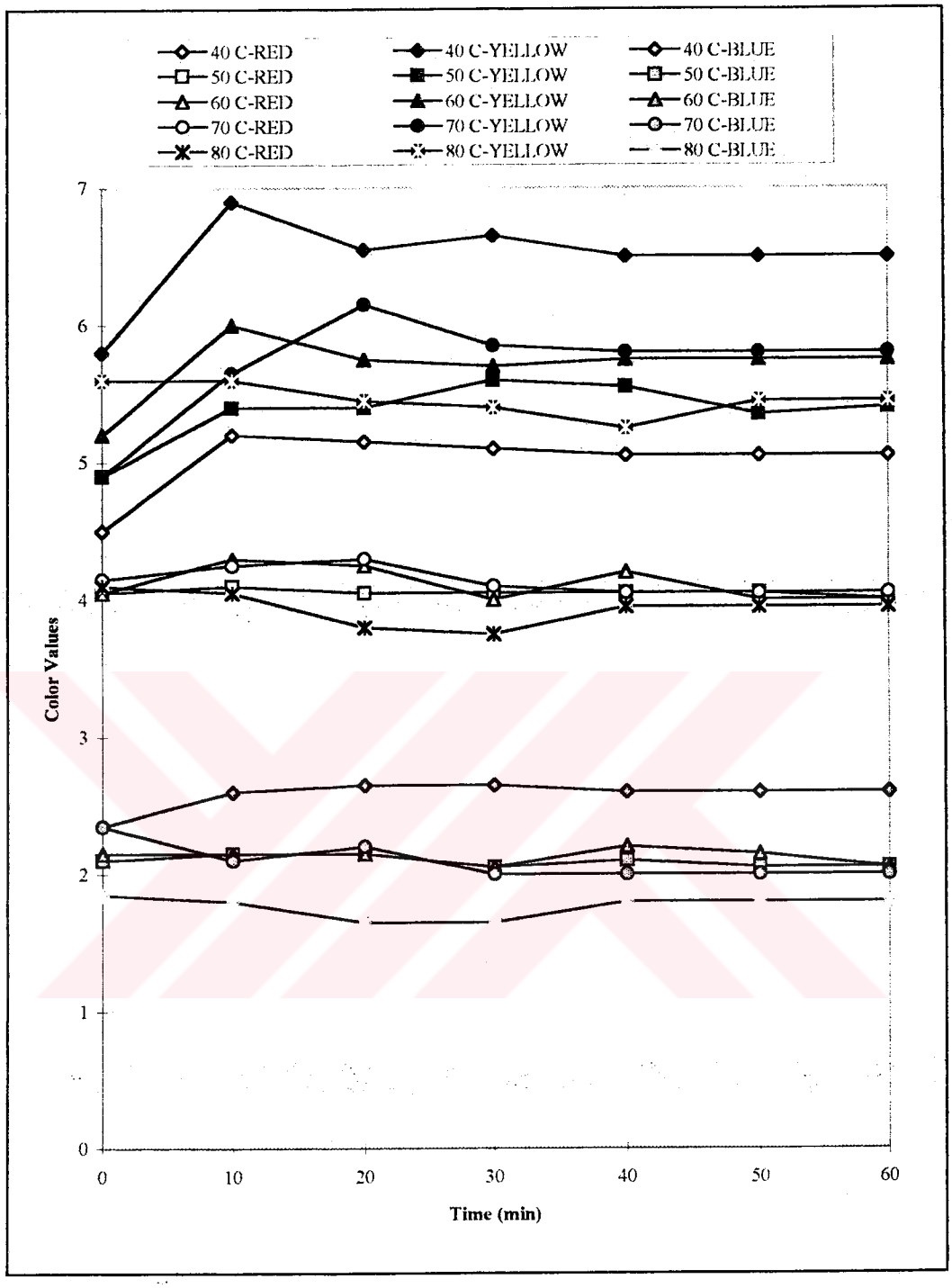

Figure 3.6. Color Values, average of Treatment I and II, of grains during Soaking

Maximum starch concentration in soaking water was 0.88% at 80 °C for 60 minutes. This value was lower than maximum value of atmospheric cooking (Table B.9. and Figure 3.7.).

Summary of statistical analysis were given in Tables 3.4., 3.5. and 3.6. Statistically, temperature did not effect the density change. But, other parameters were changed with soaking temperature. Additionally, soaking time affected parameters except density, color and % starch in soaking water (Table 3.4.).

Statistical homogeneous groups were also given in Table 3.5. It was interesting that parameters were not significantly different at 50 and 60 °C soaking except m.c. and yellow color scale. But, when temperature was increased, properties of grains changed.

In Table 3.6. effect of time was shown. Time did not effect the density. All parameters were not changed at 20 minutes and 30 minutes (except m.c.) and at 40 and 50°C. Moisture content was changed with respect to soaking time significantly.

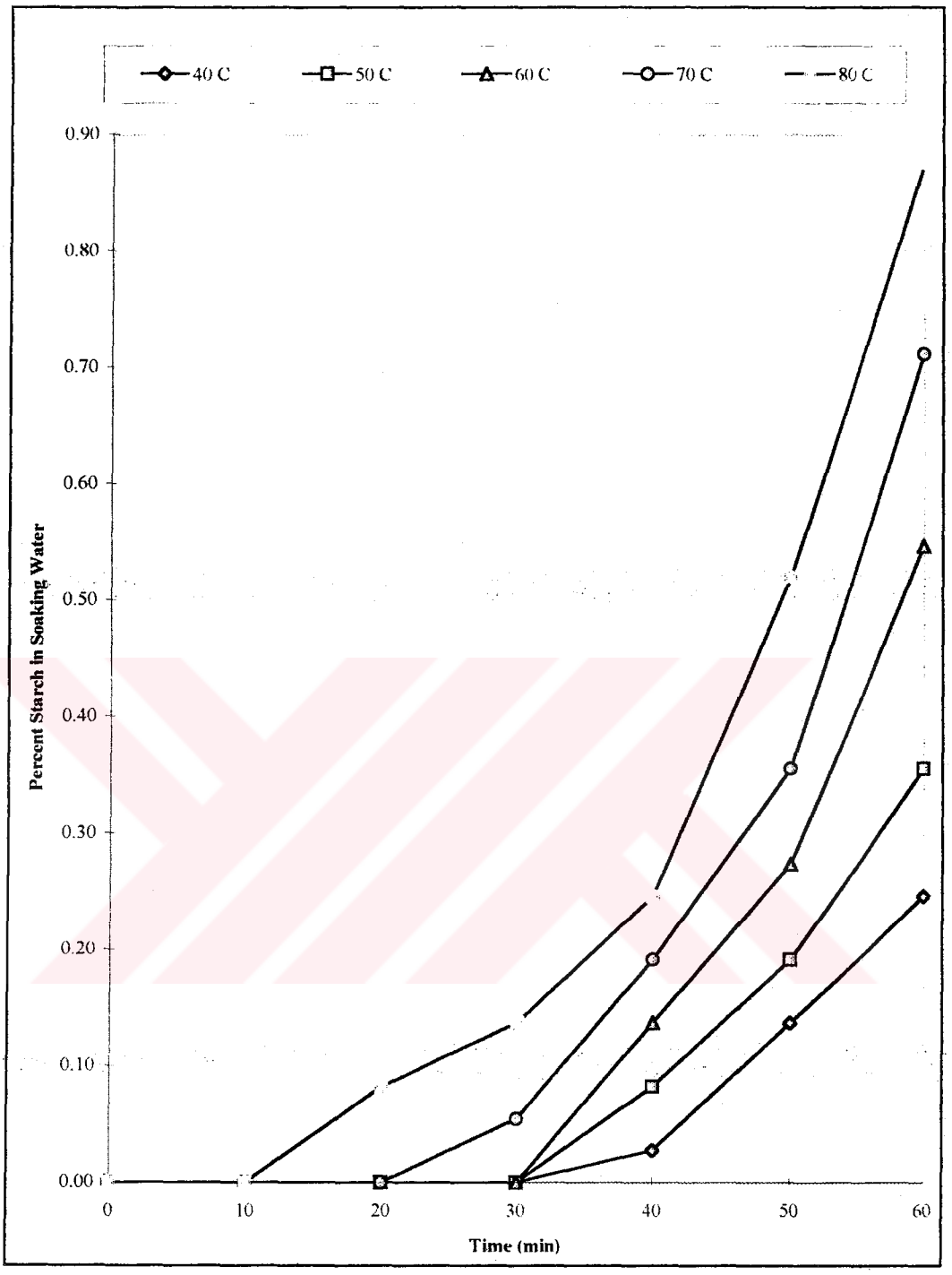

Figure 3.7. Percent Starch in Soaking Water, average of Treatment I and II, of grains during Soaking

Table 3.4. Summary Table of Analysis of Variance (ANOVA) for Soaking

Variations	(af-ai)	%a	(bf-bi)	%b	(cf-ci)	%c	(Wf-Wi)	%W	(Vf-Vi)	%V	(pf-pi)	%p	%mc	RED	YELLOW	BLUE	%Starch
Temperature	*	*	*	*	*	*	*	*	*	*			*	*	*	*	*
Time	*	*	*	*	*	*	*	*	*	*			*				
INTERACTIONS																	
TempXTime			*	*					*	*			*				

* : denotes a statistically significant difference

Table 3.5. Summary Table of Multiple Range Analysis of Temperature for Soaking

Temperature	(af-ai)	%a	(bf-bi)	%b	(cf-ci)	%c	(Wf-Wi)	%W	(Vf-Vi)	%V	(pf-pi)	%p	%mc	RED	YELLOW	BLUE	%Starch
40 C	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a
50 C	a/b	a/b	a/b	a	a	a	a/b	a/b	a/b	a/b	a/b	a/b	b	b	a	b	a/b
60 C	b/c	b/c	b	a	a	a	b	b	b/c	b	b	b	c	b	b	b	a/b
70 C	c	c	c	b	a	a	c	c	c	c	b	b	d	b	b	b	a/b
80 C	d	d	d	c	b	b	d	c	d	d	b	b	e	c	c	c	b

Same letters show the homogenous groups

Table 3.6. Summary Table of Multiple Range Analysis of Time for Soaking

Time	(af-ai)	%a	(bf-bi)	%b	(cf-ci)	%c	(Wf-Wi)	%W	(Vf-Vi)	%V	(pf-pi)	%p	%mc	RED	YELLOW	BLUE	%Starch
0	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a
10	b	b	a/b	a/b	a	a	a/b	a/b	a	a/b	a	a	b	a	a	a	a
20	b	b	a/b	a/b	a/b	a/b	b/c	b/c	a	b	a	a	c	a/b	a	a	a
30	b/c	b/c	b/c	b/c	b/c	b/c	c	c	b	c	a	a	d	a/b	a	a	a
40	b/c	b/c	c	c	c	c	c/d	c	b	c/d	a	a	e	a/b	a	a	a
50	c	c	d	d	c	c	d	d	b	d	a	a	f	b	a	a	a

Same letters show the homogenous groups

3.3. Pressure Cooking

Pressure cooking was performed after soaking process. Firstly, wheat grain was soaked at 70 °C and 80 °C then cooked under pressure. These two soaking temperature were selected because the moisture content of wheat reached to 40% in less than 60 minutes. To decide the which soaking temperature was the better, these two soaking temperature were examined at pressure cooking operation.

In Tables C.1., C.2., C.3. and C.4. percent change of lengths, two widths and weights of grain were given. In these data, some percent changes were negative. This was because of when pressure cooker was opened at the end of cooking operation, absorbed water was removed from grain as a steam because of pressure difference between atmosphere and cooker. That's why, negative change occured (Figures C.1.,C.2.,C.3. and C.4.) From these values, volume and density were calculated and given in Tables C.5. and C.6. Negative changes were obtained in these results also (Results were shown on Figures C.5. and C.6.). Moisture content increased when applied pressure, time and soaking temperature were increased (Table C.7. and Figure 3.8.). Additionally, at this conditions gelatinization reached the 100% (Table C.8. and Figure 3.9.). This result was perfect. Because, at atmospheric cooking, maximum percent gelatinization nearly half of this value and its moisture content was higher than this pressure cooked wheat value (Table A.7.). Selected parameters as criteria, were moisture content and percent gelatinization because when moisture was higher, energy consumption would be higher during drying. Gelatinization was the most important parameter for bulgur production. Additionally, percent extracted starch in cooking water of atmospheric cooking was higher than pressure cooking. Because, starch was not extracted during pressure cooking, only it was extracted during soaking period. Color changes (red, yellow and blue) were given in Table C.9. and Table C.10. Percent changes were shown on Figures 3.10,11,12 individually. They increased during pressure cooking. Significant change was observed at blue scale (Figure 3.12.).

The analysis of variance of pressure cooking was given in Table 3.7. Significances were observed at %a, differences and percent change of volume, moisture content and at percent starch gelatinization. In Table 3.8., soaking

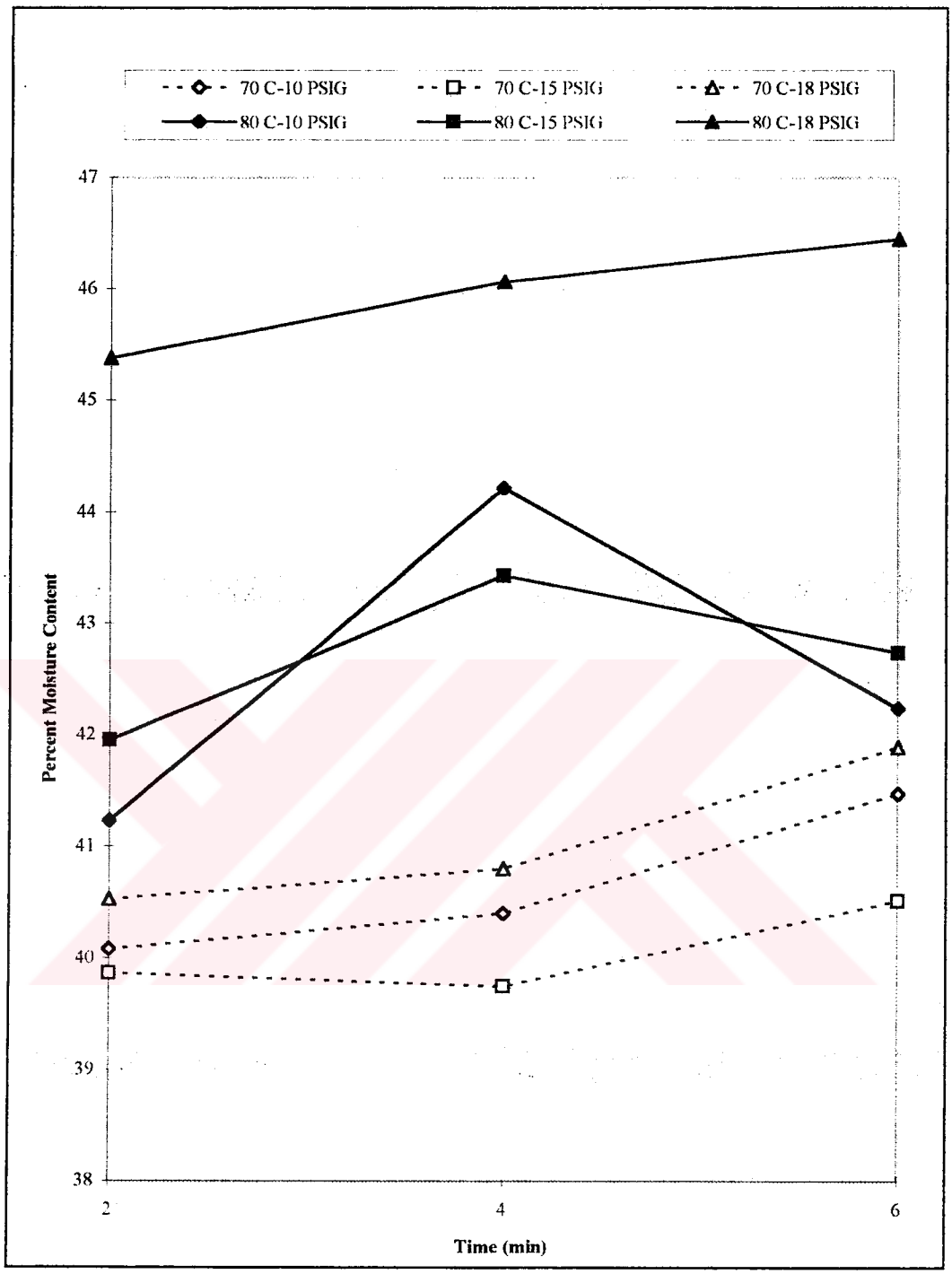

Figure 3.8. Percent Moisture Content, average of Treatment I and II, of grain during Pressure Cooking

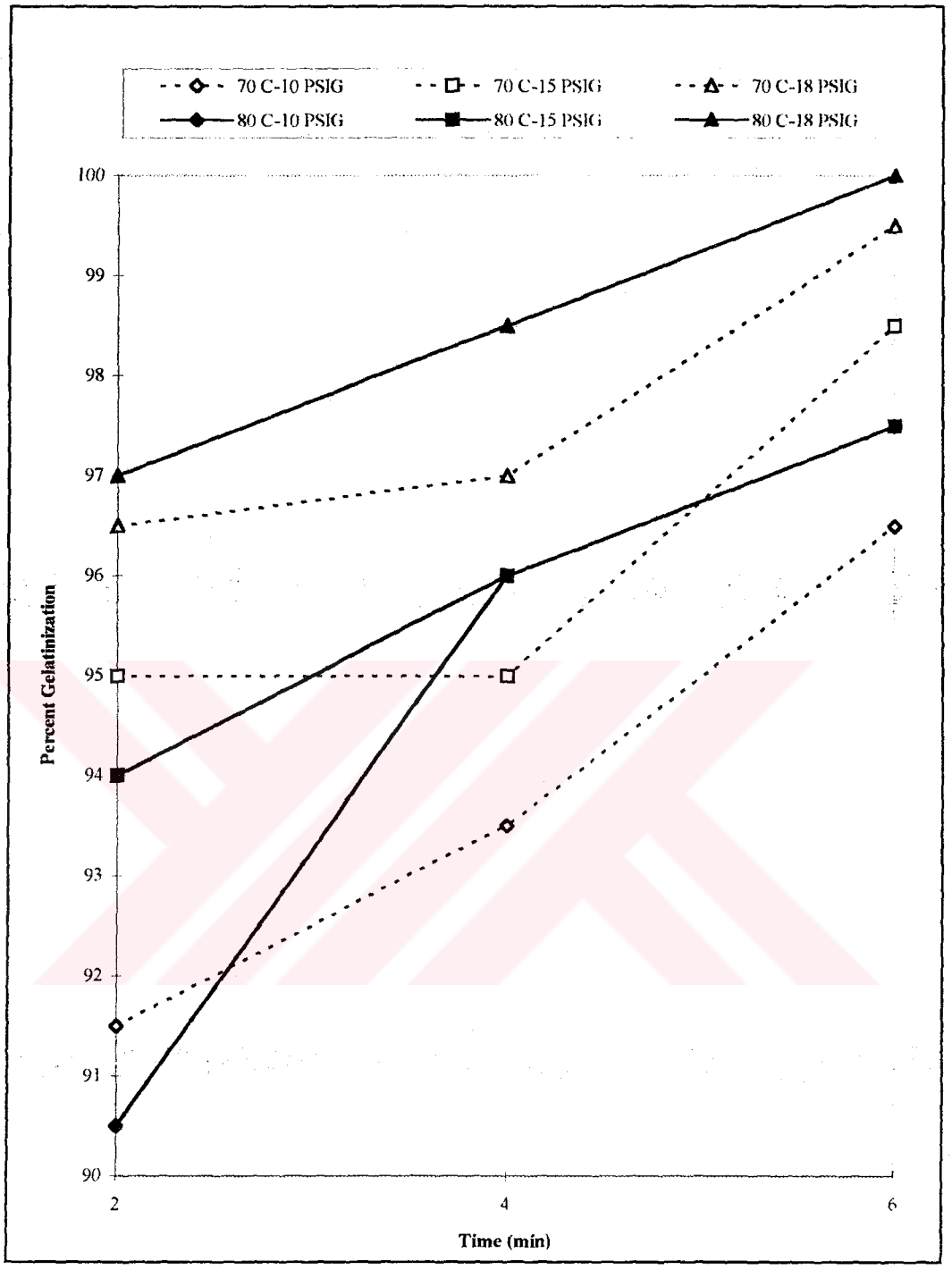

Figure 3.9. Percent Gelatinization, average of Treatment I and II, of grain during Pressure Cooking

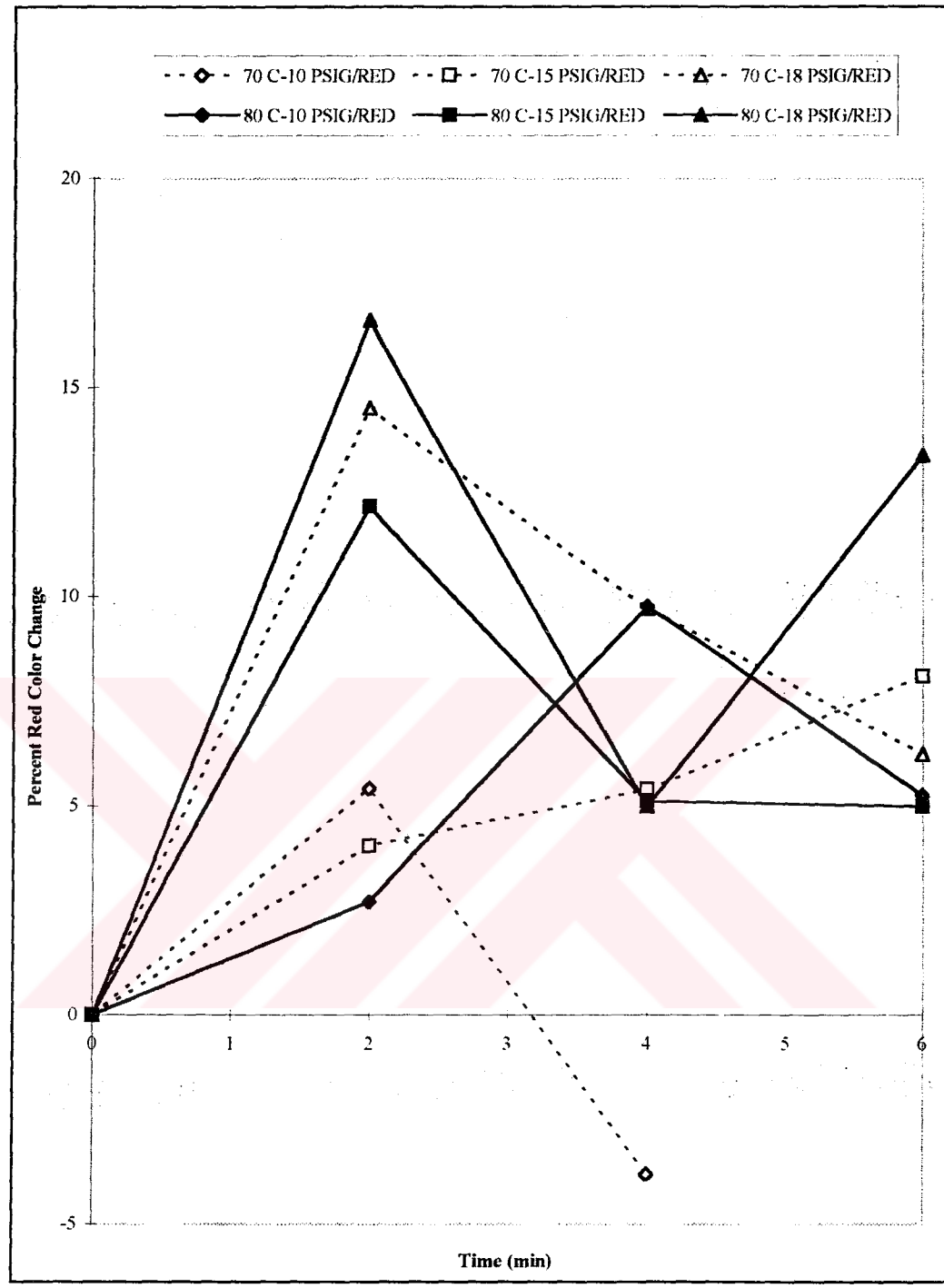

Figure 3.10. Percent Red Color Change, average of Treatment I and II, of grain during Pressure Cooking

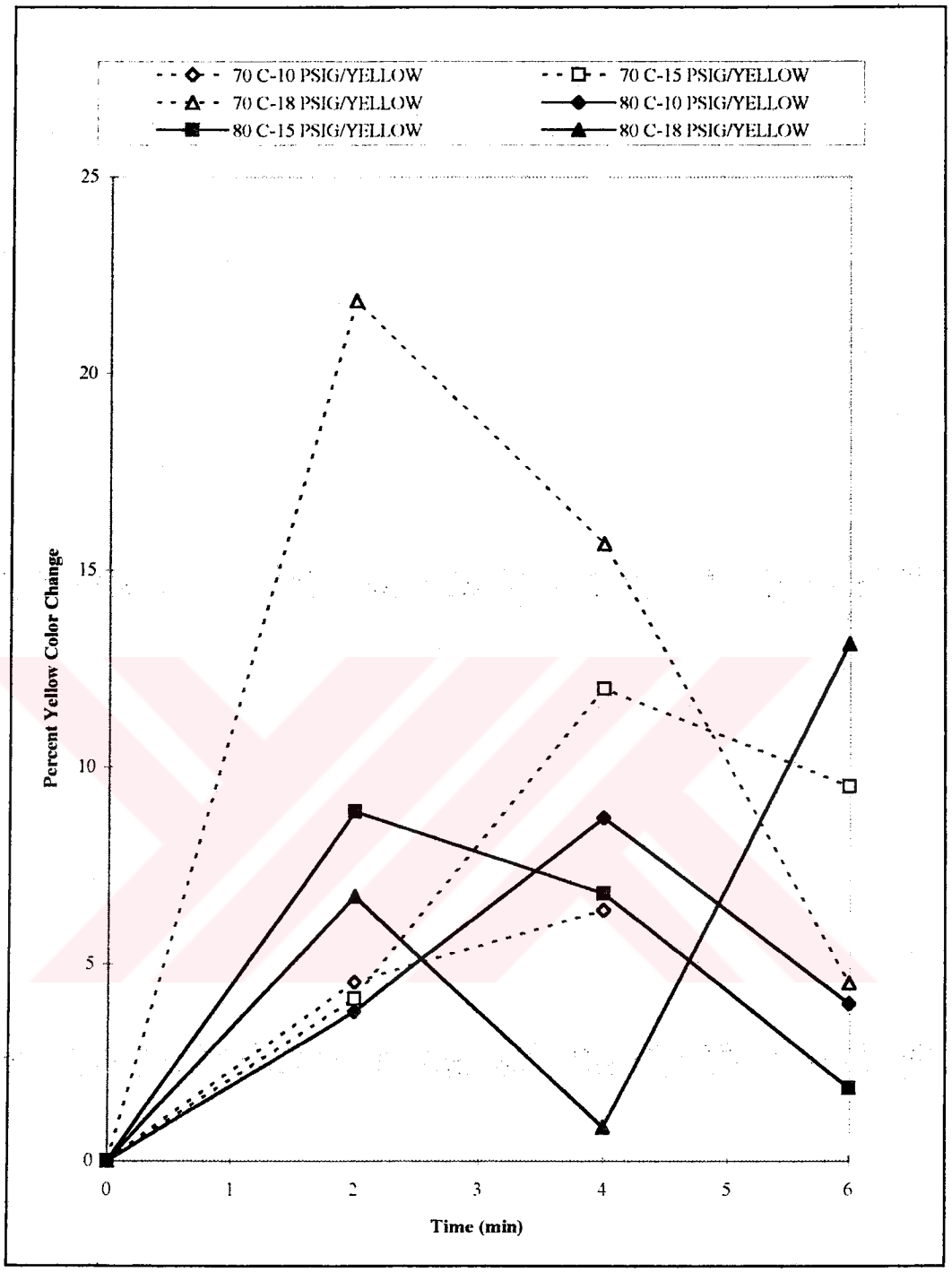

Figure 3.11. Percent Yellow Color Change, average of Treatment I and II, of grain during Pressure Cooking

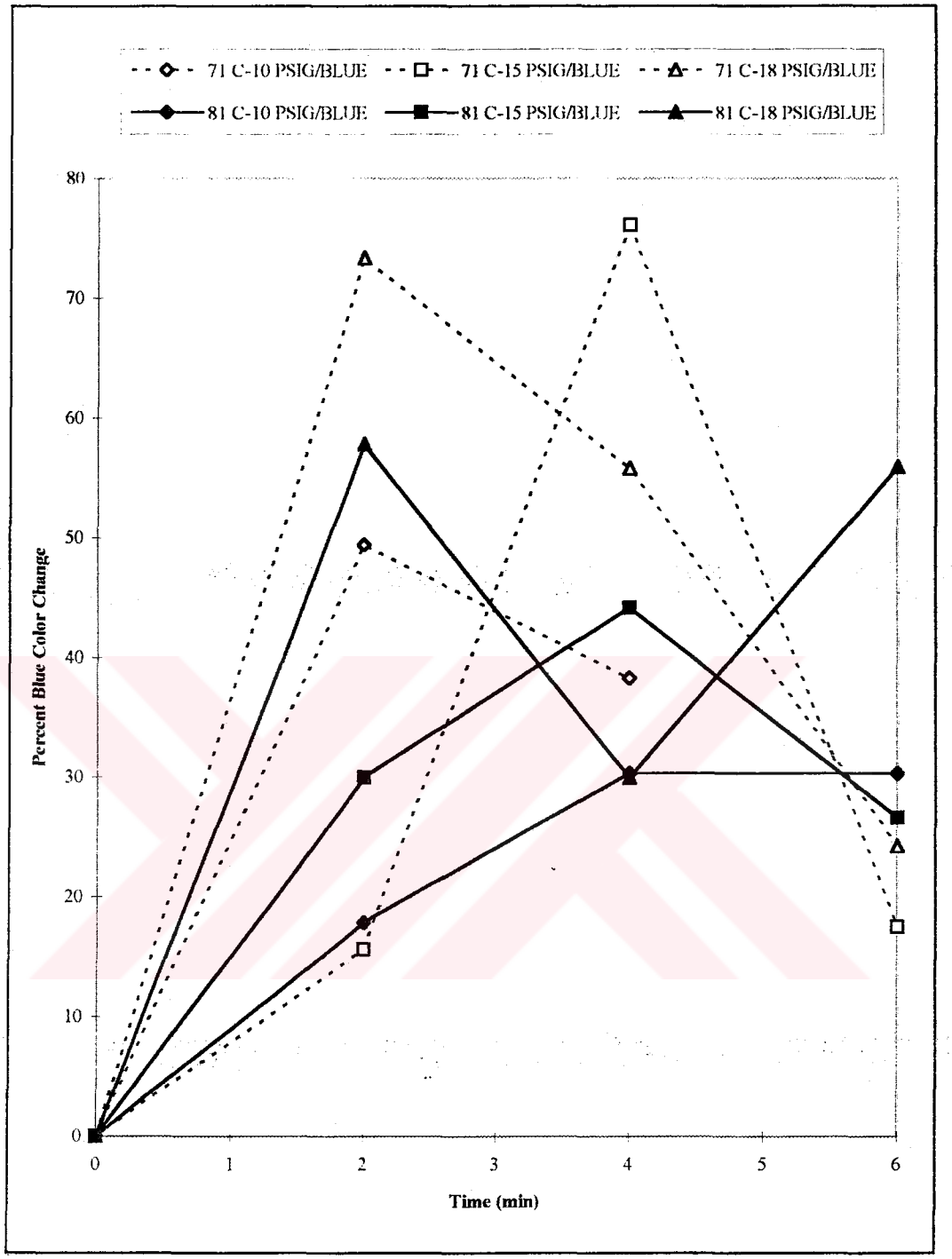

Figure 3.12. Percent Blue Color Change, average of Treatment I and II, of grain during Pressure Cooking

Table 3.7. Summary Table of Analysis of Variance (ANOVA) for Pressure Cooking

Variations	(af-ai)	%ad	(bf-bi)	%ab	(cf-ci)	%ac	(Wf-Wi)	%W	(Vf-Vi)	%V	(pf-pi)	%p	%me	%Gelatinization	%RED	%YELLOW	%BLUE
Soak Temp		*											*				
Pressure									*	*			*	*			
Time														*			
INTERACTIONS																	
STempXPress													*				
STempXTime														*			
PressXTime														*			

* : denotes a statistically significant difference

Table 3.8. Summary Table of Multiple Range Analysis of Temperature for Pressure Cooking

Temperature	(af-ai)	%ad	(bf-bi)	%ab	(cf-ci)	%ac	(Wf-Wi)	%W	(Vf-Vi)	%V	(pf-pi)	%p	%me	%Gelatinization	%RED	%YELLOW	%BLUE
70 C	a	b	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a
80 C	a	a	a	a	a	a	a	a	a	a	a	a	b	a	a	a	a

Same letters show the homogenous groups

temperatures were analyzed and all parameters showed the statistically homogeneous relation except %a and % mc. But, in moisture content, there was no significant difference at different temperatures. That's why, soaking temperature was not important. Pressure effect was given in Table 3.9. Pressure did not effect the color and weight of grain significantly. Pressure cooking time did not effect the dimensions, weight, density, and volume significantly. Moisture content and percent gelation were effected from cooking time(Table 3.10.)

Table 3.9. Summary Table of Multiple Range Analysis of Pressure for Pressure Cooking

Pressure	(ai'-ai)	%ai	(bi'-bi)	%bi	(ci'-ci)	%ci	(Wi'-Wi)	%Wi	(Vi'-Vi)	%Vi	(pi'-pi)	%pi	%mc	%Gelatinization	%RED	%YELLOW	%BLUE
10 psig	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a
15 psig	b	b	a/b	a/b	b	b	a	a	b	b	a/b	a	a	b	a	a	a
18 psig	a/b	a/b	b	b	b	b	a	a	b	b	b	a	b	c	a	a	a

Same letters show the homogenous groups

Table 3.10. Summary Table of Multiple Range Analysis of Time for Pressure Cooking

Time	(ai'-ai)	%ai	(bi'-bi)	%bi	(ci'-ci)	%ci	(Wi'-Wi)	%Wi	(Vi'-Vi)	%Vi	(pi'-pi)	%pi	%mc	%Gelatinization	%RED	%YELLOW	%BLUE
2 min	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a
4 min	a	a	a	a	a	a	a	a	a	a	a	a	a/b	b	a	a	a
6 min	a	a	a	a	a	a	a	a	a	a	a	a	b	c	a	a	a

Same letters show the homogenous groups

3.4. Drying

Drying operation was made after cooking. 20 minutes of soaking at 80 °C and then 6 minutes of pressure cooking at 18 psig were found to be optimum processing conditions and wheats cooked at these conditions were used in drying operations.

Wheat which was soaked at 80 °C for 20 minutes then pressure cooked at 18 psig for 6 minutes contained 46.45% moisture and its temperature was 100 °C.

Industrially, cooked wheat was waited for a certain time before drying operation. During resting time, air circulation was made to prevent sticking of wheat particles. Cooked wheat was rested until its temperature decreased to 50 °C. Moisture content decreased to 41 % at this temperature because of evaporation.

3.4.1. Fluidized Bed Drying:

In Tables D.1.-D.6., results of fluidized bed drying were given. Fluidized bed drying was made at 70, 80 and 90 °C with replication.

Drying rates of fluidized bed drying were calculated. Summary of calculated results were extracted into Table 3.11., Figures 3.13., D.1 and D.2.. Constant rate period was 4-5 minutes for 90 °C of drying. Additionally, constant rate periods were started at 6^{th}(Treatment I) - 7^{th} (Treatment II) and 9^{th} (Treatmnet I) - 11^{th} (TreatmentII) for 80 °C and 70 °C of drying respectively. Moisture content of product was reached to 10 % of moisture at 45^{th} minute at 90°C.

Color of wheat kernels become darker at high temperature (at 80 °C and 90 °C). But, at 70 °C, color values did not change. Although, drying rate was low, drying time was shorter than other convectional drying system. Because, during fluidized bed drying, mass transfer occured from all surface of the grains in turn surface area was very large. However, drying rate was found to be lower than the other dryers used.

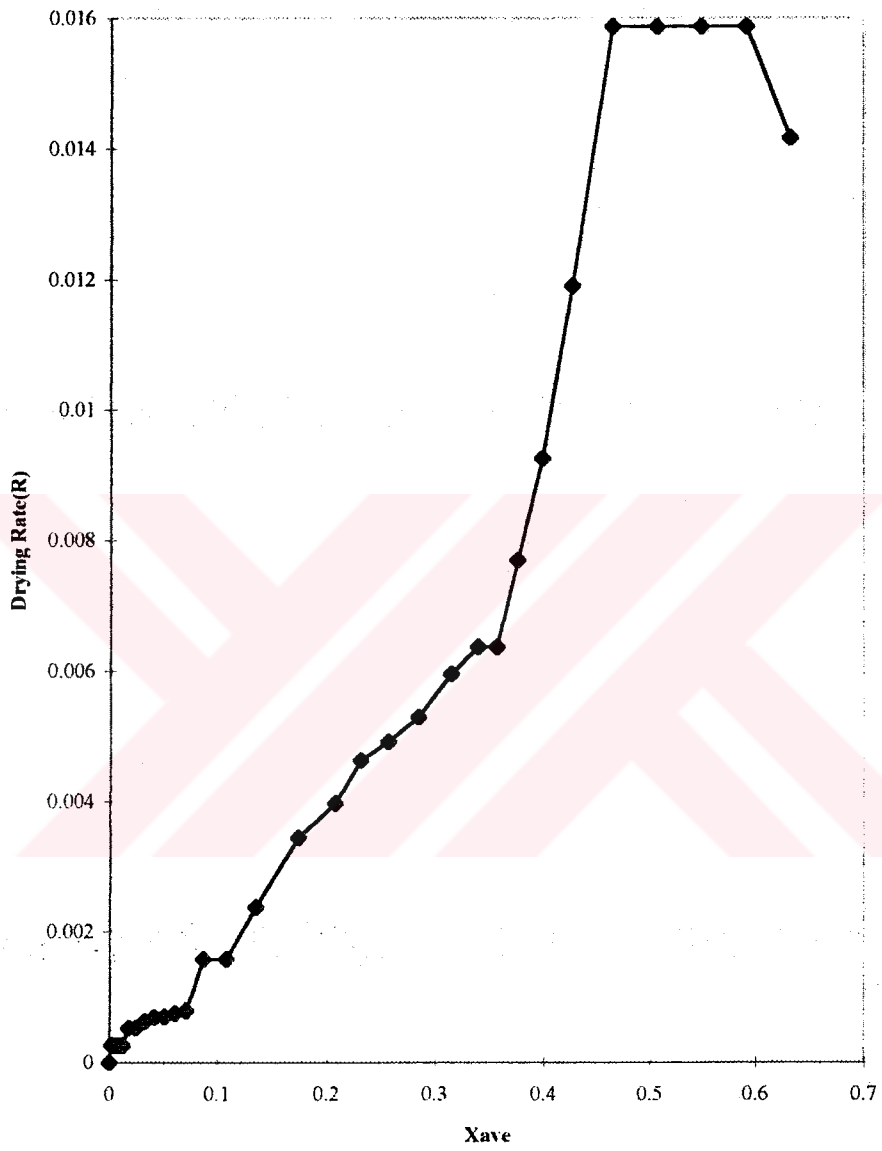

Figure 3.13. Drying Rate Graph for Fluidized Bed Drying at 90 C (Treatment I)

Table 3.11.Summary Data of Color and Drying Time for Fluidized Bed Drying

Fluidized Bed Drying						
	90 °C-I	90 °C-II	80 °C-I	80 °C-II	70 °C-I	70 °C-II
Color						
Initial	4.4R-5.7Y-2.6B	4R-5.9Y-2.5B	4R-5.9Y-2.5B	4R-5.9Y- 2.5B	4.4R-5.6Y-2.8B	4.4R-5.6Y-2.8B
At 10% m.c.	4.4R-5.5Y-2.9B	4.3R-5.4Y-2.6B	4.2R-5.6Y-2.6B	4.4R-5.7Y-2.8B	4R-5.6Y-2.5B	4.4R-5.7Y-2.5B
At equilibrium	4.5R-5.9Y-3B	4.3R-5.4Y-2.6 B	4.6R-6.6Y-2.6B	4.4R-5.6Y-2.8B	4.4R-5.7Y- 2.7B	4.2R-5.7Y- 2.7B
Drying Time(minutes)						
To reach 10% m.c.	45	45	65	75	75	75
To reach equilibrium	95	100	125	125	145	145
Constant Rate Period	4	5	6	7	9	11

(R:Red, Y:Yellow, B:Blue)

3.4.2. Tray Drying:

In Tables D.7-D.12., results of tray drying were given. Tray drying was a convectional type dryer. Moisture of product was removed only from surface of tray. That's why, drying surface area was limited with tray area. As it is seen from Figure 3.14. and Figures D.3.-D.4., drying curves for tray drying, decrease step by step. Drying rate was constant for a certain time then, immediately decreased, after then, drying rate was constant again. Balance used for the determination of weight of product for tray drying was not sensitive (1g sensitivity). So, step wise decrease can be partially explained with low sensitivity of balance used.

Summary of data were given in Table 3.12. According to this table. Constant rate periods were started at 23^{rd} (Treatment I) - 27^{th} (Treatment II), 71^{st} (Treatment I) - 73^{rd} (Treatment II) and 110^{th} (Treatment I) - 100^{th} (Treatment II) minutes at 90, 80 and 70 °C respectively. These values were higher than fluidized bed drying values. Additionally, minimum drying time occured at 90 °C as 150 minutes. When temperature was decreased to 70 °C, time increased to 290 minutes. Color values also changed at high drying temperatures but, color did not change at 70 °C.

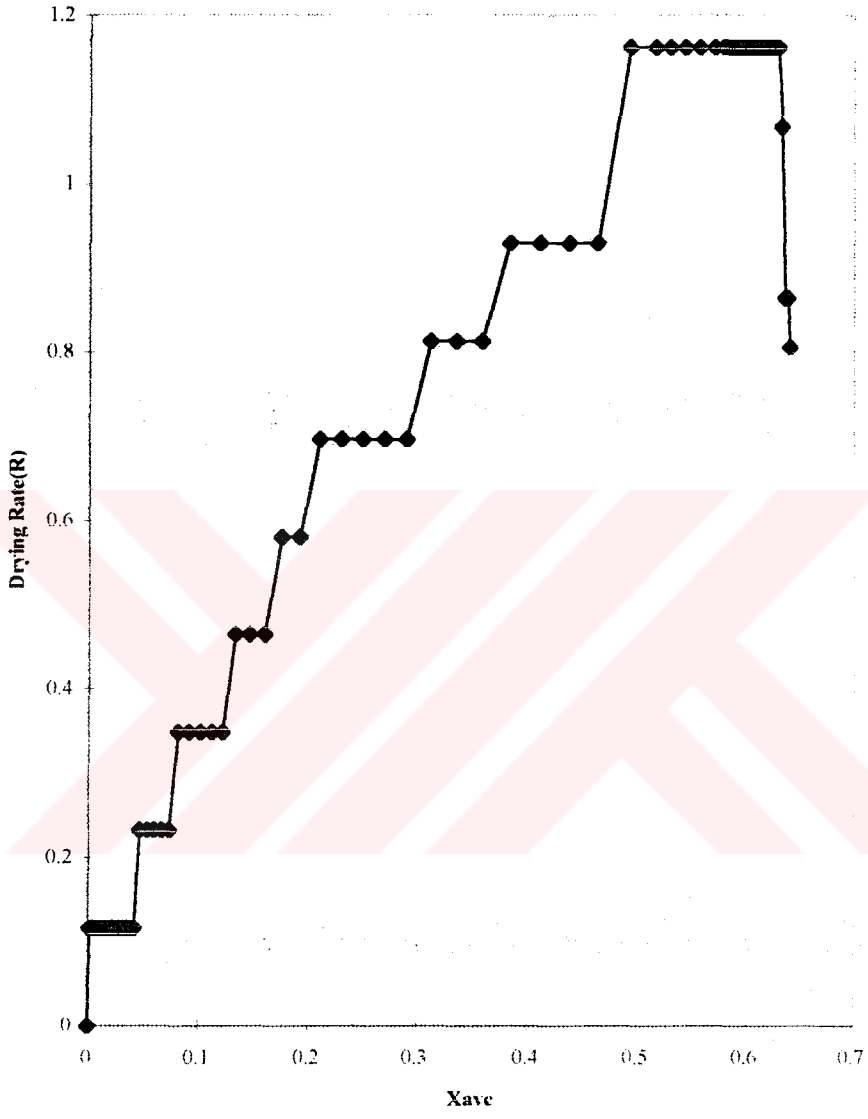

Figure 3.14. Drying Rate Graph for Tray Drying at 90 C (Treatment I)

Table 3.12.Summary Data of Color and Drying Time for Tray Drying

Tray Drying						
	90 °C-I	**90 °C-II**	**80 °C-I**	**80 °C-II**	**70 °C-I**	**70 °C-II**
Color						
Initial	4.4R-5.7Y-2.6B	4R-5.9Y-2.5B	4.8R-6.3Y-3.2B	4.2R-5.7Y- 2.7B	4.5R-6.0Y-2.9B	4.5R-6.0Y-2.9B
At 10% m.c.	4.5R-5.7Y-3.2B	4.6R-5.9Y-3.1B	4.4R-5.7Y-2.5B	4.2R-5.5Y-2.6B	4.3R-5.9Y- 2.8B	4.5R-6.2- 2.9B
At equilibrium	4.1R-5.4Y-2.6 B	4R-5.2Y-2.6 B	4.4R-5.6Y-2.8B	4.2R-5.5Y-2.6B	4.3R-5.9Y- 2.8B	4.5R-6.2- 2.9B
Drying Time(minutes)						
To reach 10% m.c.	150	160	220	235	290	290
To reach equilibrium	225	225	290	295	335	340
Constant Rate Period	23	27	71	73	110	100

(R:Red. Y:Yellow. B:Blue)

3.4.3. Conductional Drying:

In Tables D.13-D.18., results of conductional drying were given. In conductional drying, drying operation was made by using the conductional heat transfer principle. Drying rate area was also limited with dryer area. Additionally, capacity was lower than tray and fluidized bed dryer. Constant rate and drying periods were lower than tray dryer but higher than fluidized bed dryer. Additionally, when drying temperature was decreased, drying rate decreased Figure 3.15., D.5. and D.6.. Minimum drying time was 70 minutes at 90 °C, and drying operation reaches the equilibrium at 180 minutes at 90 °C as minimum (Table 3.13). Color values changed significantly at high temperatures (80 °C and 90 °C).

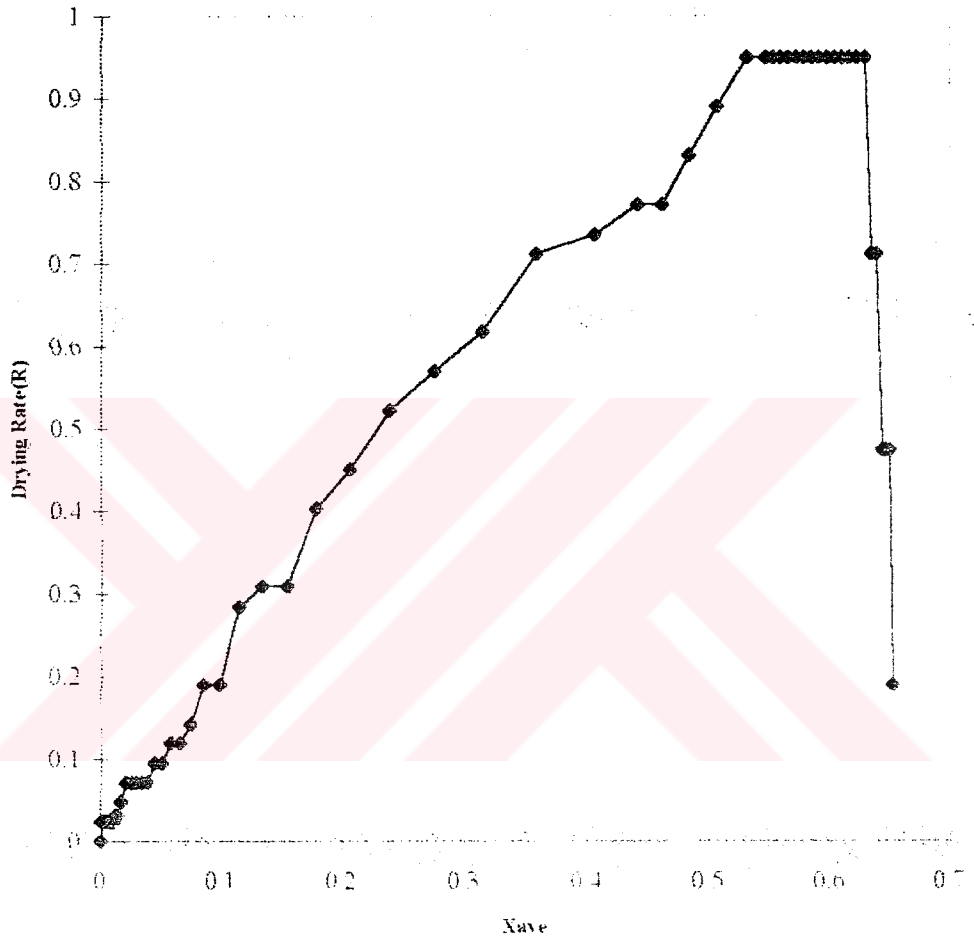

Figure 3.15. Drying Rate Graph for Conductional Drying at 90 C (Treatment I)

Table 3.13.Summary Data of Color and Drying Time for Conductional Drying

Conductional Drying						
	90 °C-I	**90 °C-II**	**80 °C-I**	**80 °C-II**	**70 °C-I**	**70 °C-II**
Color						
Initial	4.4R-5.7Y-2.6B	4.5R-5.9Y-2.7B	4R-5.9Y-2.5B	4.2R-5.6Y- 2.8B	4.2R-5.7Y-2.7B	4.5R-6.0Y-2.9B
At 10% m.c.	4.5R-6.2Y-3B	4.6R-6.1Y-3B	4.2R-5.5Y-2.7B	4.4R-5.7Y-2.5B	4.2R-5.5Y- 2.6B	3.9R-5.9- 2.9B
At equilibrium	4.5R-5.6Y-3.0B	4.5R-5.9Y-2.9B	4.3R-5.2Y-2.6B	5.0R-6.3Y-3.0B	4.2R-5.5Y- 2.6B	3.9R-5.9- 2.9B
Drying Time(minutes)						
To reach 10% m.c.	70	70	90	90	135	145
To reach equilibrium	180	185	235	240	310	315
Constant Rate Period	14	14	22	21	31	31

(R:Red, Y:Yellow, B:Blue)

3.4.4. Infrared Drying:

In Tables D.19.-D.24., results of infrared drying were given. Drying area and capacity of infrared dryer were same with conductional dryer. Drying period of infrared drying was nearly same with fluidized bed drying. Constant rate period for infrared drying was longer than fluidized bed drying. But, infrared drying reached the equilibrium in shorter time than fluidized bed drying (Table 3.14.). Additionally, drying rate of infrared drying was higher than fluidized bed drying.

In Figures 3.16, D.7. and D.8., there was a peak during initial drying period. Peak was occured because of high intensity of infrared ligth loading at the beginning in turn large amount of water removed. Then, ligth reached the equilibrium and drying continued steadly.

Color values did not change at low and high drying temperatures.

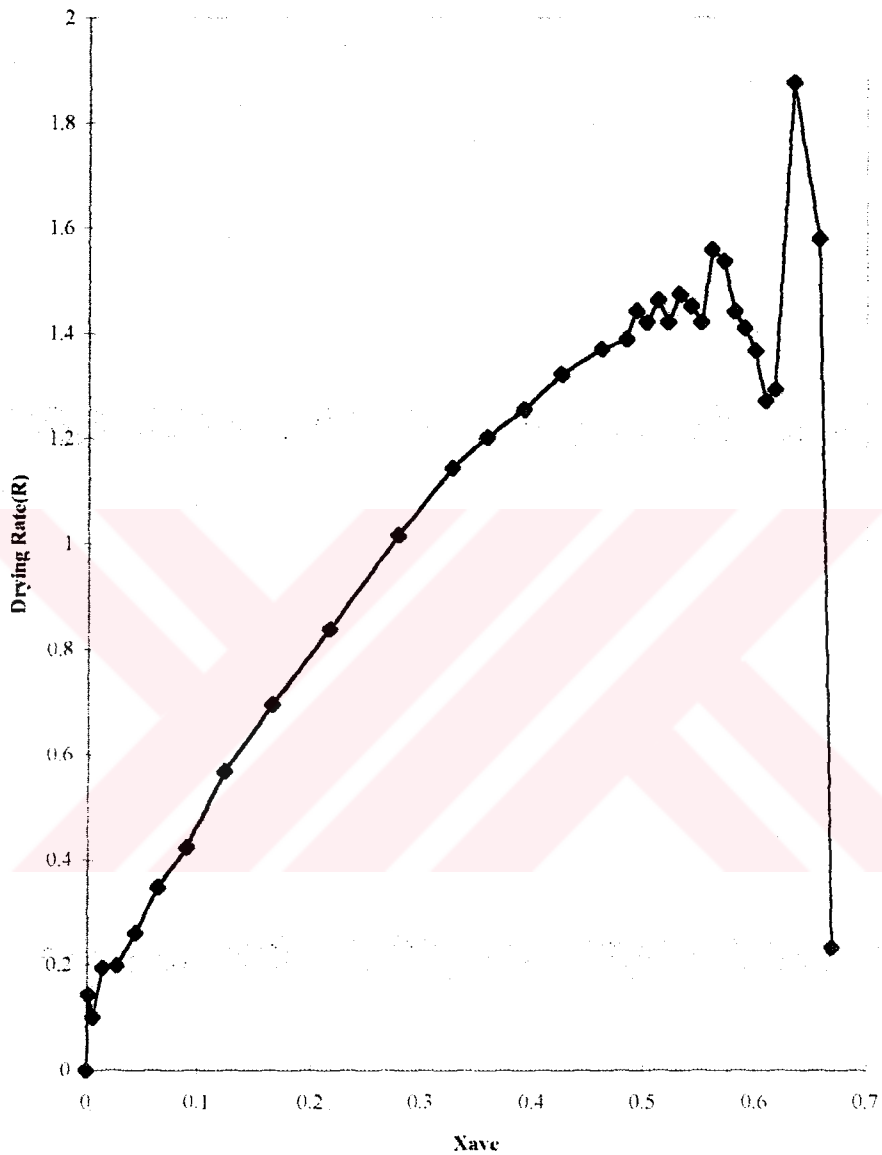

Figure 3.16. Drying Rate Graph for Infrared Drying at 90 C (Treatment 1)

Table 3.14.Summary Data of Color and Drying Time for Infrared Drying

Infrared Drying						
	90 °C-I	**90 °C-II**	**80 °C-I**	**80 °C-II**	**70 °C-I**	**70 °C-II**
Color						
Initial	3.5R-3.9Y-2.1B	3.5R-3.9Y-2.1B	3.5R-3.9Y-2.1B	3.5R-3.9Y-2.1B	3.5R-3.9Y-2.1B	3.5R-3.9Y-2.1B
At 10% m.c.	3.7R-3.9Y-2.4B	3.7R-3.9Y-2.4B	3.7R-3.9Y-2.3B	3.7R-3.9Y-2.3B	4R-5Y- 3.2B	4.2R-5.1- 3.1B
At equilibrium	3.7R-3.9Y-2.4B	3.7R-3.9Y-2.4B	3.7R-3.9Y-2.4B	3.7R-3.9Y-2.3B	4R-5Y- 3.2B	4R-5Y-3.1B
Drying Time(minutes)						
To reach 10% m.c.	40	40	55	56	66	60
To reach equilibrium	71	71	79	70	105	96
Constant Rate Period	6	5.5	5	4.5	7.5	6.5

(R:Red. Y:Yellow. B:Blue)

3.4.5. Microwave Drying:

In Tables D.25.-D.20., results of microwave drying were given. In microwave drying. microwave power was used at 100. 50 and 30% of power supply. That's why, drying temperature were not be able to controlled instead, power supply was controlled.

Minimum drying rate period was 19 minutes at 100% of power supply. But, after 10% moisture, product were burned at 100% and 50 % of powers. That's why, drying curves were not prepared. When power was decreased to 30%, drying period increased to 80 minutes and this time was longer than infrared and fluidized bed dryer (Table 3.15.).

Color values changed at each three power levels.

Table 3.15.Summary Data of Color and Drying Time for Microwave Drying

Microwave Drying						
	100%-I	**100%-II**	**50%-I**	**50%-II**	**30%-I**	**30%-II**
Color						
Initial	3.5R-4.2Y-2.1B	3.5R-4.2Y-2.1B	3.5R-4.7Y-2.4B	3.5R-4.7Y-2.4B	3.8-4.7Y-2.4B	3.8-4.7Y-2.4B
At 10% m.c.	3.5R-4.2Y-2.1B	3.5R-4.2Y-2.1B	3.7R-4.1Y-2.6B	3.7R-4.1Y-2.6B	4.1R-5Y- 3B	4.1R-4.9Y- 3B
At equilibrium			3.7R-4.1Y-3.0B	3.7R-4.1Y-3.0B	4.0R-4.5Y- 2.9B	4.1R-4.5Y- 2.8B
Drying Time(minutes)						
To reach 10% m.c.	19	19	38	40	82	78
To reach equilibrium	-	-	-	-	-	-
Constant Rate Period	-	-	-	-	-	-

(R:Red. Y:Yellow, B:Blue)

CHAPTER IV

CONCLUSIONS

In bulgur production, cooking and drying were very important steps. Atmospheric and pressure cooking were well known methods for cooking. The optimum cooking operation was found to be pressure cooking, because of maximum gelatinization and minimum cooking time, wheat kernel damage, carbohydrate loss and moisture content, in contrast to generally used atmospheric cooking in bulgur industry.

Soaking should be made before pressure cooking to supply enough moisture (40%) into kernel for cooking. The optimum soaking temperature and time were obtained as 80°C and 20 minutes respectively.

The optimum pressure cooking was obtained at 18 psig for 6 minutes and overall cooking operation (20 minutes soaking at 80 °C + 6 minutes pressure cooking at 18 psig) was completed in 26 minutes.

Five different drying operations were used and the different results were obtained. Drying time for microwave drying at 100% power supply was shorter but product burned because of difficult process control of microwave. Fluidized bed dryer was feasible due to short drying time but large amounts of air flow were required to supply fluidization. Additionally, drying rate was low in contrast to large drying area in fluidized bed drying.

Drying times of the tray and conductional drying were also longer compared to fluidized bed drying.

Infrared drying can be used instead of fluidized bed dryer because of its shorter drying time and stable product colors. Selection of optimum drying operation requires additional information such as capacity, economy and energy efficiency.

Further studies should be concentrated on determining optimum operational condition in dryers then selection of best dryer based economy, capacity and energy efficiency.

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APPENDICES

APPENDIX A. TABLES AND FIGURES OF ATMOSPHERIC COOKING

Table A.1. Lengths "a" (cm) of grains during Atmospheric Cooking

COOKING AT 87 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ai	af	af-ai	%a	ai	af	af-ai	%a	ai	af	af-ai	%a
0	7.50	7.50	0.00	0.00	7.35	7.75	0.40	5.44	7.43	7.63	0.20	2.69
10	7.35	8.00	0.65	8.84	7.20	8.00	0.80	11.11	7.28	8.00	0.73	9.97
20	7.65	8.20	0.55	7.19	6.90	7.60	0.70	10.14	7.28	7.90	0.62	8.59
30	7.60	8.35	0.75	9.87	7.15	8.10	0.95	13.29	7.38	8.23	0.85	11.53
40	7.20	7.50	0.30	4.17	6.95	7.25	0.30	4.32	7.08	7.38	0.30	4.24
50	7.40	7.20	-0.20	-2.70	7.60	8.15	0.55	7.24	7.50	7.68	0.18	2.33
60	7.00	7.00	0.00	0.00	7.40	7.55	0.15	2.03	7.20	7.28	0.08	1.04
70	7.50	7.65	0.15	2.00	7.15	8.10	0.95	13.29	7.33	7.88	0.55	7.51
80	6.90	7.15	0.25	3.62	7.20	7.40	0.20	2.78	7.05	7.28	0.23	3.19
90	7.60	7.35	-0.25	-3.29	6.75	7.35	0.60	8.89	7.18	7.35	0.18	2.44
100	7.40	7.50	0.10	1.35	6.95	8.10	1.15	16.55	7.18	7.80	0.62	8.71
110	7.35	7.00	-0.35	-4.76	6.90	7.20	0.30	4.35	7.13	7.10	-0.03	-0.35
120	7.45	6.85	-0.60	-8.05	7.75	7.25	-0.50	-6.45	7.60	7.05	-0.55	-7.24
130	6.60	7.00	0.40	6.06	7.05	7.30	0.25	3.55	6.83	7.15	0.33	4.76
140	7.20	8.00	0.80	11.11	6.90	7.40	0.50	7.25	7.05	7.70	0.65	9.22
COOKING AT 92 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ai	af	af-ai	%a	ai	af	af-ai	%a	ai	af	af-ai	%a
0	6.85	7.30	0.45	6.57	7.15	7.70	0.55	7.69	7.00	7.50	0.50	7.14
10	7.50	8.35	0.85	11.33	7.70	8.45	0.75	9.74	7.60	8.40	0.80	10.53
20	7.30	8.00	0.70	9.59	6.90	7.65	0.75	10.87	7.10	7.83	0.73	10.21
30	7.55	7.15	-0.40	-5.30	7.50	7.50	0.00	0.00	7.53	7.33	-0.20	-2.66
40	7.50	7.60	0.10	1.33	7.60	8.10	0.50	6.58	7.55	7.85	0.30	3.97
50	7.65	8.25	0.60	7.84	7.35	7.60	0.25	3.40	7.50	7.93	0.43	5.67
60	7.60	7.60	0.00	0.00	7.00	7.35	0.35	5.00	7.30	7.48	0.18	2.40
70	7.20	7.40	0.20	2.78	7.15	7.40	0.25	3.50	7.18	7.40	0.23	3.14
80	7.55	7.70	0.15	1.99	7.50	7.90	0.40	5.33	7.53	7.80	0.28	3.65
90	7.90	8.15	0.25	3.16	7.25	7.65	0.40	5.52	7.58	7.90	0.33	4.29
100	7.50	7.60	0.10	1.33	7.45	7.55	0.10	1.34	7.48	7.58	0.10	1.34
110	7.45	7.50	0.05	0.67	7.45	7.45	0.00	0.00	7.45	7.48	0.02	0.34
120	6.90	7.50	0.60	8.70	7.20	7.65	0.45	6.25	7.05	7.58	0.52	7.45
130	7.60	7.45	-0.15	-1.97	6.95	6.90	-0.05	-0.72	7.28	7.18	-0.10	-1.37
140	7.80	7.15	-0.65	-8.33	7.50	7.65	0.15	2.00	7.65	7.40	-0.25	-3.27
COOKING AT 97 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ai	af	af-ai	%a	ai	af	af-ai	%a	ai	af	af-ai	%a
0	7.05	7.70	0.65	9.22	7.65	8.20	0.55	7.19	7.35	7.95	0.60	8.16
10	7.20	7.55	0.35	4.86	7.40	8.15	0.75	10.14	7.30	7.85	0.55	7.53
20	7.05	7.41	0.36	5.11	7.40	8.15	0.75	10.14	7.23	7.78	0.56	7.68
30	7.15	7.65	0.50	6.99	7.75	8.45	0.70	9.03	7.45	8.05	0.60	8.05
40	7.55	8.25	0.70	9.27	7.35	7.85	0.50	6.80	7.45	8.05	0.60	8.05
50	6.85	7.00	0.15	2.19	7.00	7.70	0.70	10.00	6.93	7.35	0.43	6.14
60	7.00	7.15	0.15	2.14	6.90	7.25	0.35	5.07	6.95	7.20	0.25	3.60
70	7.60	7.50	-0.10	-1.32	7.85	8.05	0.20	2.55	7.73	7.78	0.05	0.65
80	7.00	7.15	0.15	2.14	7.40	8.25	0.85	11.49	7.20	7.70	0.50	6.94
90	7.35	7.15	-0.20	-2.72	7.35	7.45	0.10	1.36	7.35	7.30	-0.05	-0.68
100	7.55	7.80	0.25	3.31	7.15	7.30	0.15	2.10	7.35	7.55	0.20	2.72
110	7.40	8.20	0.80	10.81	6.90	7.00	0.10	1.45	7.15	7.60	0.45	6.29
120	-	-	-	-	7.20	8.20	1.00	13.89	7.20	8.20	1.00	13.89
130	-	-	-	-	7.50	7.65	0.15	2.00	7.50	7.65	0.15	2.00

Table A.2. Widths "b" (cm) of grains during Atmospheric Cooking

COOKING AT 87 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b
0	2.75	3.10	0.35	12.73	2.75	3.10	0.35	12.73	2.75	3.10	0.35	12.73
10	2.65	3.15	0.50	18.87	3.10	3.55	0.45	14.52	2.88	3.35	0.48	16.52
20	3.45	3.95	0.50	14.49	3.00	3.55	0.55	18.33	3.23	3.75	0.53	16.28
30	3.25	4.15	0.90	27.69	3.10	4.05	0.95	30.65	3.18	4.10	0.93	29.13
40	2.70	3.80	1.10	40.74	3.20	4.30	1.10	34.38	2.95	4.05	1.10	37.29
50	2.85	4.15	1.30	45.61	3.25	4.30	1.05	32.31	3.05	4.23	1.18	38.52
60	2.95	3.70	0.75	25.42	3.20	4.55	1.35	42.19	3.08	4.13	1.05	34.15
70	3.35	5.00	1.65	49.25	3.25	4.50	1.25	38.46	3.30	4.75	1.45	43.94
80	3.35	5.00	1.65	49.25	3.00	4.50	1.50	50.00	3.18	4.75	1.58	49.61
90	3.50	4.80	1.30	37.14	3.00	4.60	1.60	53.33	3.25	4.70	1.45	44.62
100	3.20	4.75	1.55	48.44	2.95	5.00	2.05	69.49	3.08	4.88	1.80	58.54
110	3.00	4.85	1.85	61.67	2.60	4.50	1.90	73.08	2.80	4.68	1.88	66.96
120	2.95	4.55	1.60	54.24	3.25	4.35	1.10	33.85	3.10	4.45	1.35	43.55
130	3.05	4.80	1.75	57.38	2.70	4.70	2.00	74.07	2.88	4.75	1.88	65.22
140	3.15	5.00	1.85	58.73	3.00	4.70	1.70	56.67	3.08	4.85	1.78	57.72
COOKING AT 92 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b
0	3.05	3.30	0.25	8.20	2.90	3.20	0.30	10.34	2.98	3.25	0.28	9.24
10	2.90	3.50	0.60	20.69	3.15	3.75	0.60	19.05	3.03	3.63	0.60	19.83
20	3.00	4.35	1.35	45.00	3.00	3.75	0.75	25.00	3.00	4.05	1.05	35.00
30	3.40	4.10	0.70	20.59	3.00	3.75	0.75	25.00	3.20	3.93	0.73	22.66
40	3.15	4.70	1.55	49.21	3.25	4.30	1.05	32.31	3.20	4.50	1.30	40.63
50	3.55	4.85	1.30	36.62	3.05	4.20	1.15	37.70	3.30	4.53	1.23	37.12
60	3.00	4.75	1.75	58.33	3.05	4.40	1.35	44.26	3.03	4.58	1.55	51.24
70	3.30	4.90	1.60	48.48	3.05	4.80	1.75	57.38	3.18	4.85	1.68	52.76
80	3.20	4.90	1.70	53.13	3.00	4.85	1.85	61.67	3.10	4.88	1.78	57.26
90	3.30	5.45	2.15	65.15	3.15	4.90	1.75	55.56	3.23	5.18	1.95	60.47
100	3.15	5.25	2.10	66.67	3.10	5.25	2.15	69.35	3.13	5.25	2.13	68.00
110	3.10	4.90	1.80	58.06	3.05	4.70	1.65	54.10	3.08	4.80	1.73	56.10
120	2.85	4.45	1.60	56.14	3.10	5.00	1.90	61.29	2.98	4.73	1.75	58.82
130	3.50	4.70	1.20	34.29	2.85	4.75	1.90	66.67	3.18	4.73	1.55	48.82
140	3.10	5.00	1.90	61.29	3.05	5.25	2.20	72.13	3.08	5.13	2.05	66.67
COOKING AT 97 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b
0	3.25	3.60	0.35	10.77	3.20	3.30	0.10	3.12	3.23	3.45	0.23	6.98
10	3.20	3.70	0.50	15.63	3.00	3.60	0.60	20.00	3.10	3.65	0.55	17.74
20	3.00	3.75	0.75	25.00	3.25	4.10	0.85	26.15	3.13	3.93	0.80	25.60
30	2.95	4.15	1.20	40.68	3.20	4.65	1.45	45.31	3.08	4.40	1.33	43.09
40	3.35	4.55	1.20	35.82	3.00	4.70	1.70	56.67	3.18	4.63	1.45	45.67
50	3.15	4.50	1.35	42.86	3.25	4.60	1.35	41.54	3.20	4.55	1.35	42.19
60	3.00	4.30	1.30	43.33	2.80	4.45	1.65	58.93	2.90	4.38	1.48	50.86
70	3.15	4.50	1.35	42.86	3.05	5.25	2.20	72.13	3.10	4.88	1.78	57.26
80	2.90	4.55	1.65	56.90	3.30	5.25	1.95	59.09	3.10	4.90	1.80	58.06
90	3.30	4.60	1.30	39.39	2.80	4.65	1.85	66.07	3.05	4.63	1.58	51.64
100	3.20	4.50	1.30	40.63	3.15	4.85	1.70	53.97	3.18	4.68	1.50	47.24
110	3.20	5.00	1.80	56.25	2.95	4.60	1.65	55.93	3.08	4.80	1.73	56.10
120	-	-	-	-	3.35	5.50	2.15	64.18	3.35	5.50	2.15	64.18
130	-	-	-	-	2.95	4.80	1.85	62.71	2.95	4.80	1.85	62.71

Table A.3. Widths "c (cm) of grains during Atmospheric Cooking

COOKING AT 87 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c
0	2.80	2.90	0.10	3.57	2.75	3.20	0.45	16.36	2.78	3.05	0.28	9.91
10	2.85	3.10	0.25	8.77	2.60	2.90	0.30	11.54	2.73	3.00	0.28	10.09
20	3.25	3.55	0.30	9.23	2.90	3.35	0.45	15.52	3.08	3.45	0.38	12.20
30	3.10	3.55	0.45	14.52	2.80	3.55	0.75	26.79	2.95	3.55	0.60	20.34
40	2.70	3.05	0.35	12.96	2.90	3.60	0.70	24.14	2.80	3.33	0.53	18.75
50	2.60	3.25	0.65	25.00	3.10	3.80	0.70	22.58	2.85	3.53	0.68	23.68
60	2.65	3.20	0.55	20.75	2.95	3.75	0.80	27.12	2.80	3.48	0.68	24.11
70	3.00	3.40	0.40	13.33	3.05	3.60	0.55	18.03	3.03	3.50	0.48	15.70
80	3.20	3.90	0.70	21.88	2.80	3.85	1.05	37.50	3.00	3.88	0.88	29.17
90	3.05	3.95	0.90	29.51	2.70	3.90	1.20	44.44	2.88	3.93	1.05	36.52
100	2.75	3.65	0.90	32.73	2.90	4.05	1.15	39.66	2.83	3.85	1.03	36.28
110	2.90	3.90	1.00	34.48	2.80	3.75	0.95	33.93	2.85	3.83	0.98	34.21
120	2.80	3.75	0.95	33.93	2.95	3.25	0.30	10.17	2.88	3.50	0.63	21.74
130	3.05	3.90	0.85	27.87	2.45	3.85	1.40	57.14	2.75	3.88	1.13	40.91
140	2.83	3.50	0.67	23.67	3.05	4.45	1.40	45.90	2.94	3.98	1.04	35.20
COOKING AT 92 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c
0	2.75	3.20	0.45	16.36	2.75	2.90	0.15	5.45	2.75	3.05	0.30	10.91
10	2.70	3.40	0.70	25.93	3.25	3.75	0.50	15.38	2.98	3.58	0.60	20.17
20	2.65	3.45	0.80	30.19	2.75	3.50	0.75	27.27	2.70	3.48	0.78	28.70
30	2.95	3.25	0.30	10.17	2.90	3.60	0.70	24.14	2.93	3.43	0.50	17.09
40	3.10	3.20	0.10	3.23	3.20	3.85	0.65	20.31	3.15	3.53	0.38	11.90
50	3.25	3.95	0.70	21.54	2.75	3.30	0.55	20.00	3.00	3.63	0.63	20.83
60	2.90	3.65	0.75	25.86	3.05	3.90	0.85	27.87	2.98	3.78	0.80	26.89
70	2.75	4.00	1.25	45.45	2.85	3.85	1.00	35.09	2.80	3.93	1.13	40.18
80	3.15	3.85	0.70	22.22	2.90	3.85	0.95	32.76	3.03	3.85	0.83	27.27
90	3.10	3.90	0.80	25.81	2.90	4.05	1.15	39.66	3.00	3.98	0.98	32.50
100	3.00	4.05	1.05	35.00	3.50	4.55	1.05	30.00	3.25	4.30	1.05	32.31
110	2.90	4.05	1.15	39.66	2.55	3.50	0.95	37.25	2.73	3.78	1.05	38.53
120	2.70	3.50	0.80	29.63	3.00	4.25	1.25	41.67	2.85	3.88	1.03	35.96
130	3.00	3.95	0.95	31.67	2.85	4.15	1.30	45.61	2.93	4.05	1.13	38.46
140	2.85	3.95	1.10	38.60	2.90	4.55	1.65	56.90	2.88	4.25	1.38	47.83
COOKING AT 97 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c
0	3.00	3.35	0.35	11.67	3.05	3.30	0.25	8.20	3.03	3.33	0.30	9.92
10	2.60	2.95	0.35	13.46	2.90	3.35	0.45	15.52	2.75	3.15	0.40	14.55
20	3.05	3.50	0.45	14.75	3.00	3.55	0.55	18.33	3.03	3.53	0.50	16.53
30	2.85	3.50	0.65	22.81	3.05	3.80	0.75	24.59	2.95	3.65	0.70	23.73
40	2.90	4.40	1.50	51.72	2.95	3.80	0.85	28.81	2.93	4.10	1.18	40.17
50	2.85	3.80	0.95	33.33	3.10	4.20	1.10	35.48	2.98	4.00	1.03	34.45
60	2.90	3.25	0.35	12.07	2.60	3.60	1.00	38.46	2.75	3.43	0.68	24.55
70	2.90	3.90	1.00	34.48	2.95	4.10	1.15	38.98	2.93	4.00	1.08	36.75
80	2.85	3.75	0.90	31.58	3.10	4.10	1.00	32.26	2.98	3.93	0.95	31.93
90	3.00	4.15	1.15	38.33	2.95	4.25	1.30	44.07	2.98	4.20	1.23	41.18
100	2.80	4.15	1.35	48.21	3.00	4.25	1.25	41.67	2.90	4.20	1.30	44.83
110	2.75	3.65	0.90	32.73	2.75	4.00	1.25	45.45	2.75	3.83	1.08	39.09
120	-	-	-	-	2.95	4.50	1.55	52.54	2.95	4.50	1.55	52.54
130	-	-	-	-	2.90	4.90	2.00	68.97	2.90	4.90	2.00	68.97

Table A.4. Weights "W" (g) of grains during Atmospheric Cooking

COOKING AT 87 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W
0	0.0442	0.0542	0.0100	22.62	0.0399	0.0535	0.0136	34.09	0.0421	0.0539	0.0118	28.06
10	0.0454	0.0633	0.0179	39.43	0.0479	0.0699	0.0220	45.93	0.0467	0.0666	0.0200	42.77
20	0.0646	0.0891	0.0245	37.93	0.0431	0.0599	0.0168	38.98	0.0539	0.0745	0.0207	38.35
30	0.0568	0.0878	0.0310	54.58	0.0500	0.0776	0.0276	55.20	0.0534	0.0827	0.0293	54.87
40	0.0431	0.0707	0.0276	64.04	0.0486	0.0807	0.0321	66.05	0.0459	0.0757	0.0299	65.10
50	0.0417	0.0680	0.0263	63.07	0.0575	0.0921	0.0346	60.17	0.0496	0.0801	0.0305	61.39
60	0.0431	0.0713	0.0282	65.43	0.0500	0.0860	0.0360	72.00	0.0466	0.0787	0.0321	68.96
70	0.0561	0.0999	0.0438	78.07	0.0547	0.0920	0.0373	68.19	0.0554	0.0960	0.0406	73.19
80	0.0545	0.1061	0.0516	94.68	0.0486	0.0900	0.0414	85.19	0.0516	0.0981	0.0465	90.20
90	0.0561	-	-	-	0.0394	0.0799	0.0405	102.79	0.0478	0.0400	-0.0078	-16.34
100	0.0494	0.0908	0.0414	83.81	0.0617	0.1142	0.0525	85.09	0.0556	0.1025	0.0470	84.52
110	0.0452	0.0979	0.0527	116.59	0.0394	0.0791	0.0397	100.76	0.0423	0.0885	0.0462	109.22
120	0.0483	0.0825	0.0342	70.81	0.0440	0.0740	0.0300	68.18	0.0462	0.0783	0.0321	69.56
130	0.0499	0.0974	0.0475	95.19	0.0463	0.0900	0.0437	94.38	0.0481	0.0937	0.0456	94.80
140	0.0517	0.1067	0.0550	106.38	0.0455	0.1028	0.0573	125.93	0.0486	0.1048	0.0562	115.53
COOKING AT 92 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W
0	0.0441	0.0580	0.0139	31.52	0.0425	0.0528	0.0103	24.24	0.0433	0.0554	0.0121	27.94
10	0.0464	0.0683	0.0219	47.20	0.0573	0.0795	0.0222	38.74	0.0519	0.0739	0.0221	42.53
20	0.0466	0.0832	0.0366	78.54	0.0455	0.0696	0.0241	52.97	0.0461	0.0764	0.0304	65.91
30	0.0546	0.0635	0.0089	16.30	0.0499	0.0684	0.0185	37.07	0.0523	0.0660	0.0137	26.22
40	0.0532	0.0848	0.0316	59.40	0.0581	0.0949	0.0368	63.34	0.0557	0.0899	0.0342	61.46
50	0.0689	0.1182	0.0493	71.55	0.0430	0.0743	0.0443	103.02	0.0560	0.0963	0.0403	72.03
60	0.0517	0.1017	0.0500	96.71	0.0469	0.0814	0.0345	73.56	0.0493	0.0916	0.0423	85.70
70	0.0478	0.1000	0.0522	109.21	0.0478	0.0940	0.0462	96.65	0.0478	0.0970	0.0492	102.93
80	0.0510	0.1099	0.0589	115.49	0.0499	0.0999	0.0500	100.20	0.0505	0.1049	0.0545	107.93
90	0.0590	0.1300	0.0710	120.34	0.0500	0.1059	0.0559	111.80	0.0545	0.1180	0.0635	116.42
100	0.0508	0.1069	0.0561	110.43	0.0561	0.1237	0.0676	120.50	0.0535	0.1153	0.0619	115.72
110	0.0538	0.1260	0.0722	134.20	0.0415	0.0854	0.0439	105.78	0.0477	0.1057	0.0581	121.83
120	0.0417	0.0861	0.0444	106.47	0.0461	0.1023	0.0562	121.91	0.0439	0.0942	0.0503	114.58
130	0.0600	0.1056	0.0456	76.00	0.0415	0.0882	0.0467	112.53	0.0508	0.0969	0.0462	90.94
140	0.0600	0.1053	0.0453	75.50	0.0475	0.1106	0.0631	132.84	0.0538	0.1080	0.0542	100.84
COOKING AT 97 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W
0	0.0511	0.0660	0.0149	29.16	0.0570	0.0623	0.0053	9.30	0.0541	0.0642	0.0101	18.69
10	0.0452	0.0665	0.0213	47.12	0.0499	0.0731	0.0232	46.49	0.0476	0.0698	0.0223	46.79
20	0.0504	0.0776	0.0272	53.97	0.0528	0.0802	0.0274	51.89	0.0516	0.0789	0.0273	52.91
30	0.0450	0.0793	0.0343	76.22	0.0570	0.0984	0.0414	72.63	0.0510	0.0889	0.0379	74.22
40	0.0566	0.1217	0.0651	115.02	0.0478	0.0863	0.0385	80.54	0.0522	0.1040	0.0518	99.23
50	0.0471	0.1062	0.0591	125.48	0.0528	0.0931	0.0403	76.33	0.0500	0.0997	0.0497	99.50
60	0.0460	0.0847	0.0387	84.13	0.0398	0.0814	0.0416	104.52	0.0429	0.0831	0.0402	93.59
70	0.0520	0.1006	0.0486	93.46	0.0549	0.1187	0.0638	116.21	0.0535	0.1097	0.0562	105.14
80	0.0432	0.0818	0.0386	89.35	0.0559	0.1183	0.0624	111.63	0.0496	0.1001	0.0505	101.92
90	0.0531	0.1095	0.0564	106.21	0.0450	0.0999	0.0549	122.00	0.0491	0.1047	0.0557	113.46
100	0.0506	0.1051	0.0545	107.71	0.0489	0.1045	0.0556	113.70	0.0498	0.1048	0.0551	110.65
110	0.0493	0.1173	0.0680	137.93	0.0422	0.0963	0.0541	128.20	0.0458	0.1068	0.0611	133.44
120	-	-	-	-	0.0538	0.1235	0.0697	129.55	0.0269	0.0618	0.0349	129.55
130	-	-	-	-	0.0460	0.1199	0.0739	160.65	0.0230	0.0600	0.0370	160.65

Table A.5. Volumes "V" (cm^3) of grains during Atmospheric Cooking

COOKING AT 87 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V
0	30.22	35.29	5.06	16.75	29.09	40.23	11.14	38.31	29.66	37.76	8.10	27.32
10	29.05	40.88	11.83	40.73	30.37	43.10	12.73	41.92	29.71	41.99	12.28	41.34
20	44.89	60.18	15.29	34.05	31.42	47.30	15.88	50.56	38.15	53.74	15.58	40.84
30	40.07	64.38	24.31	60.66	32.48	60.95	28.47	87.65	36.28	62.66	26.39	72.74
40	27.47	45.49	18.02	65.61	33.75	58.73	24.98	74.01	30.61	52.11	21.50	70.24
50	28.70	50.82	22.12	77.10	40.07	69.69	29.62	73.92	34.38	60.26	25.87	75.25
60	28.64	43.37	14.74	51.46	36.56	67.42	30.86	84.41	32.60	55.40	22.80	69.93
70	39.45	68.06	28.61	72.54	37.09	68.67	31.58	85.14	38.27	68.36	30.10	78.65
80	38.71	72.97	34.26	88.49	31.65	67.09	35.44	111.98	35.18	70.03	34.85	99.06
90	42.46	72.93	30.47	71.77	28.61	69.01	40.39	141.17	35.53	70.97	35.44	99.72
100	34.08	68.05	33.97	99.68	31.12	85.84	54.72	175.87	32.60	76.94	44.35	136.03
110	33.46	69.29	35.83	107.06	26.29	63.59	37.30	141.88	29.88	66.44	36.56	122.38
120	32.20	61.17	28.96	89.93	38.89	53.64	14.75	37.94	35.55	57.40	21.86	61.48
130	32.13	68.58	36.45	113.43	24.41	69.13	44.72	183.25	28.27	68.85	40.58	143.55
140	33.59	73.27	39.68	118.12	33.04	81.00	47.96	145.14	33.31	77.13	43.82	131.53
COOKING AT 92 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V
0	30.07	40.34	10.27	34.17	29.84	37.40	7.55	25.31	29.96	38.87	8.92	29.76
10	30.73	52.00	21.27	69.20	41.25	62.19	20.93	50.74	35.99	57.10	21.11	58.64
20	30.37	62.83	32.46	106.88	29.79	52.55	22.76	76.38	30.08	57.69	27.61	91.79
30	39.63	49.86	10.23	25.81	34.15	52.99	18.84	55.17	36.89	51.43	14.54	39.40
40	38.33	59.82	21.49	56.07	41.36	70.18	28.81	69.66	39.85	65.00	25.16	63.13
50	46.19	82.71	36.52	79.07	32.26	55.13	22.86	70.87	39.23	68.92	29.70	75.70
60	34.60	68.96	34.35	99.28	34.08	66.01	31.93	93.69	34.34	67.49	33.15	96.52
70	34.19	75.90	41.71	121.98	32.53	71.57	39.04	120.03	33.36	73.74	40.38	121.03
80	39.83	76.02	36.19	90.87	34.15	77.20	43.05	126.07	36.99	76.61	39.62	107.11
90	42.29	90.66	48.36	114.35	34.66	79.45	44.79	129.23	38.48	85.06	46.58	121.07
100	37.09	84.57	47.48	128.00	42.30	94.38	52.08	123.12	39.70	89.48	49.78	125.41
110	35.05	77.89	42.84	122.23	30.32	64.14	33.81	111.51	32.69	71.02	38.33	117.27
120	27.79	61.13	33.35	120.00	35.04	85.07	50.03	142.78	31.42	73.10	41.69	132.69
130	41.76	72.38	30.62	73.32	29.54	71.18	41.64	140.94	35.65	71.78	36.13	101.35
140	36.06	73.90	37.84	104.91	34.72	95.63	60.92	175.47	35.39	84.77	49.38	139.52
COOKING AT 97 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V
0	35.97	48.60	12.63	35.10	39.07	46.73	7.66	19.60	37.52	47.67	10.15	27.04
10	31.35	43.13	11.78	37.57	33.69	51.44	17.75	52.67	32.52	47.29	14.77	45.40
20	33.76	50.90	17.14	50.77	37.76	62.08	24.32	64.41	35.76	56.49	20.73	57.97
30	31.46	58.15	26.69	84.84	39.58	78.14	38.55	97.40	35.52	68.15	32.63	91.85
40	38.39	86.44	48.05	125.18	34.04	73.37	39.33	115.54	36.22	79.91	43.69	120.64
50	32.18	62.64	30.46	94.65	36.91	77.85	40.95	110.94	34.55	70.25	35.70	103.34
60	31.87	52.29	20.42	64.07	26.29	60.78	34.49	131.22	29.08	56.54	27.46	94.41
70	36.33	68.88	32.55	89.59	36.96	90.68	53.72	145.33	36.65	79.78	43.14	117.71
80	30.28	63.85	33.57	110.87	39.62	92.93	53.32	134.58	34.95	78.39	43.44	124.29
90	38.08	71.43	33.35	87.58	31.77	77.05	45.28	142.51	34.93	74.24	39.32	112.57
100	35.40	76.23	40.83	115.33	35.36	78.75	43.39	122.70	35.38	77.49	42.11	119.02
110	34.08	78.32	44.24	129.81	29.29	67.41	38.11	130.10	31.69	72.87	41.18	129.97
120	-	-	-	-	37.24	106.21	68.97	185.23	37.24	106.21	68.97	185.20
130	-	-	-	-	33.58	94.16	60.58	180.43	33.58	94.16	60.58	180.41

Table A.6. Densities "ρ" (g/cm^3) of grains during Atmospheric Cooking

COOKING AT 87 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ
0	1.462	1.536	0.074	5.035	1.372	1.330	-0.042	-3.056	1.417	1.433	0.016	1.119
10	1.563	1.548	-0.014	-0.925	1.577	1.622	0.045	2.824	1.570	1.585	0.015	0.958
20	1.439	1.481	0.042	2.889	1.372	1.266	-0.106	-7.694	1.406	1.374	-0.032	-2.276
30	1.417	1.364	-0.054	-3.785	1.539	1.273	-0.266	-17.292	1.478	1.319	-0.160	-10.817
40	1.569	1.554	-0.015	-0.950	1.440	1.374	-0.066	-4.575	1.504	1.464	-0.040	-2.685
50	1.453	1.338	-0.115	-7.921	1.435	1.322	-0.113	-7.904	1.444	1.330	-0.114	-7.913
60	1.505	1.644	0.139	9.227	1.368	1.276	-0.092	-6.730	1.436	1.460	0.023	1.630
70	1.422	1.468	0.046	3.209	1.475	1.340	-0.135	-9.157	1.448	1.404	-0.045	-3.086
80	1.408	1.454	0.046	3.281	1.535	1.341	-0.194	-12.640	1.472	1.398	-0.074	-5.024
90	1.321	-	-	-	1.377	1.158	-0.219	-15.913	-	-	-	-
100	1.450	1.334	-0.115	-7.949	1.983	1.330	-0.653	-32.907	1.716	1.332	-0.384	-22.367
110	1.351	1.413	0.062	4.604	1.499	1.244	-0.255	-16.999	1.425	1.328	-0.096	-6.759
120	1.500	1.349	-0.151	-10.069	1.132	1.380	0.248	21.920	1.316	1.364	0.049	3.687
130	1.553	1.420	-0.133	-8.547	1.897	1.302	-0.595	-31.372	1.725	1.361	-0.364	-21.098
140	1.539	1.456	-0.083	-5.382	1.377	1.269	-0.108	-7.836	1.458	1.363	-0.095	-6.541
COOKING AT 87 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ
0	1.467	1.438	-0.029	-1.978	1.424	1.412	-0.012	-0.861	1.445	1.425	-0.021	-1.428
10	1.510	1.313	-0.196	-13.005	1.389	1.278	-0.111	-7.960	1.449	1.296	-0.153	-10.588
20	1.534	1.324	-0.210	-13.696	1.527	1.325	-0.203	-13.276	1.531	1.324	-0.206	-13.487
30	1.378	1.274	-0.104	-7.561	1.461	1.291	-0.170	-11.663	1.420	1.282	-0.137	-9.673
40	1.388	1.418	0.030	2.131	1.405	1.352	-0.052	-3.723	1.396	1.385	-0.011	-0.813
50	1.492	1.429	-0.063	-4.197	1.333	1.348	0.015	1.126	1.412	1.388	-0.024	-1.685
60	1.494	1.475	-0.019	-1.290	1.376	1.233	-0.143	-10.392	1.435	1.354	-0.081	-5.654
70	1.398	1.317	-0.080	-5.754	1.470	1.313	-0.156	-10.625	1.434	1.315	-0.118	-8.250
80	1.281	1.446	0.165	12.898	1.461	1.294	-0.167	-11.444	1.371	1.370	-0.001	-0.076
90	1.395	1.434	0.039	2.796	1.443	1.333	-0.110	-7.603	1.419	1.383	-0.035	-2.491
100	1.370	1.264	-0.106	-7.705	1.326	1.311	-0.016	-1.173	1.348	1.287	-0.061	-4.492
110	1.535	1.618	0.083	5.388	1.369	1.332	-0.037	-2.707	1.452	1.475	0.023	1.573
120	1.501	1.408	-0.092	-6.150	1.316	1.202	-0.113	-8.595	1.408	1.305	-0.103	-7.292
130	1.437	1.459	0.022	1.546	1.405	1.239	-0.166	-11.793	1.421	1.349	-0.072	-5.048
140	1.664	1.425	-0.239	-14.354	1.368	1.156	-0.212	-15.474	1.516	1.291	-0.225	-14.860
COOKING AT 87 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ
0	1.421	1.358	-0.062	-4.395	1.459	1.333	-0.126	-8.613	1.440	1.346	-0.094	-6.532
10	1.442	1.542	0.100	6.947	1.481	1.421	-0.060	-4.046	1.461	1.482	0.020	1.377
20	1.493	1.525	0.032	2.123	1.398	1.292	-0.106	-7.614	1.446	1.408	-0.037	-2.586
30	1.430	1.364	-0.067	-4.664	1.440	1.259	-0.181	-12.546	1.435	1.311	-0.124	-8.618
40	1.475	1.408	-0.067	-4.513	1.404	1.176	-0.228	-16.235	1.439	1.292	-0.147	-10.231
50	1.464	1.695	0.232	15.839	1.431	1.196	-0.235	-16.409	1.447	1.446	-0.001	-0.101
60	1.443	1.620	0.176	12.224	1.514	1.339	-0.175	-11.545	1.479	1.479	0.001	0.055
70	1.431	1.460	0.029	2.042	1.485	1.309	-0.176	-11.869	1.458	1.385	-0.074	-5.042
80	1.427	1.281	-0.146	-10.203	1.411	1.273	-0.138	-9.784	1.419	1.277	-0.142	-9.995
90	1.394	1.533	0.139	9.934	1.416	1.297	-0.120	-8.458	1.405	1.415	0.009	0.666
100	1.429	1.379	-0.051	-3.539	1.383	1.327	-0.056	-4.040	1.406	1.353	-0.053	-3.785
110	1.447	1.498	0.051	3.535	1.441	1.429	-0.012	-0.825	1.444	1.463	0.020	1.360
120	-	-	-	-	1.445	1.163	-0.282	-19.519	1.445	1.163	-0.282	-19.519
130	-	-	-	-	1.370	1.273	-0.097	-7.051	1.370	1.273	-0.097	-7.051

Table A.7. Percent Moisture Content "%mc" (w.b.) Atmospheric Cooking

COOKING AT 87 °C			
Time	TREATMENT I	TREATMENT II	AVERAGE
(min)	%mc	%mc	%mc
0	38.76	41.53	40.14
10	43.29	48.58	45.94
20	41.66	46.96	44.31
30	45.03	49.77	47.40
40	55.22	52.72	53.97
50	56.54	53.58	55.06
60	53.02	56.87	54.94
70	37.99	55.32	46.66
80	56.71	59.28	57.99
90	60.14	61.84	60.99
100	65.87	62.12	64.00
110	61.80	63.59	62.69
120	62.53	52.95	57.74
130	64.24	64.58	64.41
140	63.69	65.73	64.71
COOKING AT 92 °C			
Time	TREATMENT I	TREATMENT II	AVERAGE
(min)	%mc	%mc	%mc
0	41.14	41.08	41.11
10	46.77	46.98	46.87
20	48.60	51.02	49.81
30	50.13	47.98	49.05
40	52.96	53.60	53.28
50	0.05	56.93	28.49
60	56.76	61.48	59.12
70	58.87	62.76	60.82
80	60.25	64.66	62.46
90	61.13	62.80	61.97
100	60.73	63.60	62.16
110	60.74	67.14	63.94
120	61.19	65.50	63.34
130	60.53	65.91	63.22
140	64.28	67.97	66.12
COOKING AT 97 °C			
Time	TREATMENT I	TREATMENT II	AVERAGE
(min)	%mc	%mc	%mc
0	35.69	41.01	38.35
10	46.13	51.79	48.96
20	47.24	61.93	54.59
30	53.25	54.77	54.01
40	53.85	58.64	56.25
50	56.54	64.32	60.43
60	58.64	60.90	59.77
70	58.11	64.22	61.17
80	59.47	68.98	64.23
90	66.39	67.92	67.16
100	67.00	67.21	67.11
110	65.19	67.69	66.44
120	-	63.06	63.06
130	-	70.82	70.82
140	-	69.90	69.90

Table A.8. Percent Starch Gelatinization during Atmospheric Cooking

COOKING AT 87 °C			
Time	TREATMENT I	TREATMENT II	AVERAGE
(min)	%Gelatinization	%Gelatinization	%Gelatinization
0	0	0	0.00
10	1	0	0.50
20	1	2	1.50
30	6	5	5.50
40	12	12	12.00
50	15	17	16.00
60	18	19	18.50
70	18	20	19.00
80	19	23	21.00
90	19	22	20.50
100	23	17	20.00
110	21	19	20.00
120	22	18	20.00
130	17	14	15.50
140	11	9	10.00
COOKING AT 92 °C			
Time	TREATMENT I	TREATMENT II	AVERAGE
(min)	%Gelatinization	%Gelatinization	%Gelatinization
0	0	1	0.50
10	4	5	4.50
20	14	14	14.00
30	15	16	15.50
40	19	21	20.00
50	25	28	26.50
60	27	29	28.00
70	31	33	32.00
80	32	35	33.50
90	32	32	32.00
100	29	27	28.00
110	15	17	16.00
120	10	13	11.50
130	6	8	7.00
140	6	5	5.50
COOKING AT 97 °C			
Time	TREATMENT I	TREATMENT II	AVERAGE
(min)	Gelatinization%	Gelatinization%	Gelatinization%
0	2	3	2.50
10	8	14	11.00
20	19	25	22.00
30	31	29	30.00
40	42	44	43.00
50	54	54	54.00
60	52	55	53.50
70	50	48	49.00
80	39	37	38.00
90	27	31	29.00
100	10	11	10.50
110	6	5	5.50
120	-	4	4.00
130	-	2	2.00

Table A.9. Color Values during Atmospheric Cooking

COOKING AT 87 ^{O}C						
Time	TREATMENT I			TREATMENT II		
(min)	R	Y	B	R	Y	B
0				4,1	6,5	2,1
10	4.0	5,8	2,2	4,0	6,1	2,1
20	4.0	6,0	1,7	4,0	6,5	2,1
30	4.0	7,0	1,8	4,0	6,5	2,1
40	4,1	7,1	2,3	4,1	6,5	2,1
50	4,1	7,0	2,4	4,1	6,5	2,1
60	4,3	7,2	2,4	4,1	6,5	2,3
70	4,3	7,1	2,4	4,1	6,5	2,4
80	4,3	7,1	2,4	4,1	6,7	2,4
90	4,3	7,0	2,6	4,5	6,7	2,5
100	4,3	7,0	2,6	4,5	6,4	2,6
110	4,3	8,0	2,6	4,5	6,4	2,6
120	4,3	8,0	2,6	4,5	6,4	2,6
130	4,3	8,0	2,6	4,5	6,4	2,6
140	4,3	8,0	2,6	4,5	6,4	2,6
COOKING AT 92 ^{O}C						
Time	TREATMENT I			TREATMENT II		
(min)	R	Y	B	R	Y	B
0	3,5	5,2	1,4	4,0	6,6	1,7
10	4,0	6,2	1,6	4,0	6,1	1,7
20	3,7	6,2	1,6	4,0	6,1	2,1
30	4,1	6,2	2,4	4,0	6,3	2,1
40	4,4	6,2	2,4	4,0	6,2	2,1
50	4,2	6,2	2,4	4,1	6,2	2,1
60	4,2	6,4	2,5	4,2	6,2	2,4
70	4,4	6,6	2,7	4,2	6,2	2,4
80	4,4	6,6	2,7	4,4	6,4	2,6
90	4,4	6,6	2,7	4,4	6,5	2,6
100	4,4	6,6	2,7	4,4	6,5	2,6
110	4,4	6,6	2,7	4,4	6,5	2,6
120	4,4	6,6	2,7	4,5	6,6	2,6
130	4,4	6,6	2,7	4,6	6,7	2,6
140	4,4	6,6	2,7	4,7	6,8	2,6
COOKING AT 97 ^{O}C						
Time	TREATMENT I			TREATMENT II		
(min)	R	Y	B	R	Y	B
0	4,1	6,0	2,2	4,1	6,5	2,1
10	4,1	6,0	2,2	4,0	6,1	2,1
20	4,1	6,0	2,2	4,0	6,5	2,1
30	4,0	6,1	2,2	4,0	6,5	2,1
40	4,6	7,1	2,7	4,1	6,5	2,1
50	4,6	7,1	2,7	4,1	6,5	2,1
60	4,6	7,1	2,7	4,1	6,5	2,3
70	4,6	7,1	2,7	4,1	6,5	2,4
80	4,6	7,1	2,7	4,1	6,7	2,4
90	4,6	7,1	2,7	4,5	6,4	2,5
100	4,6	7,1	2,7	4,5	6,4	2,6
110	4,6	7,1	2,7	4,5	6,4	2,6
120	-	-	-	4,5	6,4	2,6
130	-	-	-	4,5	6,4	2,6

Table A.10. Percent Starch in Cooking Water during Atmospheric Cooking

COOKING AT 87 °C			
Time (min)	TREATMENT I %Starch	TREATMENT II %Starch	AVERAGE %Starch
initial	0.00	0.00	0.00
0	0.05	0.11	0.08
10	0.16	0.11	0.14
20	0.22	0.22	0.22
30	0.27	0.27	0.27
40	0.82	0.55	0.68
50	1.53	1.09	1.31
60	2.46	1.64	2.05
70	3.17	2.52	2.85
80	3.83	3.28	3.56
90	4.38	3.83	4.11
100	5.09	4.11	4.60
110	5.64	4.93	5.28
120	6.24	5.47	5.86
130	6.95	6.02	6.49
140	7.66	6.84	7.25
COOKING AT 92 °C			
Time (min)	TREATMENT I %Starch	TREATMENT II %Starch	AVERAGE %Starch
initial	0.00	0.00	0.00
0	0.16	0.16	0.16
10	0.33	0.22	0.27
20	0.55	0.44	0.49
30	1.09	0.82	0.96
40	1.37	1.26	1.31
50	2.03	1.81	1.92
60	2.68	2.52	2.60
70	3.56	3.28	3.42
80	4.11	3.89	4.00
90	4.93	4.49	4.71
100	5.47	5.31	5.39
110	6.02	5.91	5.97
120	8.21	6.84	7.53
130	9.85	8.21	9.03
140	10.95	10.07	10.51
COOKING AT 97 °C			
Time (min)	TREATMENT I %Starch	TREATMENT II %Starch	AVERAGE %Starch
initial	0.00	0.00	0.00
0	0.27	0.27	0.27
10	0.55	0.55	0.55
20	0.82	1.09	0.96
30	1.37	1.92	1.64
40	1.92	2.74	2.33
50	2.46	3.28	2.87
60	3.01	4.11	3.56
70	3.83	4.65	4.24
80	4.38	5.20	4.79
90	5.47	6.84	6.16
100	7.12	8.65	7.88
110	8.21	10.29	9.25
120	-	11.33	11.33
130	-	12.59	12.59
140	-	13.36	13.36

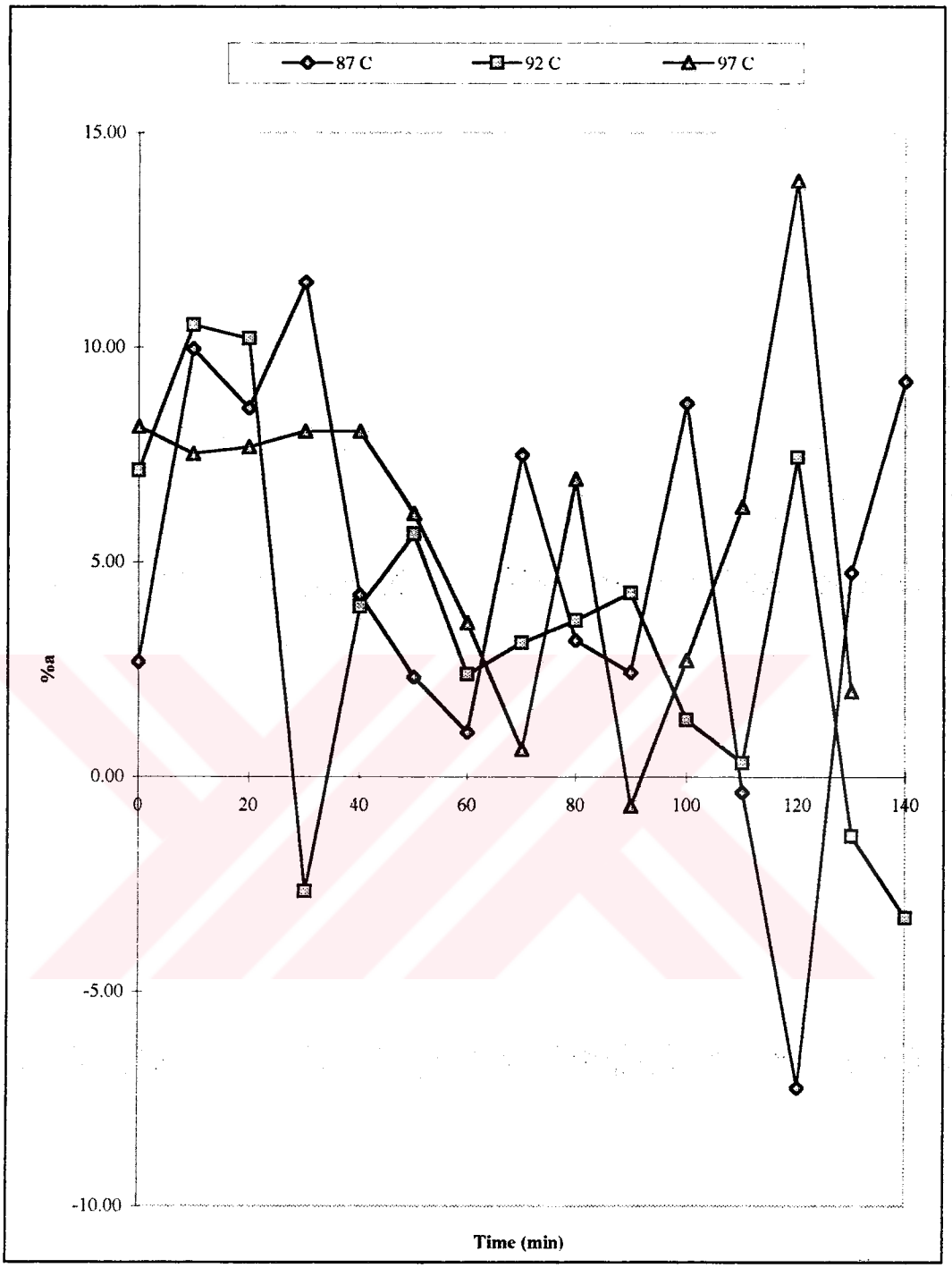

Figure A.1. Change (as percentage) in "a", average of Treatment I and II, of grains during Atmospheric Cooking

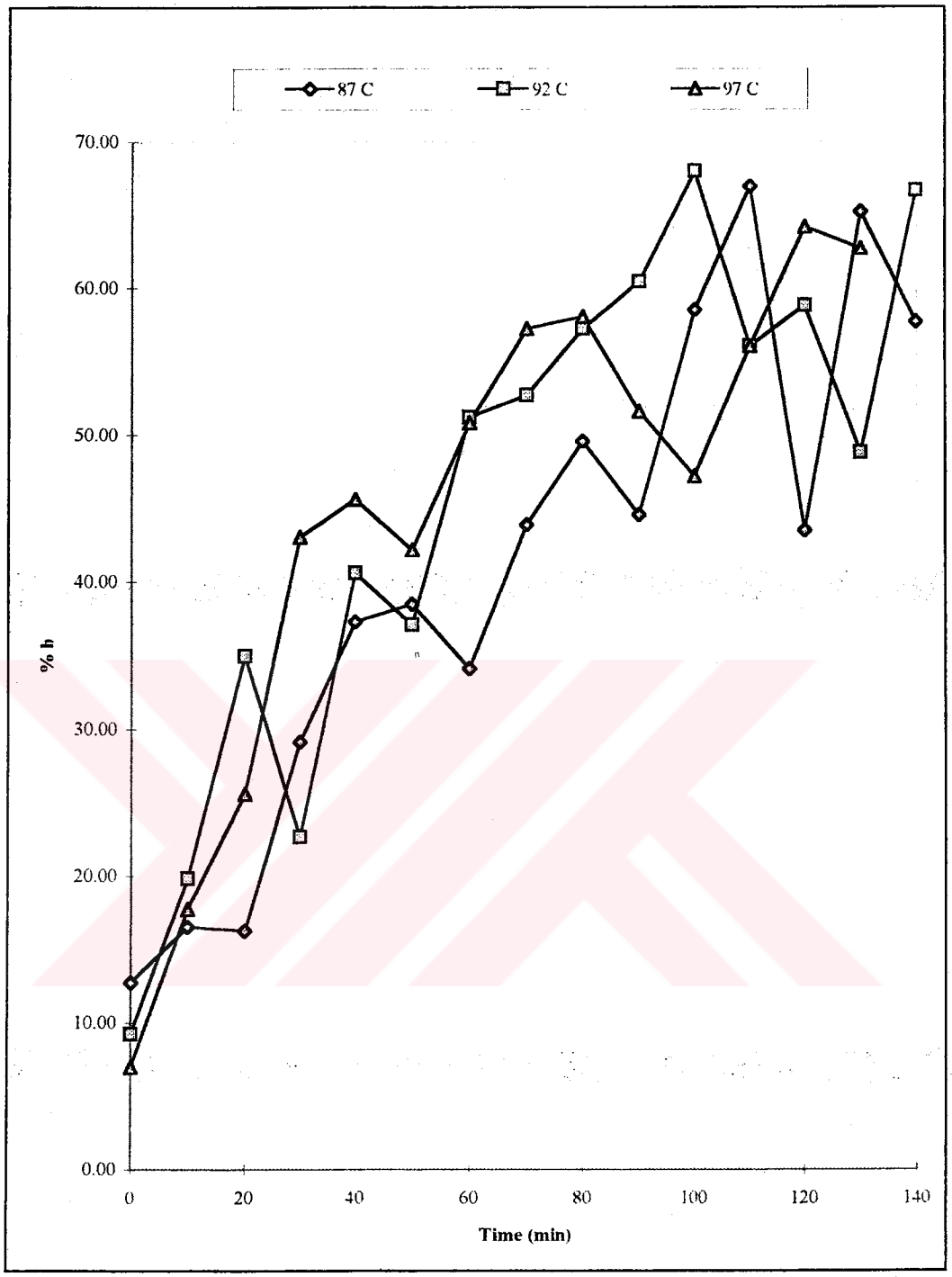

Figure A.2. Change (as percentage) in "b", average of Treatment I and II, of grains during Atmospheric Cooking

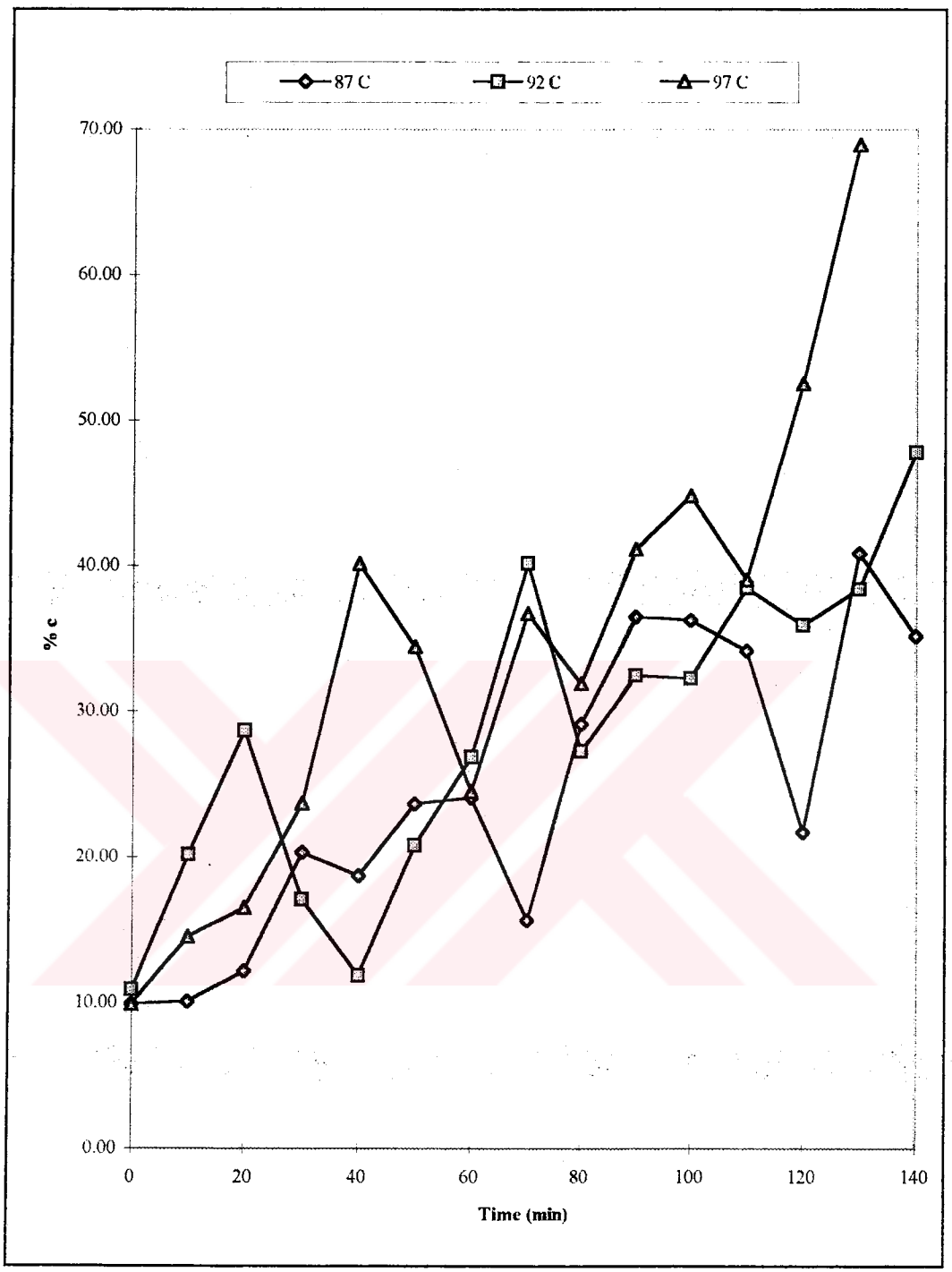

Figure A.3. Change (as percentage) in "c", average of Treatment I and II, of grains during Atmospheric Cooking

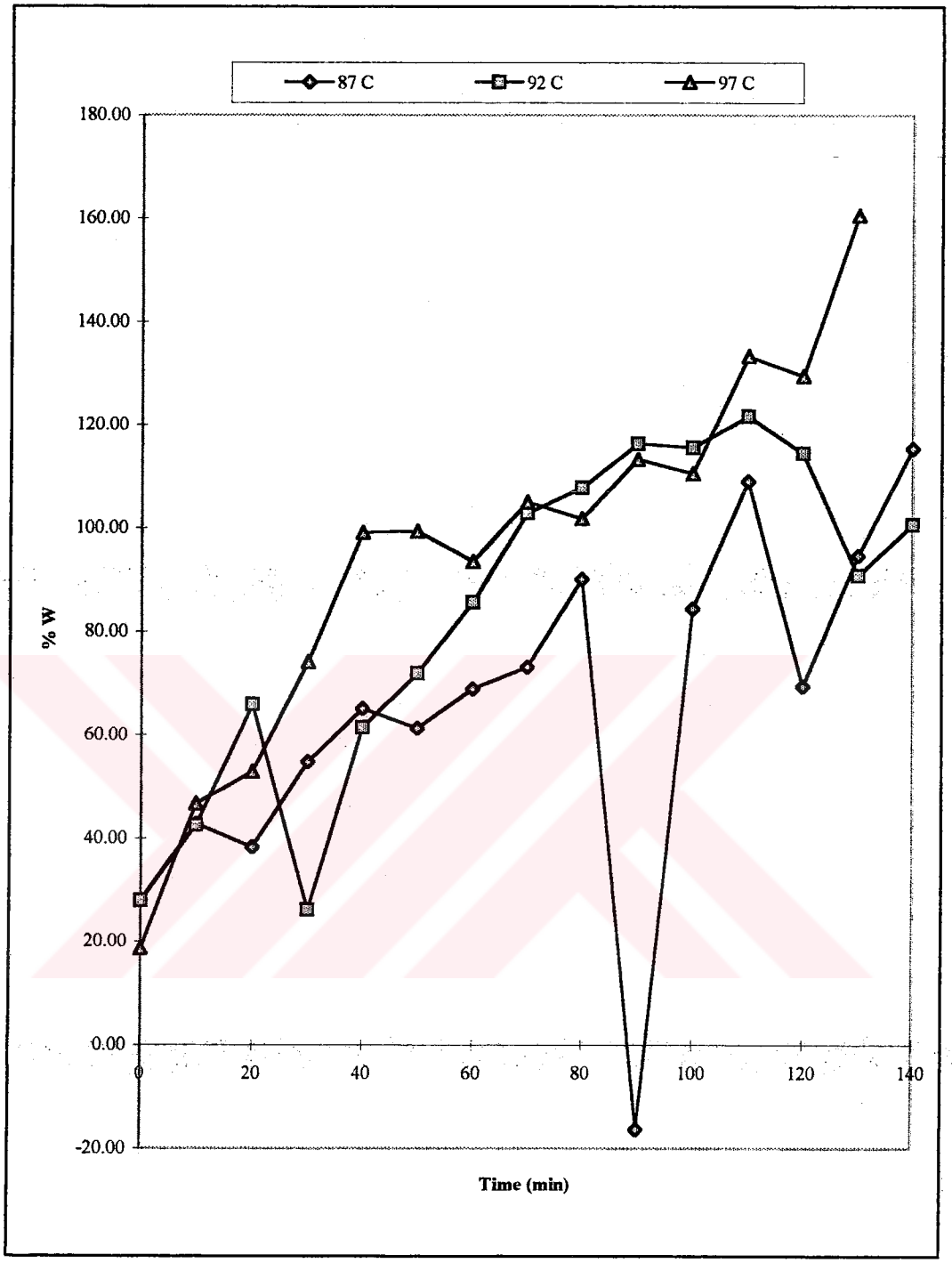

Figure A.4. Change (as percentage) in "W", average of Treatment I and II, of grains during Atmospheric Cooking

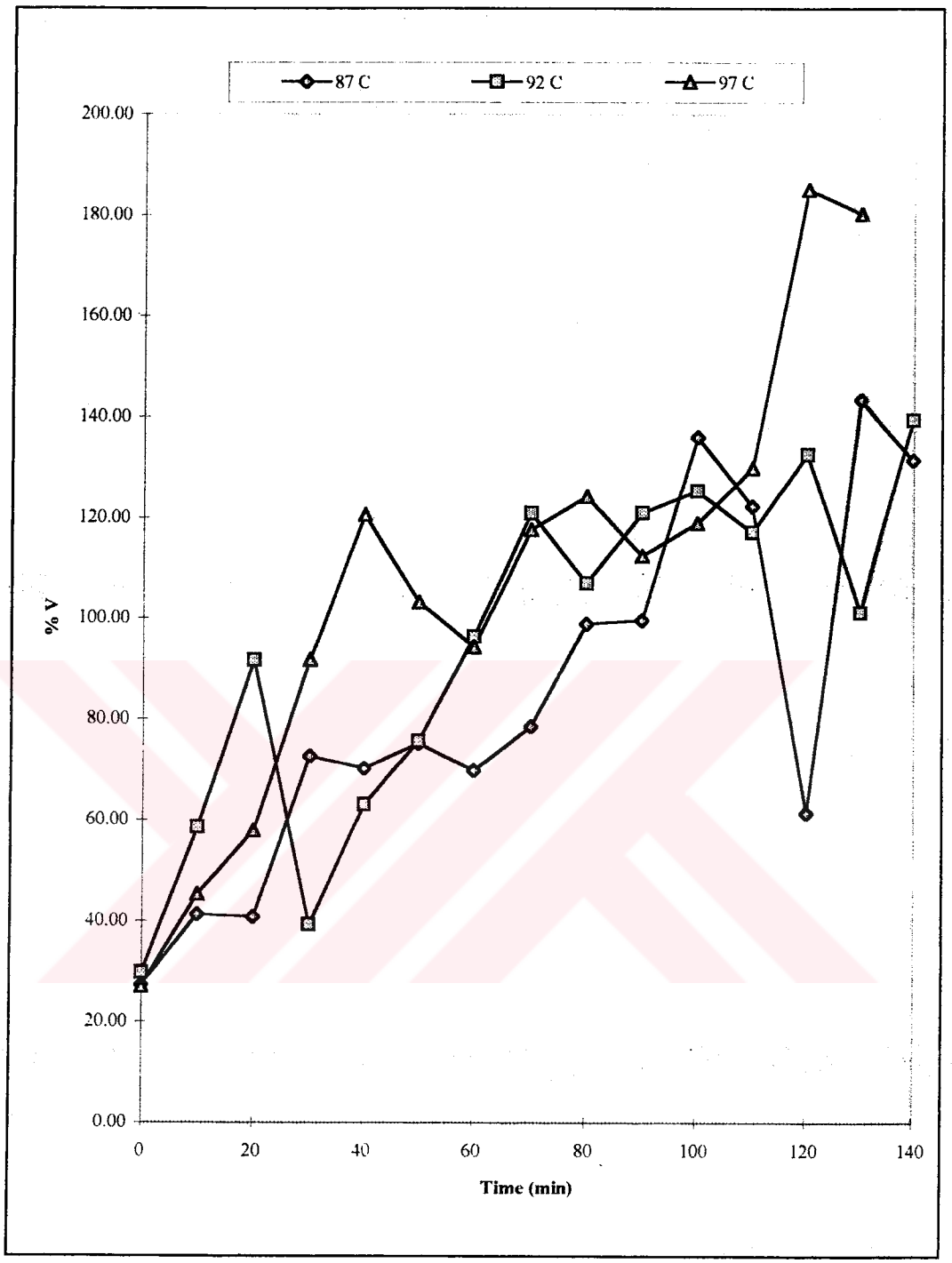

Figure A.5. Change (as percentage) in "V", average of Treatment I and II, of grains during Atmospheric Cooking

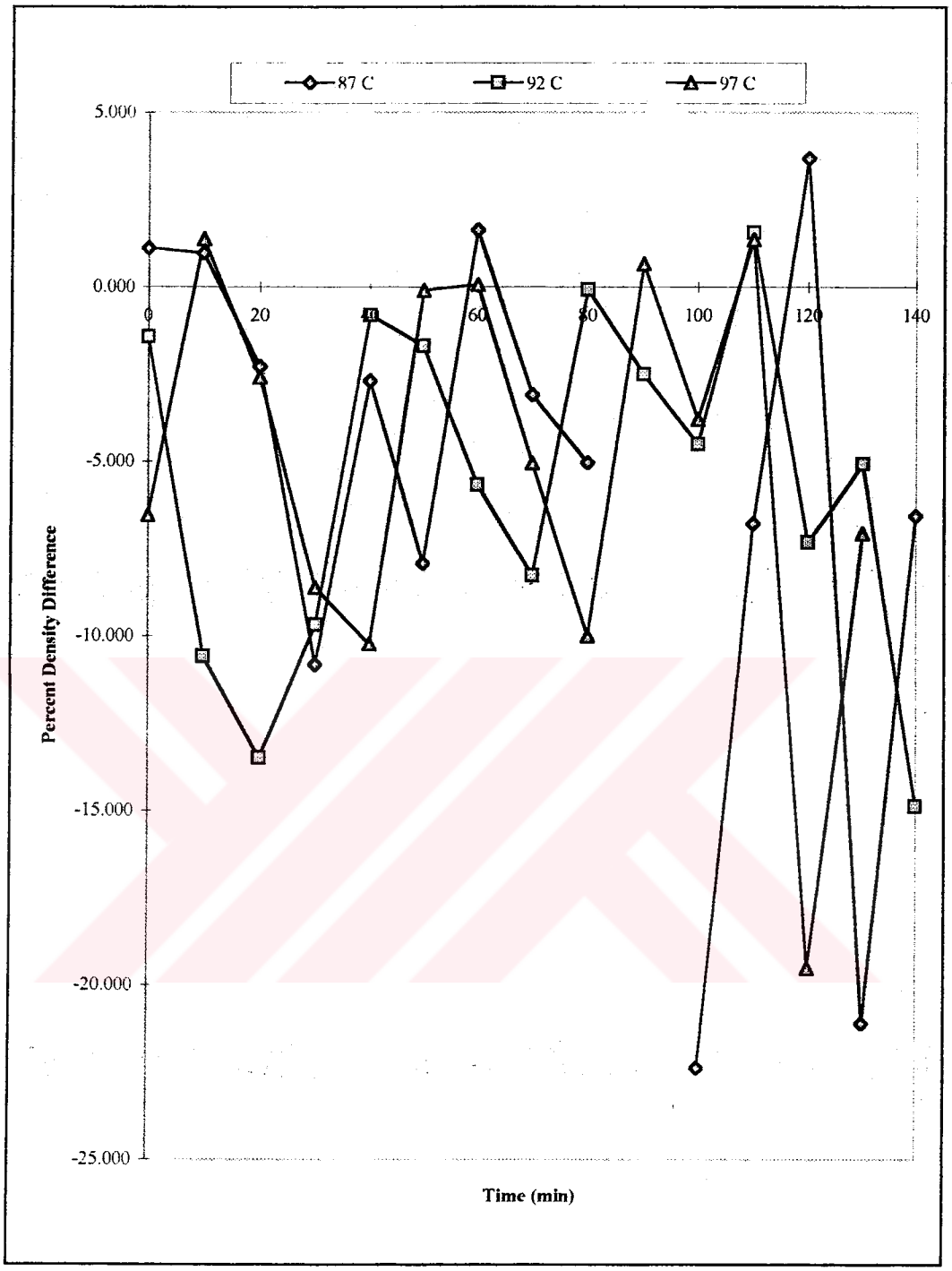

Figure A.6. Change (as percentage) in "ρ", average of Treatment I and II, of grains during Atmospheric Cooking

APPENDIX B. TABLES AND FIGURES OF SOAKING

Table B.1. Lengths "a" (cm) of grains during Soaking

SOAKING AT 40 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ai	af	af-ai	%a	ai	af	af-ai	%a	ai	af	af-ai	%a
10	7.35	7.60	0.25	3.40	7.40	7.50	0.10	1.35	7.38	7.55	0.18	2.37
20	6.85	7.05	0.20	2.92	7.25	7.25	0.00	0.00	7.05	7.15	0.10	1.42
30	7.10	7.30	0.20	2.82	6.70	6.90	0.20	2.99	6.90	7.10	0.20	2.90
40	7.40	7.70	0.30	4.05	7.10	7.50	0.40	5.63	7.25	7.60	0.35	4.83
50	6.85	7.25	0.40	5.84	7.25	7.55	0.30	4.14	7.05	7.40	0.35	4.96
60	6.85	7.25	0.40	5.84	6.90	6.90	0.00	0.00	6.88	7.08	0.20	2.91
SOAKING AT 50 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ai	af	af-ai	%a	ai	af	af-ai	%a	ai	af	af-ai	%a
10	7.40	7.60	0.20	2.70	6.90	7.00	0.10	1.45	7.15	7.30	0.15	2.10
20	7.45	7.70	0.25	3.36	7.15	7.55	0.40	5.59	7.30	7.63	0.32	4.45
30	7.25	7.80	0.55	7.59	7.10	7.25	0.15	2.11	7.18	7.53	0.35	4.88
40	7.50	8.20	0.70	9.33	7.10	7.40	0.30	4.23	7.30	7.80	0.50	6.85
50	7.50	8.00	0.50	6.67	7.15	7.50	0.35	4.90	7.33	7.75	0.43	5.80
60	7.00	7.50	0.50	7.14	7.45	7.70	0.25	3.36	7.23	7.60	0.38	5.19
SOAKING AT 60 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ai	af	af-ai	%a	ai	af	af-ai	%a	ai	af	af-ai	%a
10	7.70	8.00	0.30	3.90	7.55	7.60	0.05	0.66	7.63	7.80	0.18	2.30
20	7.00	7.70	0.70	10.00	7.25	7.60	0.35	4.83	7.13	7.65	0.53	7.37
30	7.15	7.40	0.25	3.50	7.25	7.50	0.25	3.45	7.20	7.45	0.25	3.47
40	7.15	7.50	0.35	4.90	6.85	7.25	0.40	5.84	7.00	7.38	0.38	5.36
50	7.15	7.90	0.75	10.49	7.50	8.25	0.75	10.00	7.33	8.08	0.75	10.24
60	7.20	8.00	0.80	11.11	7.40	7.95	0.55	7.43	7.30	7.98	0.67	9.25
SOAKING AT 70 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ai	af	af-ai	%a	ai	af	af-ai	%a	ai	af	af-ai	%a
10	7.40	7.60	0.20	2.70	7.20	7.50	0.30	4.17	7.30	7.55	0.25	3.42
20	8.05	8.60	0.55	6.83	7.70	8.20	0.50	6.49	7.88	8.40	0.52	6.67
30	7.45	7.90	0.45	6.04	7.50	8.05	0.55	7.33	7.48	7.98	0.50	6.69
40	6.65	7.45	0.80	12.03	6.55	7.00	0.45	6.87	6.60	7.23	0.63	9.47
50	7.20	8.05	0.85	11.81	7.25	7.75	0.50	6.90	7.23	7.90	0.68	9.34
60	6.60	7.30	0.70	10.61	6.95	7.30	0.35	5.04	6.78	7.30	0.52	7.75
SOAKING AT 80 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ai	af	af-ai	%a	ai	af	af-ai	%a	ai	af	af-ai	%a
10	7.30	7.95	0.65	8.90	7.65	8.00	0.35	4.58	7.48	7.98	0.50	6.69
20	7.30	8.10	0.80	10.96	8.10	8.65	0.55	6.79	7.70	8.38	0.68	8.77
30	6.60	7.30	0.70	10.61	7.20	8.00	0.80	11.11	6.90	7.65	0.75	10.87
40	7.85	8.85	1.00	12.74	7.00	7.85	0.85	12.14	7.43	8.35	0.93	12.46
50	7.70	8.55	0.85	11.04	7.35	8.15	0.80	10.88	7.53	8.35	0.83	10.96
60	7.55	8.45	0.90	11.92	7.30	8.15	0.85	11.64	7.43	8.30	0.88	11.78

Table B.2. Widths "b" (cm) of grains during Soaking

SOAKING AT 40 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	bi	bf	bf-bi	% b	bi	bf	bf-bi	% b	bi	bf	bf-bi	% b
10	3.30	3.70	0.40	12.12	3.20	3.30	0.10	3.12	3.25	3.50	0.25	7.69
20	2.95	3.10	0.15	5.08	2.95	3.10	0.15	5.08	2.95	3.10	0.15	5.08
30	3.15	3.25	0.10	3.17	2.85	2.90	0.05	1.75	3.00	3.08	0.08	2.50
40	3.40	3.50	0.10	2.94	3.10	3.15	0.05	1.61	3.25	3.33	0.08	2.31
50	2.85	3.00	0.15	5.26	3.30	3.45	0.15	4.55	3.08	3.23	0.15	4.88
60	3.10	3.25	0.15	4.84	2.70	2.95	0.25	9.26	2.90	3.10	0.20	6.90
SOAKING AT 50 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	bi	bf	bf-bi	% b	bi	bf	bf-bi	% b	bi	bf	bf-bi	% b
10	3.35	3.45	0.10	2.99	3.10	3.20	0.10	3.23	3.23	3.33	0.10	3.10
20	2.80	3.20	0.40	14.29	3.10	3.15	0.05	1.61	2.95	3.18	0.23	7.63
30	3.30	3.45	0.15	4.55	3.05	3.20	0.15	4.92	3.18	3.33	0.15	4.72
40	3.15	3.40	0.25	7.94	2.95	3.10	0.15	5.08	3.05	3.25	0.20	6.56
50	3.30	3.50	0.20	6.06	3.05	3.20	0.15	4.92	3.18	3.35	0.18	5.51
60	2.85	3.15	0.30	10.53	3.00	3.25	0.25	8.33	2.93	3.20	0.28	9.40
SOAKING AT 60 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	bi	bf	bf-bi	% b	bi	bf	bf-bi	% b	bi	bf	bf-bi	% b
10	3.50	3.55	0.05	1.43	3.15	3.25	0.10	3.17	3.33	3.40	0.07	2.26
20	3.00	3.15	0.15	5.00	3.30	3.40	0.10	3.03	3.15	3.28	0.13	3.97
30	2.95	3.15	0.20	6.78	3.10	3.35	0.25	8.06	3.03	3.25	0.23	7.44
40	3.00	3.25	0.25	8.33	3.30	3.60	0.30	9.09	3.15	3.43	0.28	8.73
50	3.05	3.50	0.45	14.75	3.20	3.60	0.40	12.50	3.13	3.55	0.43	13.60
60	3.00	3.35	0.35	11.67	3.10	3.35	0.25	8.06	3.05	3.35	0.30	9.84
SOAKING AT 70 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	bi	bf	bf-bi	% b	bi	bf	bf-bi	% b	bi	bf	bf-bi	% b
10	3.20	3.35	0.15	4.69	3.10	3.25	0.15	4.84	3.15	3.30	0.15	4.76
20	3.60	4.10	0.50	13.89	3.00	3.15	0.15	5.00	3.30	3.63	0.33	9.85
30	2.90	3.30	0.40	13.79	2.80	3.05	0.25	8.93	2.85	3.18	0.33	11.40
40	2.60	3.00	0.40	15.38	2.90	3.30	0.40	13.79	2.75	3.15	0.40	14.55
50	2.85	3.20	0.35	12.28	3.00	3.40	0.40	13.33	2.93	3.30	0.38	12.82
60	3.00	3.60	0.60	20.00	2.75	3.65	0.90	32.73	2.88	3.63	0.75	26.09
SOAKING AT 80 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	bi	bf	bf-bi	% b	bi	bf	bf-bi	% b	bi	bf	bf-bi	% b
10	3.15	3.40	0.25	7.94	3.00	3.25	0.25	8.33	3.08	3.33	0.25	8.13
20	3.15	3.45	0.30	9.52	3.00	3.35	0.35	11.67	3.08	3.40	0.33	10.57
30	3.10	3.50	0.40	12.90	3.20	3.75	0.55	17.19	3.15	3.63	0.48	15.08
40	3.35	4.00	0.65	19.40	3.05	3.65	0.60	19.67	3.20	3.83	0.63	19.53
50	2.90	3.55	0.65	22.41	3.40	4.20	0.80	23.53	3.15	3.88	0.73	23.02
60	3.25	4.05	0.80	24.62	3.00	3.90	0.90	30.00	3.13	3.98	0.85	27.20

Table B.3. Widths "c (cm) of grains during Soaking

SOAKING AT 40 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ci	cf	cf-ci	% c	ci	cf	cf-ci	% c	ci	cf	cf-ci	% c
10	3.00	3.60	0.60	20.00	2.80	2.90	0.10	3.57	2.90	3.25	0.35	11.79
20	2.90	2.95	0.05	1.72	2.90	3.05	0.15	5.17	2.90	3.00	0.10	3.45
30	2.95	3.20	0.25	8.47	2.75	2.95	0.20	7.27	2.85	3.08	0.23	7.87
40	3.30	3.50	0.20	6.06	2.75	2.90	0.15	5.45	3.03	3.20	0.18	5.76
50	2.80	3.00	0.20	7.14	2.95	3.15	0.20	6.78	2.88	3.08	0.20	6.96
60	2.90	3.15	0.25	8.62	2.50	2.75	0.25	10.00	2.70	2.95	0.25	9.31
SOAKING AT 50 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ci	cf	cf-ci	% c	ci	cf	cf-ci	% c	ci	cf	cf-ci	% c
10	2.85	2.90	0.05	1.75	2.85	3.00	0.15	5.26	2.85	2.95	0.10	3.51
20	2.70	2.85	0.15	5.56	2.60	2.90	0.30	11.54	2.65	2.88	0.23	8.55
30	3.05	3.20	0.15	4.92	2.75	2.95	0.20	7.27	2.90	3.08	0.18	6.10
40	3.25	3.60	0.35	10.77	2.75	2.95	0.20	7.27	3.00	3.28	0.28	9.02
50	3.10	3.50	0.40	12.90	3.15	3.30	0.15	4.76	3.13	3.40	0.28	8.83
60	2.85	3.25	0.40	14.04	2.75	2.90	0.15	5.45	2.80	3.08	0.28	9.74
SOAKING AT 60 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ci	cf	cf-ci	% c	ci	cf	cf-ci	% c	ci	cf	cf-ci	% c
10	3.60	3.75	0.15	4.17	3.05	3.25	0.20	6.56	3.33	3.50	0.18	5.36
20	3.05	3.15	0.10	3.28	2.90	3.05	0.15	5.17	2.98	3.10	0.13	4.23
30	2.65	2.95	0.30	11.32	3.00	3.25	0.25	8.33	2.83	3.10	0.28	9.83
40	2.80	3.05	0.25	8.93	2.90	3.15	0.25	8.62	2.85	3.10	0.25	8.77
50	2.75	3.10	0.35	12.73	2.95	3.25	0.30	10.17	2.85	3.18	0.33	11.45
60	2.80	3.15	0.35	12.50	3.10	3.35	0.25	8.06	2.95	3.25	0.30	10.28
SOAKING AT 70 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ci	cf	cf-ci	% c	ci	cf	cf-ci	% c	ci	cf	cf-ci	% c
10	2.90	3.10	0.20	6.90	2.95	3.15	0.20	6.78	2.93	3.13	0.20	6.84
20	3.20	3.40	0.20	6.25	3.00	3.25	0.25	8.33	3.10	3.33	0.23	7.29
30	2.80	3.10	0.30	10.71	2.75	2.90	0.15	5.45	2.78	3.00	0.23	8.08
40	2.70	3.10	0.40	14.81	2.70	3.00	0.30	11.11	2.70	3.05	0.35	12.96
50	2.75	3.10	0.35	12.73	2.85	3.15	0.30	10.53	2.80	3.13	0.33	11.63
60	2.50	2.80	0.30	12.00	2.80	3.40	0.60	21.43	2.65	3.10	0.45	16.71
SOAKING AT 80 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ci	cf	cf-ci	% c	ci	cf	cf-ci	% c	ci	cf	cf-ci	% c
10	2.80	3.05	0.25	8.93	2.75	2.90	0.15	5.45	2.78	2.98	0.20	7.19
20	3.10	3.40	0.30	9.68	2.85	3.25	0.40	14.04	2.98	3.33	0.35	11.86
30	2.65	3.00	0.35	13.21	3.15	3.45	0.30	9.52	2.90	3.23	0.33	11.37
40	2.70	3.30	0.60	22.22	3.05	3.45	0.40	13.11	2.88	3.38	0.50	17.67
50	2.85	3.50	0.65	22.81	3.10	3.85	0.75	24.19	2.98	3.68	0.70	23.50
60	2.95	3.45	0.50	16.95	2.85	3.40	0.55	19.30	2.90	3.43	0.53	18.12

Table B.4. Weights "W" (g) of grains during Soaking

SOAKING AT 40 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W
10	0.0539	0.0656	0.0117	21.707	0.0475	0.0525	0.005	10.526	0.0507	0.0590	0.0083	16.116
20	0.0413	0.0471	0.0058	14.044	0.0495	0.0541	0.0046	9.2929	0.0454	0.0506	0.0052	11.668
30	0.0486	0.0562	0.0076	15.638	0.0397	0.0473	0.0076	19.143	0.0441	0.0517	0.0076	17.390
40	0.0597	0.0672	0.0075	12.563	0.0476	0.0560	0.0084	17.647	0.0536	0.0616	0.0079	15.104
50	0.0413	0.0488	0.0075	18.160	0.0535	0.0613	0.0078	14.579	0.0474	0.0550	0.0076	16.369
60	0.0452	0.0540	0.0088	19.469	0.0396	0.0464	0.0068	17.171	0.0424	0.0502	0.0078	18.320
SOAKING AT 50 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W
10	0.0499	0.0543	0.0044	8.818	0.0480	0.0512	0.0032	6.667	0.0489	0.0527	0.0038	7.7421
20	0.0477	0.0558	0.0081	16.981	0.0486	0.0559	0.0073	15.021	0.0481	0.0558	0.0077	16.000
30	0.0557	0.0655	0.0098	17.594	0.0444	0.0517	0.0073	16.441	0.0500	0.0586	0.0085	17.017
40	0.0563	0.0676	0.0113	20.071	0.0430	0.0511	0.0081	18.837	0.0496	0.0593	0.0097	19.454
50	0.0577	0.0700	0.0123	21.317	0.0489	0.0599	0.0110	22.495	0.0533	0.0649	0.0116	21.906
60	0.0453	0.0566	0.0113	24.945	0.0486	0.0610	0.0124	25.514	0.0465	0.0588	0.0118	25.229
SOAKING AT 60 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W
10	0.0630	0.0699	0.0069	10.952	0.0522	0.0599	0.0077	14.751	0.0576	0.0649	0.0073	12.851
20	0.0464	0.0550	0.0086	18.534	0.0515	0.0593	0.0078	15.146	0.0489	0.0571	0.0082	16.840
30	0.0420	0.0508	0.0088	20.952	0.0499	0.0611	0.0112	22.445	0.0459	0.0559	0.0100	21.698
40	0.0429	0.0522	0.0093	21.678	0.0522	0.0666	0.0144	27.586	0.0475	0.0594	0.0118	24.632
50	0.0469	0.0617	0.0148	31.557	0.0563	0.0722	0.0159	28.242	0.0516	0.0669	0.0153	29.899
60	0.0463	0.0637	0.0174	37.581	0.0513	0.0662	0.0149	29.045	0.0488	0.0649	0.0161	33.312
SOAKING AT 70 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W
10	0.0500	0.0585	0.0085	17.000	0.0519	0.0606	0.0087	16.763	0.0509	0.0595	0.0086	16.881
20	0.0686	0.0822	0.0136	19.825	0.0492	0.0620	0.0128	26.016	0.0589	0.0721	0.0132	22.920
30	0.0460	0.0606	0.0146	31.739	0.0459	0.0616	0.0157	34.205	0.0459	0.0611	0.0151	32.972
40	0.0381	0.0526	0.0145	38.058	0.0420	0.0554	0.0134	31.905	0.0400	0.0540	0.0139	34.981
50	0.0389	0.0530	0.0141	36.247	0.0479	0.0657	0.0178	37.161	0.0434	0.0593	0.0159	36.703
60	0.0418	0.0587	0.0169	40.431	0.0424	0.0814	0.0390	91.981	0.0421	0.0700	0.0279	66.205
SOAKING AT 80 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W
10	0.0492	0.0563	0.0071	14.431	0.0500	0.0612	0.0112	22.400	0.0496	0.0587	0.0091	18.415
20	0.0500	0.0617	0.0117	23.400	0.0493	0.0660	0.0167	33.874	0.0496	0.0638	0.0142	28.637
30	0.0400	0.0559	0.0159	39.750	0.0574	0.0800	0.0226	39.373	0.0487	0.0679	0.0192	39.561
40	0.0561	0.0795	0.0234	41.711	0.0499	0.0737	0.0238	47.695	0.0530	0.0766	0.0236	44.703
50	0.0442	0.0655	0.0213	48.190	0.0599	0.0921	0.0322	53.756	0.0520	0.0788	0.0267	50.973
60	0.0528	0.0828	0.0300	56.818	0.0483	0.0785	0.0302	62.526	0.0505	0.0806	0.0301	59.672

Table B.5. Volumes "V" (cm^3) of grains during Soaking

SOAKING AT 40 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Vi	Vf	Vf-Vi	% V	Vi	Vf	Vf-Vi	% V	Vi	Vf	Vf-Vi	% V
10	38.08	52.98	14.90	39.12	34.70	37.56	2.86	8.25	36.39	45.27	8.88	23.69
20	30.67	33.74	3.07	10.02	32.46	35.87	3.41	10.52	31.56	34.81	3.24	10.27
30	34.53	39.73	5.20	15.07	27.48	30.89	3.41	12.41	31.00	35.31	4.31	13.74
40	43.45	49.36	5.91	13.61	31.68	35.85	4.18	13.19	37.56	42.61	5.05	13.40
50	28.61	34.15	5.54	19.37	36.94	42.94	6.00	16.25	32.77	38.54	5.77	17.81
60	32.23	38.84	6.62	20.53	24.37	29.29	4.92	20.19	28.30	34.07	5.77	20.36
SOAKING AT 50 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Vi	Vf	Vf-Vi	% V	Vi	Vf	Vf-Vi	% V	Vi	Vf	Vf-Vi	% V
10	36.97	39.79	2.82	7.62	31.90	35.17	3.26	10.23	34.44	37.48	3.04	8.93
20	29.48	36.75	7.28	24.68	30.16	36.09	5.93	19.68	29.82	36.42	6.61	22.18
30	38.19	45.07	6.88	18.01	31.17	35.82	4.65	14.93	34.68	40.44	5.76	16.47
40	40.18	52.53	12.34	30.72	30.14	35.42	5.27	17.49	35.16	43.97	8.81	24.10
50	40.15	51.29	11.13	27.73	35.95	41.45	5.50	15.29	38.05	46.37	8.32	21.51
60	29.76	40.18	10.43	35.04	32.17	37.98	5.81	18.08	30.96	39.08	8.12	26.56
SOAKING AT 60 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Vi	Vf	Vf-Vi	% V	Vi	Vf	Vf-Vi	% V	Vi	Vf	Vf-Vi	% V
10	50.77	55.74	4.96	9.77	37.96	42.01	4.05	10.67	44.37	48.87	4.51	10.22
20	33.52	39.98	6.46	19.29	36.31	41.24	4.93	13.59	34.91	40.61	5.70	16.44
30	29.25	35.99	6.74	23.02	35.29	42.73	7.45	21.11	32.27	39.36	7.09	22.07
40	31.43	38.91	7.48	23.78	34.31	43.03	8.72	25.41	32.87	40.97	8.10	24.60
50	31.38	44.86	13.47	42.93	37.05	50.51	13.46	36.33	34.22	47.69	13.47	39.63
60	31.65	44.18	12.53	39.58	37.22	46.69	9.47	25.46	34.43	45.44	11.00	32.52
SOAKING AT 70 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Vi	Vf	Vf-Vi	% V	Vi	Vf	Vf-Vi	% V	Vi	Vf	Vf-Vi	% V
10	35.94	41.30	5.37	14.93	34.46	40.18	5.72	16.61	35.20	40.74	5.55	15.77
20	48.53	62.74	14.21	29.27	36.27	43.93	7.67	21.14	42.40	53.34	10.94	25.21
30	31.66	42.29	10.64	33.60	30.22	37.26	7.04	23.29	30.94	39.78	8.84	28.44
40	24.43	36.26	11.83	48.42	26.84	36.27	9.43	35.12	25.64	36.26	10.63	41.77
50	29.53	41.79	12.26	41.51	32.44	43.44	11.00	33.90	30.99	42.61	11.63	37.71
60	25.91	38.51	12.60	48.65	28.01	47.41	19.40	69.29	26.96	42.96	16.00	58.97
SOAKING AT 80 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Vi	Vf	Vf-Vi	% V	Vi	Vf	Vf-Vi	% V	Vi	Vf	Vf-Vi	% V
10	33.70	43.14	9.45	28.04	33.03	39.46	6.43	19.47	33.36	41.30	7.94	23.76
20	37.31	49.72	12.42	33.29	36.24	49.29	13.04	35.99	36.77	49.50	12.73	34.64
30	28.37	40.11	11.74	41.37	37.98	54.17	16.18	42.61	33.18	47.14	13.96	41.99
40	37.16	61.14	23.98	64.53	34.08	51.73	17.65	51.80	35.62	56.43	20.82	58.17
50	33.31	55.60	22.29	66.93	40.54	68.97	28.43	70.11	36.92	62.28	25.36	68.52
60	37.88	61.79	23.91	63.11	32.66	56.56	23.89	73.15	35.27	59.17	23.90	68.13

Table B.6. Densities "ρ" (g/cm^3) of grains during Soaking

SOAKING AT 40 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ρi	ρf	ρf-ρi	% ρ	ρi	ρf	ρf-ρi	% ρ	ρi	ρf	ρf-ρi	% ρ
10	1.42	1.24	-0.18	-12.52	1.37	1.40	0.03	2.10	1.39	1.32	-0.07	-5.21
20	1.35	1.40	0.05	3.66	1.53	1.51	-0.02	-1.11	1.44	1.45	0.02	1.27
30	1.41	1.41	0.01	0.49	1.44	1.53	0.09	5.99	1.43	1.47	0.05	3.24
40	1.37	1.36	-0.01	-0.92	1.50	1.56	0.06	3.94	1.44	1.46	0.02	1.51
50	1.44	1.43	-0.02	-1.01	1.45	1.43	-0.02	-1.44	1.45	1.43	-0.02	-1.23
60	1.40	1.39	-0.01	-0.88	1.62	1.58	-0.04	-2.51	1.51	1.49	-0.03	-1.69
SOAKING AT 50 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ρi	ρf	ρf-ρi	% ρ	ρi	ρf	ρf-ρi	% ρ	ρi	ρf	ρf-ρi	% ρ
10	1.35	1.36	0.02	1.11	1.50	1.46	-0.05	-3.24	1.43	1.41	-0.02	-1.06
20	1.62	1.52	-0.10	-6.18	1.61	1.55	-0.06	-3.89	1.61	1.53	-0.08	-5.03
30	1.46	1.45	-0.01	-0.35	1.42	1.44	0.02	1.32	1.44	1.45	0.01	0.48
40	1.40	1.29	-0.11	-8.15	1.43	1.44	0.02	1.15	1.41	1.36	-0.05	-3.50
50	1.44	1.36	-0.07	-5.02	1.36	1.45	0.09	6.25	1.40	1.41	0.01	0.61
60	1.52	1.41	-0.11	-7.48	1.51	1.61	0.10	6.30	1.52	1.51	-0.01	-0.59
SOAKING AT 60 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ρi	ρf	ρf-ρi	% ρ	ρi	ρf	ρf-ρi	% ρ	ρi	ρf	ρf-ρi	% ρ
10	1.24	1.25	0.01	1.08	1.38	1.43	0.05	3.69	1.31	1.34	0.03	2.38
20	1.38	1.38	-0.01	-0.63	1.42	1.44	0.02	1.37	1.40	1.41	0.01	0.37
30	1.44	1.41	-0.02	-1.68	1.41	1.43	0.02	1.10	1.42	1.42	0.00	-0.29
40	1.36	1.34	-0.02	-1.70	1.52	1.55	0.03	1.73	1.44	1.44	0.00	0.02
50	1.49	1.38	-0.12	-7.96	1.52	1.43	-0.09	-5.94	1.51	1.40	-0.10	-6.95
60	1.46	1.44	-0.02	-1.43	1.38	1.42	0.04	2.86	1.42	1.43	0.01	0.71
SOAKING AT 70 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ρi	ρf	ρf-ρi	% ρ	ρi	ρf	ρf-ρi	% ρ	ρi	ρf	ρf-ρi	% ρ
10	1.39	1.42	0.03	1.80	1.51	1.51	0.00	0.13	1.45	1.46	0.01	0.96
20	1.41	1.31	-0.10	-7.31	1.36	1.41	0.06	4.03	1.39	1.36	-0.02	-1.64
30	1.45	1.43	-0.02	-1.39	1.52	1.65	0.13	8.85	1.49	1.54	0.06	3.73
40	1.56	1.45	-0.11	-6.98	1.56	1.53	-0.04	-2.38	1.56	1.49	-0.07	-4.68
50	1.32	1.27	-0.05	-3.72	1.48	1.51	0.04	2.43	1.40	1.39	-0.01	-0.64
60	1.61	1.52	-0.09	-5.53	1.51	1.72	0.20	13.41	1.56	1.62	0.06	3.94
SOAKING AT 80 °C												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ρi	ρf	ρf-ρi	% ρ	ρi	ρf	ρf-ρi	% ρ	ρi	ρf	ρf-ρi	% ρ
10	1.46	1.30	-0.16	-10.63	1.51	1.55	0.04	2.45	1.49	1.43	-0.06	-4.09
20	1.34	1.24	-0.10	-7.42	1.36	1.34	-0.02	-1.55	1.35	1.29	-0.06	-4.49
30	1.41	1.39	-0.02	-1.15	1.51	1.48	-0.03	-2.27	1.46	1.44	-0.03	-1.71
40	1.51	1.30	-0.21	-13.87	1.46	1.42	-0.04	-2.71	1.49	1.36	-0.12	-8.29
50	1.33	1.18	-0.15	-11.23	1.48	1.34	-0.14	-9.62	1.40	1.26	-0.15	-10.42
60	1.39	1.34	-0.05	-3.86	1.48	1.39	-0.09	-6.13	1.44	1.36	-0.07	-5.00

Table B.7. Percent Moisture Content "%mc" (w.b.) during Soaking

SOAKED AT 40°C			
Time (min)	TREATMENT I % mc	TREATMENT II % mc	AVERAGE % mc
10	25,17	25,00	25.09
20	29,76	29,45	29.61
30	32,27	32,10	32.19
40	32,72	33,07	32.90
50	34,60	34,21	34.41
60	35,70	35,74	35.72
SOAKED AT 50°C			
Time (min)	TREATMENT I % mc	TREATMENT II % mc	AVERAGE % mc
10	25,95	25,99	25.97
20	29,96	29,98	29.97
30	32,62	32,52	32.57
40	33,06	32,97	33.02
50	35,68	34,93	35.31
60	37,46	37,85	37.66
SOAKED AT 60°C			
Time (min)	TREATMENT I % mc	TREATMENT II % mc	AVERAGE % mc
10	26,82	27,01	26.92
20	30,66	31,22	30.94
30	33,85	34,12	33.99
40	35,70	35,85	35.78
50	37,46	37,52	37.49
60	38,96	39,75	39.36
SOAKED AT 70°C			
Time (min)	TREATMENT I % mc	TREATMENT II % mc	AVERAGE % mc
10	29,50	29,95	29.73
20	33,89	33,85	33.87
30	37,46	37,98	37.70
40	41,29	42,14	41.72
50	42,60	43,51	43.06
60	47,03	47,89	47.46
SOAKED AT 80°C			
Time (min)	TREATMENT I % mc	TREATMENT II % mc	AVERAGE % mc
10	30,23	31,20	30.72
20	36,12	36,87	36.50
30	41,26	41,20	41.23
40	43,92	44,52	44.22
50	44,08	44,54	44.31
60	47,64	48,06	47.85

Table B.8. Color Values during Soaking

SOAKING AT 40 °C									
Time	TREATMENT I			TREATMENT II			AVERAGE		
(min)	R	Y	B	R	Y	B	R	Y	B
10	5.2	6.7	2.8	5.2	7.1	2.4	5.20	6.90	2.60
20	5.2	6.7	2.9	5.1	6.4	2.4	5.15	6.55	2.65
30	5.2	6.7	2.9	5.0	6.6	2.4	5.10	6.65	2.65
40	5.2	6.7	2.9	4.9	6.3	2.3	5.05	6.50	2.60
50	5.2	6.7	2.9	4.9	6.3	2.3	5.05	6.50	2.60
60	5.2	6.7	2.9	4.9	6.3	2.3	5.05	6.50	2.60
SOAKING AT 50 °C									
Time	TREATMENT I			TREATMENT II			AVERAGE		
(min)	R	Y	B	R	Y	B	R	Y	B
10	4.1	5.7	2.1	4.1	5.1	2.2	4.10	5.40	2.15
20	4.1	5.6	2.1	4.0	5.2	2.2	4.05	5.40	2.15
30	4.1	5.6	2.1	4.0	5.6	2.0	4.05	5.60	2.05
40	4.1	5.5	2.1	4.0	5.6	2.1	4.05	5.55	2.10
50	4.1	5.3	2.0	4.0	5.4	2.1	4.05	5.35	2.05
60	4.0	5.4	2.0	4.0	5.4	2.1	4.00	5.40	2.05
SOAKING AT 60 °C									
Time	TREATMENT I			TREATMENT II			AVERAGE		
(min)	R	Y	B	R	Y	B	R	Y	B
10	4.1	6.1	2.1	4.5	5.9	2.2	4.30	6.00	2.15
20	4.1	6.0	2.1	4.4	5.5	2.2	4.25	5.75	2.15
30	4.0	6.0	2.1	4.0	5.4	2.0	4.00	5.70	2.05
40	4.4	6.0	2.3	4.0	5.5	2.1	4.20	5.75	2.20
50	4.0	6.0	2.3	4.0	5.5	2.0	4.00	5.75	2.15
60	4.0	6.0	2.1	4.0	5.5	2.0	4.00	5.75	2.05
SOAKING AT 70 °C									
Time	TREATMENT I			TREATMENT II			AVERAGE		
(min)	R	Y	B	R	Y	B	R	Y	B
10	4.3	5.5	2.2	4.2	5.8	2.0	4.25	5.65	2.10
20	4.5	6.7	2.4	4.1	5.6	2.0	4.30	6.15	2.20
30	4.1	6.1	2.0	4.1	5.6	2.0	4.10	5.85	2.00
40	4.1	6.0	2.0	4.0	5.6	2.0	4.05	5.80	2.00
50	4.1	6.0	2.0	4.0	5.6	2.0	4.05	5.80	2.00
60	4.1	6.0	2.0	4.0	5.6	2.0	4.05	5.80	2.00
SOAKING AT 80 °C									
Time	TREATMENT I			TREATMENT II			AVERAGE		
(min)	R	Y	B	R	Y	B	R	Y	B
10	4.1	5.6	2.0	4.0	5.6	1.6	4.05	5.60	1.80
20	4.1	5.6	2.0	3.5	5.3	1.3	3.80	5.45	1.65
30	4.0	5.2	2.0	3.5	5.6	1.3	3.75	5.40	1.65
40	4.0	5.2	2.0	3.9	5.3	1.6	3.95	5.25	1.80
50	4.0	5.6	2.0	3.9	5.3	1.6	3.95	5.45	1.80
60	4.0	5.6	2.0	3.9	5.3	1.6	3.95	5.45	1.80

Table B.9. Percent Starch in Soaking Water during Soaking

SOAKED AT 40 °C			
Time (min)	TREATMENT I % Starch	TREATMENT % Starch	AVERAGE % Starch
0	0	0	0
10	0	0	0
20	0	0	0
30	0	0	0
40	0.05	0	0.03
50	0.16	0.11	0.14
60	0.27	0.22	0.25
SOAKED AT 50 °C			
Time (min)	TREATMENT I % Starch	TREATMENT % Starch	AVERAGE % Starch
0	0	0	0
10	0	0	0
20	0	0	0
30	0	0	0
40	0.11	0.05	0.08
50	0.22	0.16	0.19
60	0.33	0.38	0.36
SOAKED AT 60 °C			
Time (min)	TREATMENT I % Starch	TREATMENT % Starch	AVERAGE % Starch
0	0	0	0
10	0	0	0
20	0	0	0
30	0	0	0
40	0.16	0.11	0.14
50	0.33	0.22	0.27
60	0.55	0.55	0.55
SOAKED AT 70 °C			
Time (min)	TREATMENT I % Starch	TREATMENT % Starch	AVERAGE % Starch
0	0	0	0
10	0	0	0
20	0	0	0
30	0.05	0.05	0.05
40	0.22	0.16	0.19
50	0.38	0.33	0.36
60	0.66	0.77	0.71
SOAKED AT 80 °C			
Time (min)	TREATMENT I % Starch	TREATMENT % Starch	AVERAGE % Starch
0	0	0	0
10	0	0	0
20	0.05	0.11	0.08
30	0.11	0.16	0.14
40	0.22	0.27	0.25
50	0.49	0.55	0.52
60	0.82	0.93	0.88

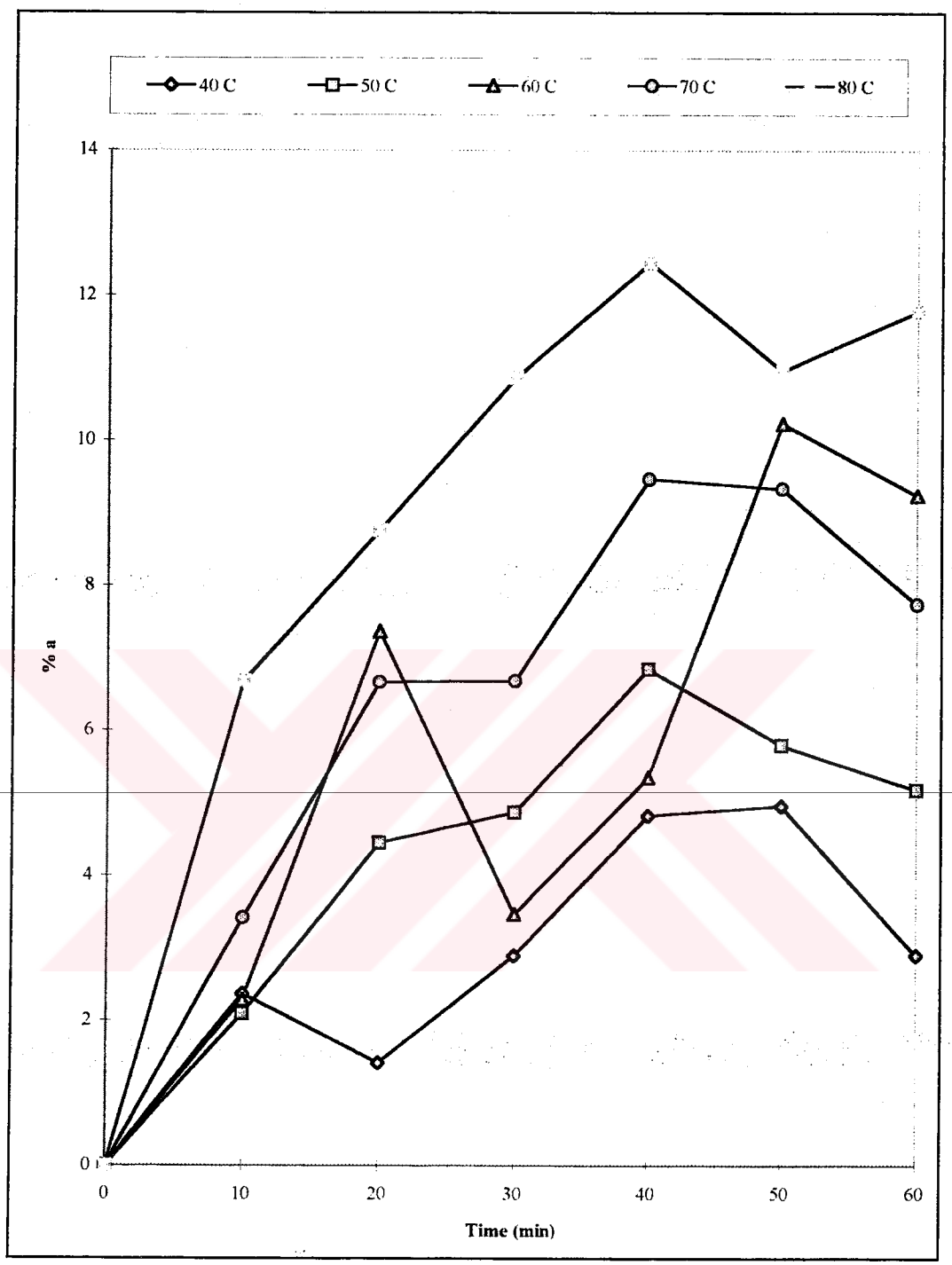

Figure B.1. Change (as percentage) in "a", average of Treatment I and II, of grains during Soaking

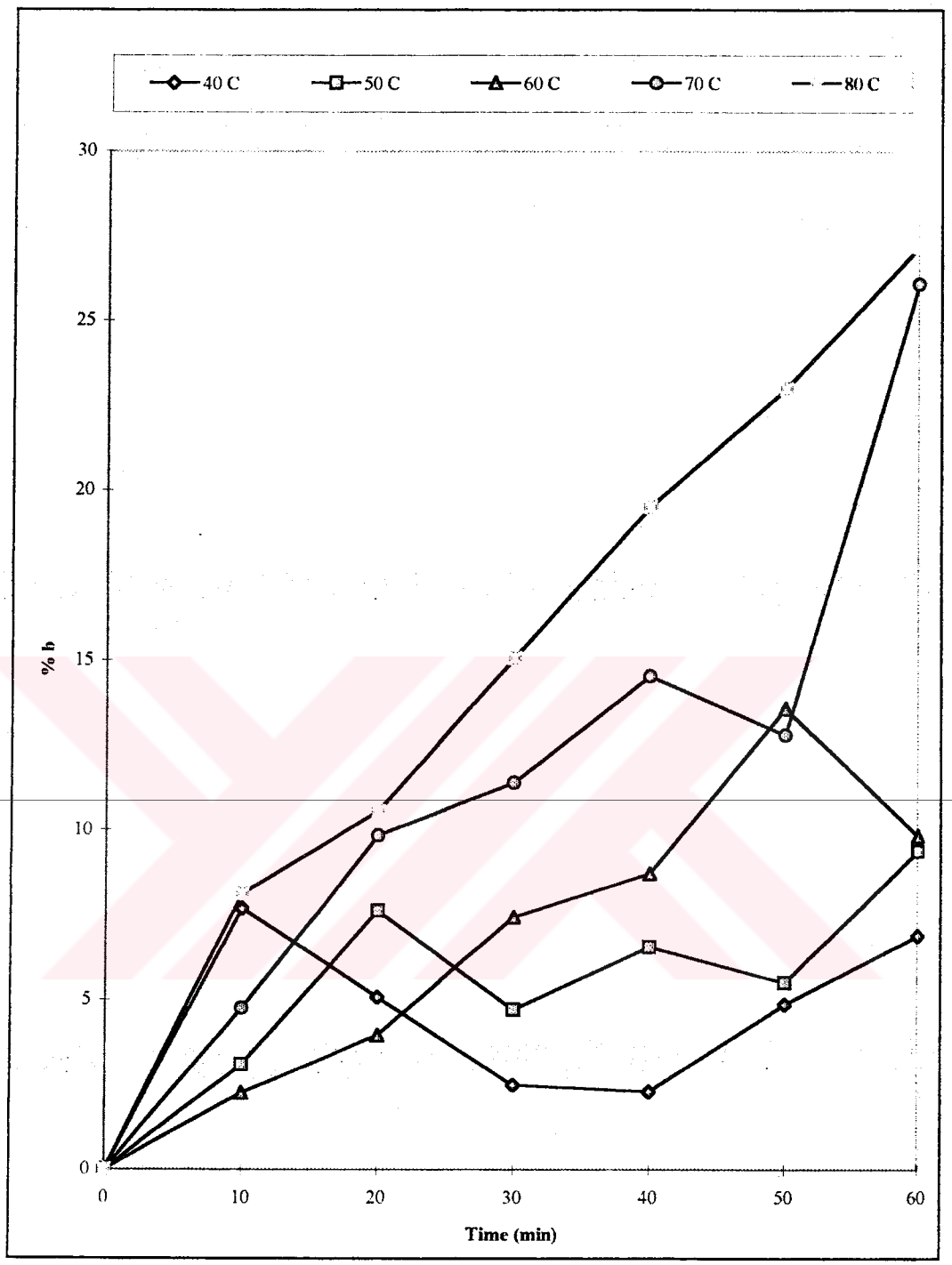

Figure B.2. Change (as percentage) in "b", average of Treatment I and II, of grains during Soaking

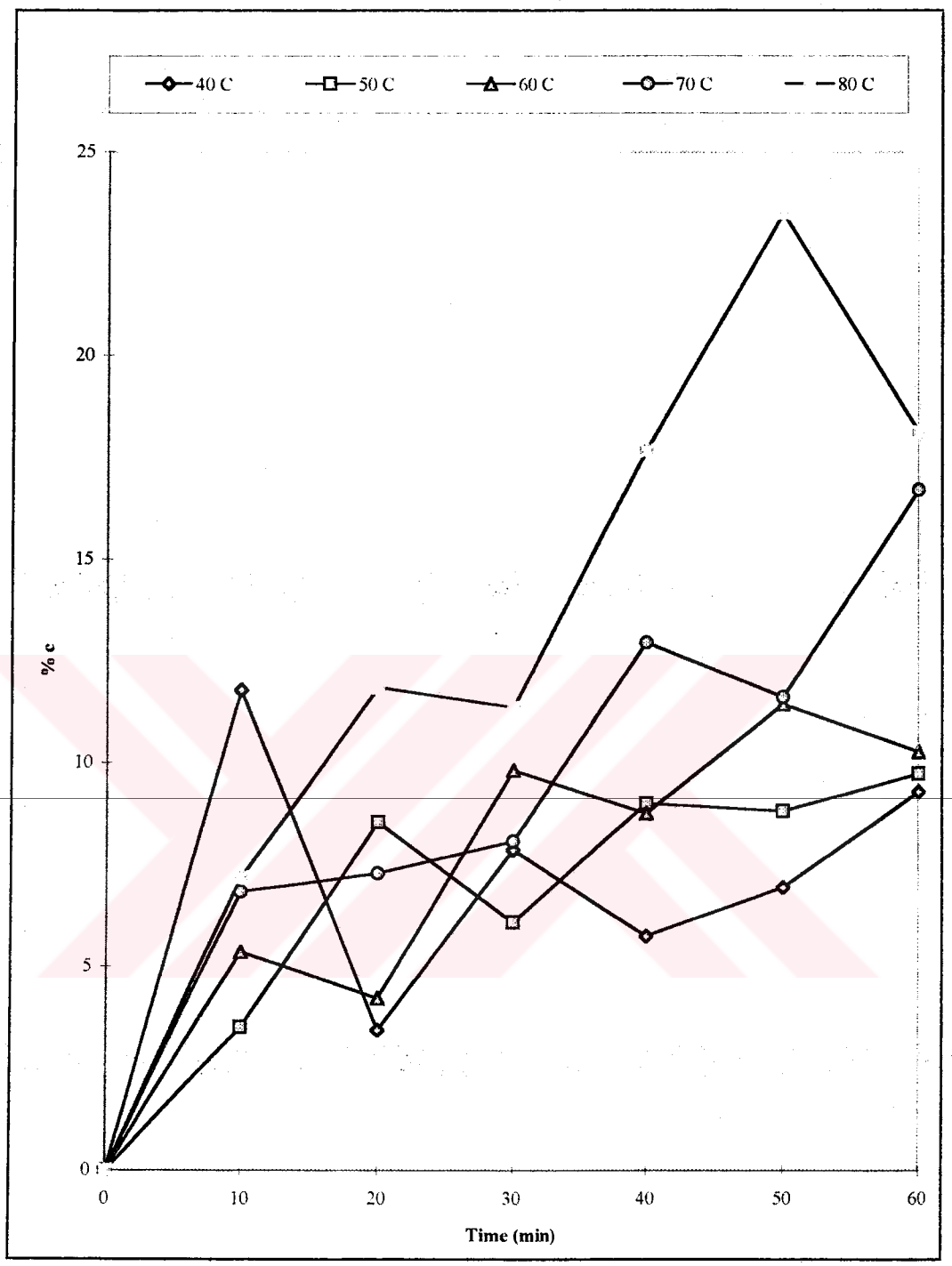

Figure B.3. Change (as percentage) in "c", average of Treatment I and II, of grains during Soaking

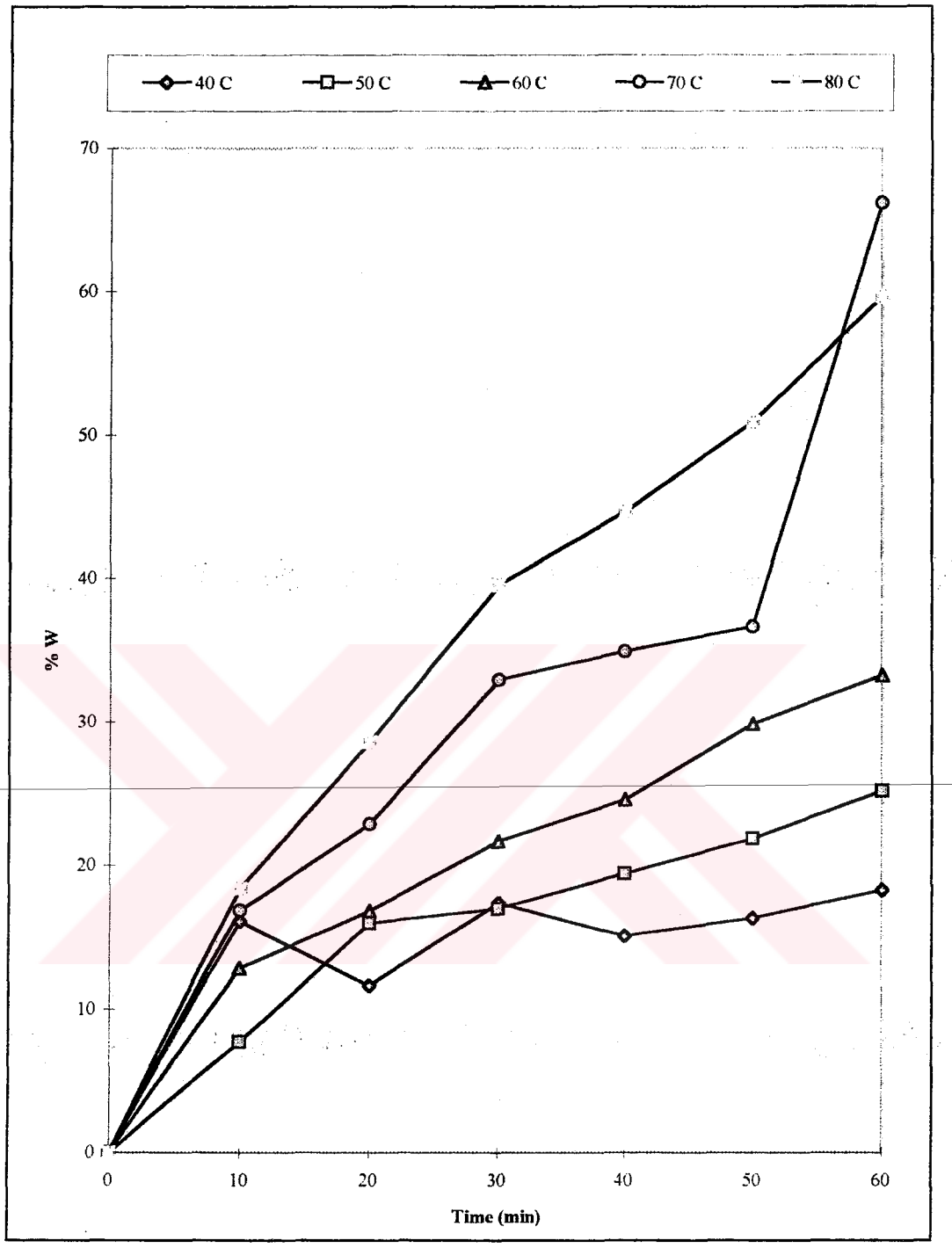

Figure B.4. Change (as percentage) in "W", average of Treatment I and II, of grains during Soaking

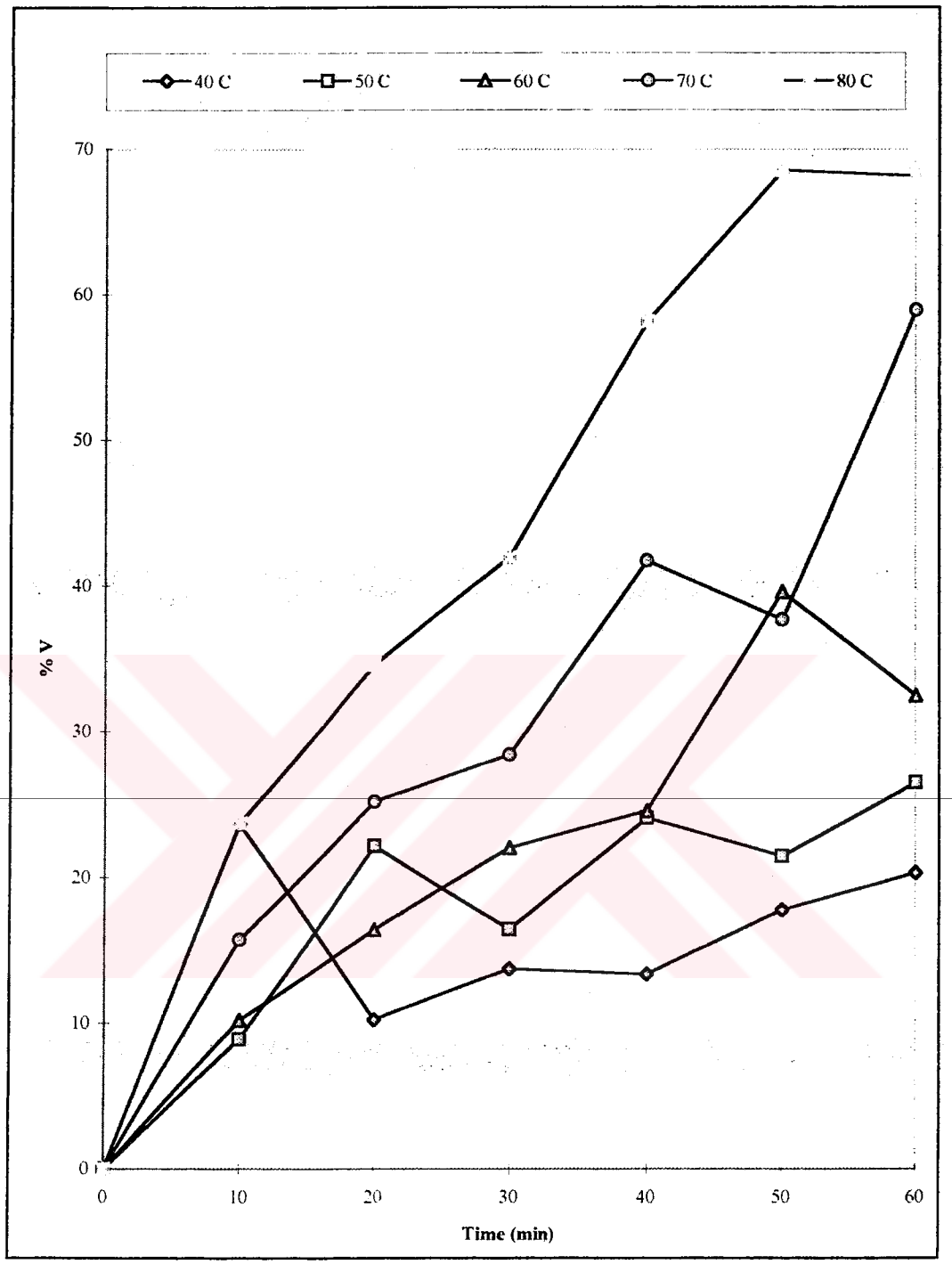

Figure B.5. Change (as percentage) in "V", average of Treatment I and II, of grains during Soaking

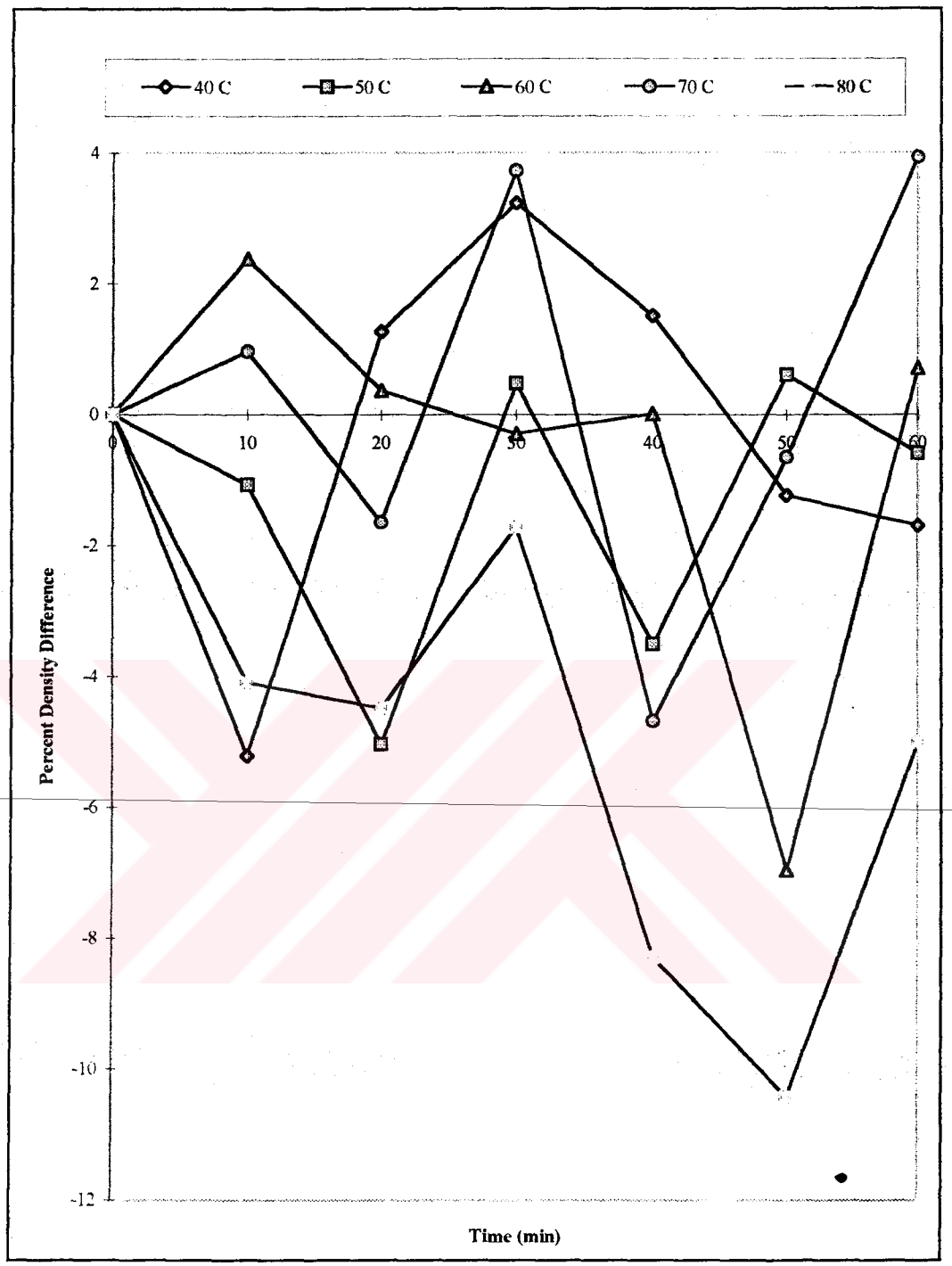

Figure B.6. Change (as percentage) in "ρ", average of Treatment I and II, of grains during Soaking

APPENDIX C. TABLES AND FIGURES OF PRESSURE COOKING

Table C.1. Lengths "a" (cm) of grains during Pressure Cooking

PRESSURE COOKING AT 10 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ai	af	af-ai	%a	ai	af	af-ai	%a	ai	af	af-ai	%a
2	8.15	7.95	-0.20	-2.45	8.60	8.40	-0.20	-2.33	8.38	8.18	-0.20	-2.39
4	8.35	8.15	-0.20	-2.40	7.80	7.60	-0.20	-2.56	8.08	7.88	-0.20	-2.48
6	7.95	7.72	-0.23	-2.89	7.70	7.60	-0.10	-1.30	7.83	7.66	-0.17	-2.10
PRESSURE COOKING AT 15 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ai	af	af-ai	%a	ai	af	af-ai	%a	ai	af	af-ai	%a
2	7.90	7.60	-0.30	-3.80	7.50	7.25	-0.25	-3.33	7.70	7.43	-0.28	-3.57
4	7.45	7.35	-0.10	-1.34	8.70	8.35	-0.35	-4.02	8.08	7.85	-0.23	-2.68
6	8.35	7.90	-0.45	-5.39	8.20	8.00	-0.20	-2.44	8.28	7.95	-0.32	-3.91
PRESSURE COOKING AT 18 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ai	af	af-ai	%a	ai	af	af-ai	%a	ai	af	af-ai	%a
2	7.75	7.40	-0.35	-4.52	7.65	7.50	-0.15	-1.96	7.70	7.45	-0.25	-3.24
4	8.30	8.00	-0.30	-3.61	7.90	7.60	-0.30	-3.80	8.10	7.80	-0.30	-3.71
6	8.65	8.30	-0.35	-4.05	7.65	7.50	-0.15	-1.96	8.15	7.90	-0.25	-3.00
PRESSURE COOKING AT 10 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ai	af	af-ai	%a	ai	af	af-ai	%a	ai	af	af-ai	%a
2	7.65	7.55	-0.10	-1.31	7.65	7.30	-0.35	-4.58	7.65	7.43	-0.23	-2.94
4	7.50	7.15	-0.35	-4.67	8.25	8.10	-0.15	-1.82	7.88	7.63	-0.25	-3.24
6	8.00	7.70	-0.30	-3.75	7.90	7.65	-0.25	-3.16	7.95	7.68	-0.28	-3.46
PRESSURE COOKING AT 15 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ai	af	af-ai	%a	ai	af	af-ai	%a	ai	af	af-ai	%a
2	7.30	7.05	-0.25	-3.42	8.00	7.20	-0.80	-10.00	7.65	7.13	-0.53	-6.71
4	8.20	7.90	-0.30	-3.66	7.55	6.90	-0.65	-8.61	7.88	7.40	-0.47	-6.13
6	7.60	7.30	-0.30	-3.95	7.70	7.35	-0.35	-4.55	7.65	7.33	-0.33	-4.25
PRESSURE COOKING AT 18 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ai	af	af-ai	%a	ai	af	af-ai	%a	ai	af	af-ai	%a
2	8.25	7.70	-0.55	-6.67	7.20	6.90	-0.30	-4.17	7.73	7.30	-0.43	-5.42
4	7.55	7.25	-0.30	-3.97	7.95	7.65	-0.30	-3.77	7.75	7.65	-0.30	-3.87
6	7.85	7.50	-0.35	-4.46	7.35	7.10	-0.25	-3.40	7.60	7.30	-0.30	-3.93

Table C.2. Widths "b" (cm) of grains during Pressure Cooking

PRESSURE COOKING AT 10 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b
2	3.70	3.65	-0.05	-1.35	4.10	4.30	0.20	4.88	3.90	3.98	0.08	1.76
4	3.90	3.95	0.05	1.28	3.90	3.90	0.00	0.00	3.90	3.93	0.03	0.64
6	3.70	3.85	0.15	4.05	3.40	4.00	0.60	17.65	3.55	3.93	0.38	10.85
PRESSURE COOKING AT 15 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b
2	3.65	3.85	0.20	5.48	3.75	3.70	-0.05	-1.33	3.70	3.78	0.08	2.07
4	3.70	3.70	0.00	0.00	3.65	3.90	0.25	6.85	3.68	3.80	0.13	3.42
6	4.10	4.00	-0.10	-2.44	4.00	3.90	-0.10	-2.50	4.05	3.95	-0.10	-2.47
PRESSURE COOKING AT 18 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b
2	3.65	3.80	0.15	4.11	4.05	4.05	0.00	0.00	3.85	3.93	0.08	2.05
4	3.95	4.00	0.05	1.27	4.00	4.00	0.00	0.00	3.98	4.00	0.02	0.63
6	4.10	4.10	0.00	0.00	3.55	3.50	-0.05	-1.41	3.83	3.80	-0.02	-0.70
PRESSURE COOKING AT 10 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b
2	3.75	3.95	0.20	5.33	3.80	3.80	0.00	0.00	3.78	3.88	0.10	2.67
4	4.15	4.25	0.10	2.41	4.15	4.55	0.40	9.64	4.15	4.40	0.25	6.02
6	3.95	3.85	-0.10	-2.53	3.80	4.00	0.20	5.26	3.88	3.93	0.05	1.37
PRESSURE COOKING AT 15 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b
2	3.65	3.60	-0.05	-1.37	3.60	3.85	0.25	6.94	3.63	3.73	0.10	2.79
4	3.90	4.15	0.25	6.41	3.90	4.05	0.15	3.85	3.90	4.10	0.20	5.13
6	3.55	3.85	0.30	8.45	3.80	3.85	0.05	1.32	3.68	3.85	0.18	4.88
PRESSURE COOKING AT 18 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b	bi	bf	bf-bi	%b
2	4.05	4.15	0.10	2.47	3.90	3.70	-0.20	-5.13	3.98	3.93	-0.05	-1.33
4	4.05	3.95	-0.10	-2.47	4.35	4.20	-0.15	-3.45	4.20	4.06	-0.12	-2.96
6	4.10	4.10	0.00	0.00	3.80	3.90	0.10	2.63	3.95	4.00	0.05	1.32

Table C.3. Widths "c (cm) of grains during Pressure Cooking

PRESSURE COOKING AT 10 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c
2	3.50	3.20	-0.30	-8.57	3.55	3.60	0.05	1.41	3.53	3.40	-0.13	-3.58
4	3.45	3.50	0.05	1.45	3.40	3.30	-0.10	-2.94	3.43	3.40	-0.03	-0.75
6	3.80	3.70	-0.10	-2.63	3.20	3.25	0.05	1.56	3.50	3.48	-0.02	-0.53
PRESSURE COOKING AT 15 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c
2	3.40	3.30	-0.10	-2.94	3.30	3.15	-0.15	-4.55	3.35	3.23	-0.13	-3.74
4	3.65	3.55	-0.10	-2.74	3.35	3.15	-0.20	-5.97	3.50	3.35	-0.15	-4.35
6	3.45	3.30	-0.15	-4.35	3.60	3.45	-0.15	-4.17	3.53	3.38	-0.15	-4.26
PRESSURE COOKING AT 18 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c
2	3.45	3.25	-0.20	-5.80	3.65	3.55	-0.10	-2.74	3.55	3.40	-0.15	-4.27
4	3.65	3.50	-0.15	-4.11	3.50	3.30	-0.20	-5.71	3.58	3.40	-0.18	-4.91
6	3.65	3.50	-0.15	-4.11	3.10	2.90	-0.20	-6.45	3.38	3.20	-0.18	-5.28
PRESSURE COOKING AT 10 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c
2	3.25	3.10	-0.15	-4.62	3.60	3.40	-0.20	-5.56	3.43	3.25	-0.18	-5.09
4	3.60	3.65	0.05	1.39	3.80	3.90	0.10	2.63	3.70	3.78	0.08	2.01
6	3.45	3.35	-0.10	-2.90	3.50	3.35	-0.15	-4.29	3.48	3.35	-0.13	-3.59
PRESSURE COOKING AT 15 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c
2	3.35	3.10	-0.25	-7.46	3.40	3.25	-0.15	-4.41	3.38	3.18	-0.20	-5.94
4	3.40	3.25	-0.15	-4.41	3.55	3.40	-0.15	-4.23	3.48	3.33	-0.15	-4.32
6	3.25	3.20	-0.05	-1.54	3.45	3.30	-0.15	-4.35	3.35	3.25	-0.10	-2.94
PRESSURE COOKING AT 18 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c	ci	cf	cf-ci	%c
2	3.60	3.50	-0.10	-2.78	3.50	3.20	-0.30	-8.57	3.55	3.35	-0.20	-5.67
4	3.60	3.50	-0.10	-2.78	3.80	3.70	-0.10	-2.63	3.70	3.60	-0.10	-2.70
6	3.45	3.30	-0.15	-4.35	3.30	3.25	-0.05	-1.52	3.38	3.28	-0.10	-2.93

Table C.4. Weights "W" (g) of grains during Pressure Cooking

PRESSURE COOKING AT 10 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W
2	0.0663	0.0669	0.0006	0.90	0.0925	0.0938	0.0013	1.41	0.0794	0.0804	0.0009	1.16
4	0.0839	0.0862	0.0023	2.74	0.0718	0.0729	0.0011	1.53	0.0779	0.0796	0.0017	2.14
6	0.0808	0.0835	0.0027	3.34	0.0650	0.0701	0.0051	7.85	0.0729	0.0768	0.0039	5.59
PRESSURE COOKING AT 15 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W
2	0.0704	0.0719	0.0015	2.13	0.0683	0.0645	-0.0038	-5.56	0.0694	0.0682	-0.0012	-1.72
4	0.0693	0.0679	-0.0014	-2.02	0.0770	0.0783	0.0013	1.69	0.0732	0.0731	-0.0001	-0.17
6	0.0834	0.0828	-0.0006	-0.72	0.0831	0.0794	-0.0037	-4.45	0.0833	0.0811	-0.0022	-2.59
PRESSURE COOKING AT 18 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W
2	0.0613	0.0654	0.0041	6.69	0.0783	0.0765	-0.0018	-2.30	0.0698	0.0710	0.0012	2.19
4	0.0830	0.0822	-0.0008	-0.96	0.0755	0.0741	-0.0014	-1.85	0.0793	0.0782	-0.0011	-1.41
6	0.0852	0.0836	-0.0016	-1.88	0.0632	0.0645	0.0013	2.06	0.0742	0.0741	-0.0002	0.09
PRESSURE COOKING AT 10 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W
2	0.0622	0.0658	0.0036	5.79	0.0698	0.0689	-0.0009	-1.29	0.0660	0.0674	0.0014	2.25
4	0.0776	0.0770	-0.0006	-0.77	0.0891	0.0951	0.0060	6.73	0.0834	0.0861	0.0027	2.98
6	0.0760	0.0725	-0.0035	-4.61	0.0693	0.0730	0.0037	5.34	0.0727	0.0728	0.0001	0.37
PRESSURE COOKING AT 15 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W
2	0.0634	0.0607	-0.0027	-4.26	0.0662	0.0674	0.0012	1.81	0.0648	0.06405	-0.0007	-1.22
4	0.0779	0.0768	-0.0011	-1.41	0.0714	0.0717	0.0003	0.42	0.07465	0.07425	-0.0004	-0.50
6	0.0621	0.0664	0.0043	6.92	0.0699	0.0709	0.001	1.43	0.066	0.06865	0.00265	4.18
PRESSURE COOKING AT 18 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W	Wi	Wf	Wf-Wi	%W
2	0.0831	0.086	0.0029	3.49	0.0671	0.0666	-0.0005	-0.75	0.0751	0.0763	0.0012	1.37
4	0.0773	0.0743	-0.003	-3.88	0.0865	0.0899	0.0034	3.93	0.0819	0.0821	0.0002	0.02
6	0.0777	0.0762	-0.0015	-1.93	0.0661	0.0658	-0.0003	-0.45	0.0719	0.071	-0.0009	-1.19

Table C.5. Volumes "V" (cm^3) of grains during Pressure Cooking

PRESSURE COOKING AT 10 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V
2	55.23	48.59	-6.64	-12.02	65.51	68.05	2.54	3.88	60.37	58.32	-2.05	-4.07
4	58.80	58.97	0.17	0.29	54.13	51.19	-2.94	-5.43	56.46	55.08	-1.38	-2.57
6	58.50	57.55	-0.94	-1.62	43.84	51.71	7.86	17.93	51.17	54.63	3.46	8.16
PRESSURE COOKING AT 15 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V
2	51.31	50.53	-0.78	-1.51	48.57	44.22	-4.35	-8.96	49.94	47.38	-2.56	-5.23
4	52.65	50.52	-2.13	-4.05	55.67	53.68	-1.99	-3.57	54.16	52.10	-2.06	-3.81
6	61.81	54.57	-7.24	-11.71	61.80	56.33	-5.46	-8.84	61.80	55.45	-6.35	-10.28
PRESSURE COOKING AT 18 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V
2	51.07	47.83	-3.25	-6.35	59.18	56.43	-2.75	-4.65	55.13	52.13	-3.00	-5.50
4	62.62	58.61	-4.01	-6.41	57.88	52.50	-5.38	-9.29	60.25	55.56	-4.70	-7.85
6	67.74	62.33	-5.41	-7.99	44.06	39.84	-4.22	-9.58	55.90	51.09	-4.82	-8.78
PRESSURE COOKING AT 10 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V
2	48.79	48.38	-0.41	-0.84	54.77	49.36	-5.41	-9.88	51.78	48.87	-2.91	-5.36
4	58.64	58.05	-0.59	-1.01	68.09	75.22	7.13	10.48	63.36	66.63	3.27	4.73
6	57.05	51.97	-5.08	-8.91	54.99	53.65	-1.34	-2.44	56.02	52.81	-3.21	-5.67
PRESSURE COOKING AT 15 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V
2	46.71	41.17	-5.54	-11.86	51.24	47.15	-4.10	-8.00	48.98	44.16	-4.82	-9.93
4	56.90	55.76	-1.14	-2.01	54.70	49.72	-4.98	-9.10	55.80	52.74	-3.06	-5.55
6	45.89	47.07	1.18	2.57	52.83	48.87	-3.96	-7.49	49.36	47.97	-1.39	-2.46
PRESSURE COOKING AT 18 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V	Vi	Vf	Vf-Vi	%V
2	62.95	58.53	-4.42	-7.02	51.43	42.75	-8.68	-16.87	57.19	50.64	-6.55	-11.95
4	57.61	52.45	-5.15	-8.95	68.77	62.21	-6.56	-9.54	63.19	50.64	-5.86	-9.24
6	58.11	53.11	-5.00	-8.61	48.24	47.10	-1.14	-2.36	53.17	50.10	-3.07	-5.49

Table C.6. Densities "ρ" (g/cm^3) of grains during Pressure Cooking

PRESSURE COOKING AT 10 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ
2	1.2003	1.3767	0.1763	14.69	1.4121	1.3784	-0.0337	-2.38	1.3062	1.3775	0.0713	6.15
4	1.4270	1.4619	0.0349	2.45	1.3265	1.4242	0.0977	7.36	1.3767	1.4430	0.0663	4.90
6	1.3813	1.4509	0.0696	5.04	1.4826	1.3558	-0.1268	-8.55	1.4319	1.4033	-0.0286	-1.76
PRESSURE COOKING AT 15 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ
2	1.3721	1.4229	0.0507	3.70	1.4062	1.4586	0.0524	3.73	1.3891	1.4407	0.0516	3.71
4	1.3161	1.3439	0.0278	2.11	1.3831	1.4586	0.0754	5.45	1.3496	1.4012	0.0516	3.78
6	1.3493	1.5172	0.1680	12.45	1.3448	1.4095	0.0647	4.81	1.3470	1.4634	0.1164	8.63
PRESSURE COOKING AT 18 PSIG (SOAKED AT 70 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ
2	1.2002	1.3674	0.1672	13.93	1.3230	1.3556	0.0326	2.46	1.2616	1.3615	0.0999	8.20
4	1.3254	1.4024	0.0771	5.81	1.3044	1.4114	0.1070	8.20	1.3149	1.4069	0.0920	7.01
6	1.2577	1.3412	0.0835	6.64	1.4345	1.6190	0.1846	12.87	1.3461	1.4801	0.1341	9.75
PRESSURE COOKING AT 10 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ
2	1.2748	1.3600	0.0852	6.69	1.2745	1.3959	0.1214	9.53	1.2746	1.3780	0.1033	8.11
4	1.3233	1.3266	0.0032	0.24	1.3086	1.2643	-0.0443	-3.39	1.3160	1.2954	-0.0206	-1.57
6	1.3321	1.3950	0.0629	4.72	1.2603	1.3607	0.1004	7.97	1.2962	1.3779	0.0817	6.35
PRESSURE COOKING AT 15 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ
2	1.3572	1.4742	0.1170	8.62	1.2918	1.4296	0.1377	10.66	1.3245	1.4519	0.1274	9.64
4	1.3690	1.3773	0.0083	0.61	1.3052	1.4420	0.1368	10.48	1.3371	1.4096	0.0725	5.54
6	1.3533	1.4108	0.0575	4.25	1.3231	1.4508	0.1277	9.65	1.3382	1.4308	0.0926	6.95
PRESSURE COOKING AT 18 PSIG (SOAKED AT 80 °C)												
Time	TREATMENT I				TREATMENT II				AVERAGE			
(min)	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ	ρi	ρf	ρf-ρi	%ρ
2	1.3201	1.4693	0.1492	11.30	1.3046	1.5577	0.2531	19.40	1.3124	1.5135	0.2012	15.35
4	1.3418	1.4165	0.0746	5.56	1.2578	1.4450	0.1872	14.89	1.2998	1.4307	0.1309	10.22
6	1:3371	1.4349	0.0978	7.31	1.3704	1.3971	0.0268	1.95	1.3537	1.4160	0.0623	4.63

Table C.7. Percent Moisture Content "%mc" (w.b.) Pressure Cooking

PRESSURE COOKING AT 10 PSIG (SOAKED AT 70 °C)			
Time (min)	TREATMENT I %mc	TREATMENT %mc	AVERAGE %mc
2	40.51	39.66	40.08
4	40.49	40.32	40.40
6	40.13	42.82	41.48
PRESSURE COOKING AT 15 PSIG (SOAKED AT 70 °C)			
Time (min)	TREATMENT I %mc	TREATMENT %mc	AVERAGE %mc
2	39.54	40.19	39.86
4	39.22	40.28	39.75
6	40.53	40.50	40.52
PRESSURE COOKING AT 18 PSIG (SOAKED AT 70 °C)			
Time (min)	TREATMENT I %mc	TREATMENT %mc	AVERAGE %mc
2	40.45	40.61	40.53
4	40.82	40.78	40.80
6	41.82	41.97	41.89
PRESSURE COOKING AT 10 PSIG (SOAKED AT 80 °C)			
Time (min)	TREATMENT I %mc	TREATMENT %mc	AVERAGE %mc
2	41.00	41.47	41.23
4	46.79	41.65	44.22
6	41.40	43.08	42.24
PRESSURE COOKING AT 15 PSIG (SOAKED AT 80 °C)			
Time (min)	TREATMENT I %mc	TREATMENT %mc	AVERAGE %mc
2	42.15	41.76	41.95
4	44.14	42.73	43.43
6	42.97	42.52	42.74
PRESSURE COOKING AT 18 PSIG (SOAKED AT 80 °C)			
Time (min)	TREATMENT I %mc	TREATMENT %mc	AVERAGE %mc
2	45.75	45.01	45.38
4	46.67	45.46	46.07
6	45.91	46.98	46.45

Table C.8. Percent Starch Gelatinization during Pressure Cooking

PRESSURE COOKING AT 10 PSIG (SOAKED AT 70 °C)			
Time	TREATMENT I	TREATMENT II	AVERAGE
(min)	%Gelatinization	%Gelatinization	%Gelatinization
2	92	91	91.5
4	94	93	93.5
6	97	96	96.5
PRESSURE COOKING AT 15 PSIG (SOAKED AT 70 °C)			
Time	TREATMENT I	TREATMENT II	AVERAGE
(min)	%Gelatinization	%Gelatinization	%Gelatinization
2	96	94	95
4	95	95	95
6	98	99	98.5
PRESSURE COOKING AT 18 PSIG (SOAKED AT 70 °C)			
Time	TREATMENT I	TREATMENT II	AVERAGE
(min)	%Gelatinization	%Gelatinization	%Gelatinization
2	97	96	96.5
4	97	97	97
6	99	100	99.5
PRESSURE COOKING AT 10 PSIG (SOAKED AT 80 °C)			
Time	TREATMENT I	TREATMENT II	AVERAGE
(min)	%Gelatinization	%Gelatinization	%Gelatinization
2	91	90	90.5
4	97	95	96
6	98	97	97.5
PRESSURE COOKING AT 15 PSIG (SOAKED AT 80 °C)			
Time	TREATMENT I	TREATMENT II	AVERAGE
(min)	%Gelatinization	%Gelatinization	%Gelatinization
2	94	94	94
4	96	96	96
6	97	98	97.5
PRESSURE COOKING AT 18 PSIG (SOAKED AT 80 °C)			
Time	TREATMENT I	TREATMENT II	AVERAGE
(min)	%Gelatinization	%Gelatinization	%Gelatinization
2	97	97	97
4	99	98	98.5
6	100	100	100

Table C.9. Color Values during Pressure Cooking

PRESSURE COOKING AT 10 PSIG (SOAKED AT 70 °C)																		
Time	TREATMENT I						TREATMENT II						AVERAGE					
	INITIAL			FINAL			INITIAL			FINAL			INITIAL			FINAL		
(min)	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B
2	3.9	6.0	1.6	4.1	6.0	2.6	3.5	4.4	1.1	3.7	4.8	1.5	3.70	5.20	1.35	3.90	5.40	2.05
4	4.5	5.5	1.4	3.9	5.5	2.1	3.5	4.7	1.5	3.7	5.3	1.9	4.00	5.10	1.45	3.80	5.40	2.00
6	3.9	5.0	1.5	4.4	6.0	3.0	—	—	—	3.8	5.3	1.9	—	—	—	4.10	5.65	2.45
PRESSURE COOKING AT 15 PSIG (SOAKED AT 70 °C)																		
Time	TREATMENT I						TREATMENT II						AVERAGE					
	INITIAL			FINAL			INITIAL			FINAL			INITIAL			FINAL		
(min)	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B
2	3.7	4.7	1.6	3.9	4.9	2.1	3.7	5.0	2.1	3.8	5.2	2.1	3.70	4.85	1.85	3.85	5.05	2.10
4	3.7	4.5	1.1	3.9	5.4	2.5	3.7	5.0	2.0	3.9	5.2	2.5	3.70	4.75	1.55	3.90	5.30	2.50
6	3.8	5.4	2.0	4.1	5.9	2.4	3.6	5.1	2.0	3.9	5.6	2.3	3.70	5.25	2.00	4.00	5.75	2.35
PRESSURE COOKING AT 18 PSIG (SOAKED AT 70 °C)																		
Time	TREATMENT I						TREATMENT II						AVERAGE					
	INITIAL			FINAL			INITIAL			FINAL			INITIAL			FINAL		
(min)	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B
2	4.0	5.0	2.1	4.0	5.4	2.7	3.1	4.2	1.1	4.0	5.7	2.4	3.55	4.60	1.60	4.00	5.55	2.55
4	4.0	5.1	2.0	4.0	5.6	2.5	3.6	5.1	1.5	4.3	6.2	2.8	3.80	5.10	1.75	4.15	5.90	2.65
6	4.0	5.6	2.0	4.0	5.7	2.4	4.0	5.5	2.1	4.5	5.9	2.7	4.00	5.55	2.05	4.25	5.80	2.55
PRESSURE COOKING AT 10 PSIG (SOAKED AT 80 °C)																		
Time	TREATMENT I						TREATMENT II						AVERAGE					
	INITIAL			FINAL			INITIAL			FINAL			INITIAL			FINAL		
(min)	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B
2	3.9	5.5	2.0	3.9	5.6	2.0	3.7	5.2	1.4	3.9	5.5	1.9	3.80	5.35	1.70	3.90	5.55	1.95
4	3.5	5.1	1.4	3.9	5.5	1.9	3.7	5.2	1.6	4.0	5.7	2.0	3.60	5.15	1.50	3.95	5.60	1.95
6	3.7	5.0	1.4	3.7	5.4	1.9	3.8	5.5	2.0	4.2	5.5	2.5	3.75	5.25	1.70	3.95	5.45	2.20
PRESSURE COOKING AT 15 PSIG (SOAKED AT 80 °C)																		
Time	TREATMENT I						TREATMENT II						AVERAGE					
	INITIAL			FINAL			INITIAL			FINAL			INITIAL			FINAL		
(min)	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B
2	3.7	5.0	1.5	4.0	5.3	2.1	3.7	5.1	2.0	4.3	5.7	2.4	3.70	5.05	1.75	4.15	5.50	2.25
4	3.9	5.3	1.5	4.3	6.3	2.7	4.0	5.7	2.4	4.0	5.4	2.6	3.95	5.50	1.95	4.15	5.85	2.65
6	4.0	6.1	2.1	4.4	6.1	2.8	3.9	5.4	2.0	3.9	5.6	2.4	3.95	5.75	2.05	4.15	5.85	2.60
PRESSURE COOKING AT 18 PSIG (SOAKED AT 80 °C)																		
Time	TREATMENT I						TREATMENT II						AVERAGE					
	INITIAL			FINAL			INITIAL			FINAL			INITIAL			FINAL		
(min)	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B	R	Y	B
2	3.5	5.2	1.4	4.4	5.9	2.6	4.0	6.1	2.0	4.3	6.1	2.6	3.75	5.65	1.70	4.35	6.00	2.60
4	4.0	5.8	2.0	4.4	5.9	2.5	4.1	6.1	2.0	4.1	6.1	2.7	4.05	5.95	2.00	4.25	6.00	2.60
6	3.5	5.1	1.3	4.0	6.1	2.3	4.0	6.0	2.0	4.5	6.4	2.7	3.75	5.55	1.65	4.25	6.25	2.50

Table C.10. Percent Changes in Color Values during Pressure Cooking

PRESSURE COOKING AT 10 PSIG (SOAKED AT 70 °C)									
Time	INITIAL			FINAL			AVERAGE		
(min)	% R	%Y	%B	% R	%Y	%B	% R	%Y	%B
2	5.13	0.00	62.50	5.71	9.09	36.36	5.42	4.55	49.43
4	-13.33	0.00	50.00	5.71	12.77	26.67	-3.81	6.38	38.33
6	12.82	20.00	100.00	—	—		—	—	—
PRESSURE COOKING AT 15 PSIG (SOAKED AT 70 °C)									
Time	INITIAL			FINAL			AVERAGE		
(min)	% R	%Y	%B	% R	%Y	%B	% R	%Y	%B
2	5.41	4.26	31.25	2.70	4.00	0.00	4.05	4.13	15.63
4	5.41	20.00	127.27	5.41	4.00	25.00	5.41	12.00	76.14
6	7.89	9.26	20.00	8.33	9.80	15.00	8.11	9.53	17.50
PRESSURE COOKING AT 18 PSIG (SOAKED AT 70 °C)									
Time	INITIAL			FINAL			AVERAGE		
(min)	% R	%Y	%B	% R	%Y	%B	% R	%Y	%B
2	0.00	8.00	28.57	29.03	35.71	118.18	14.52	21.86	73.38
4	0.00	9.80	25.00	19.44	21.57	86.67	9.72	15.69	55.83
6	0.00	1.79	20.00	12.50	7.27	28.57	6.25	4.53	24.29
PRESSURE COOKING AT 10 PSIG (SOAKED AT 80 °C)									
Time	INITIAL			FINAL			AVERAGE		
(min)	% R	%Y	%B	% R	%Y	%B	% R	%Y	%B
2	0.00	1.82	0.00	5.41	5.77	35.71	2.70	3.79	17.86
4	11.43	7.84	35.71	8.11	9.62	25.00	9.77	8.73	30.36
6	0.00	8.00	35.71	10.53	0.00	25.00	5.26	4.00	30.36
PRESSURE COOKING AT 15 PSIG (SOAKED AT 80 °C)									
Time	INITIAL			FINAL			AVERAGE		
(min)	% R	%Y	%B	% R	%Y	%B	% R	%Y	%B
2	8.11	6.00	40.00	16.22	11.76	20.00	12.16	8.88	30.00
4	10.26	18.87	80.00	0.00	-5.26	8.33	5.13	6.80	44.17
6	10.00	0.00	33.33	0.00	3.70	20.00	5.00	1.85	26.67
PRESSURE COOKING AT 18 PSIG (SOAKED AT 80 °C)									
Time	INITIAL			FINAL			AVERAGE		
(min)	% R	%Y	%B	% R	%Y	%B	% R	%Y	%B
2	25.71	13.46	85.71	7.50	0.00	30.00	16.61	6.73	57.86
4	10.00	1.72	25.00	0.00	0.00	35.00	5.00	0.86	30.00
6	14.29	19.61	76.92	12.50	6.67	35.00	13.39	13.14	55.96

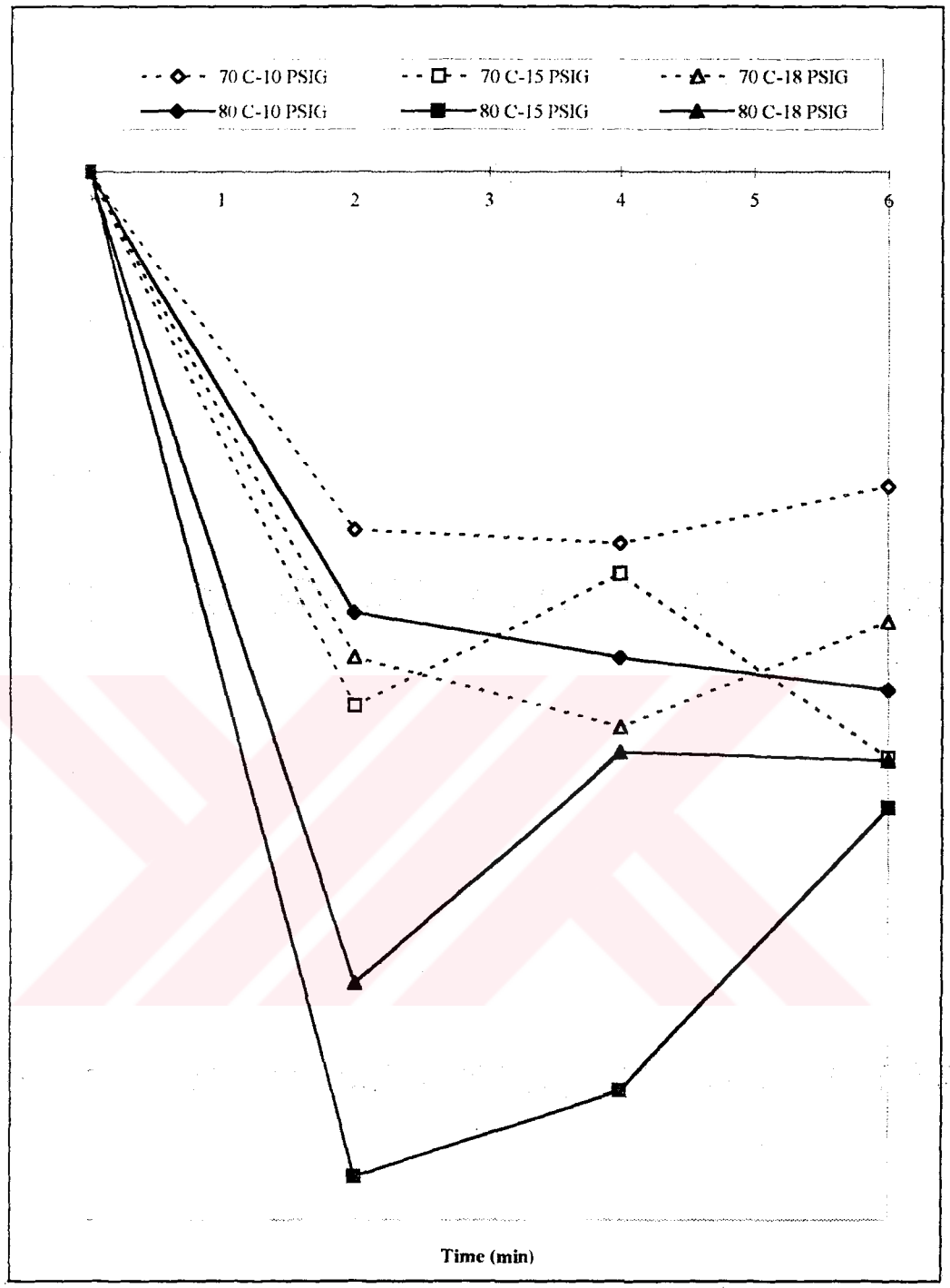

Figure C.1. [illegible] as percentage) in "a", average of Treatment I and II, of grain during Pressure Cooking

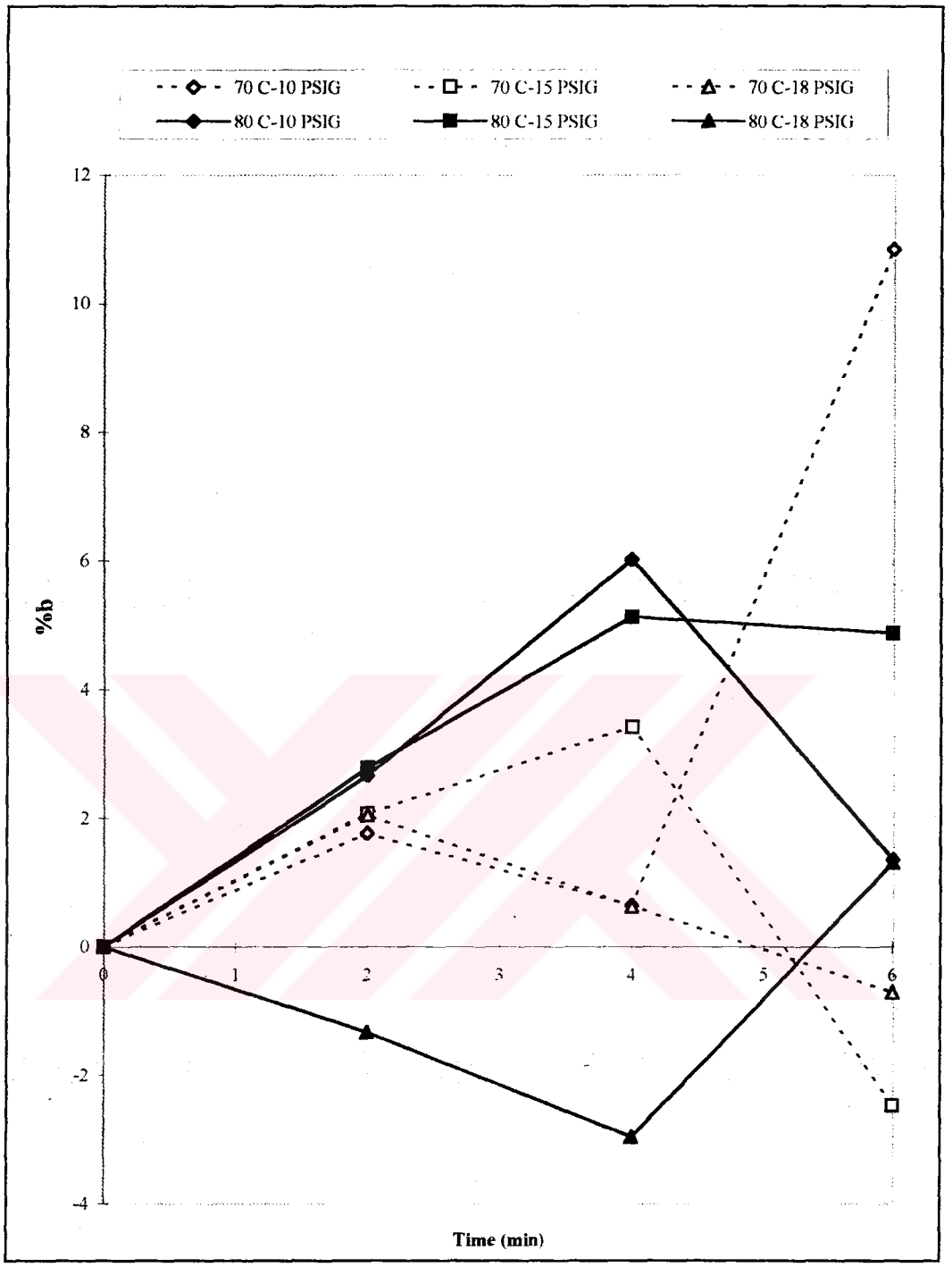

Figure C.2. Change (as percentage) in "b", average of Treatment I and II, of grain during Pressure Cooking

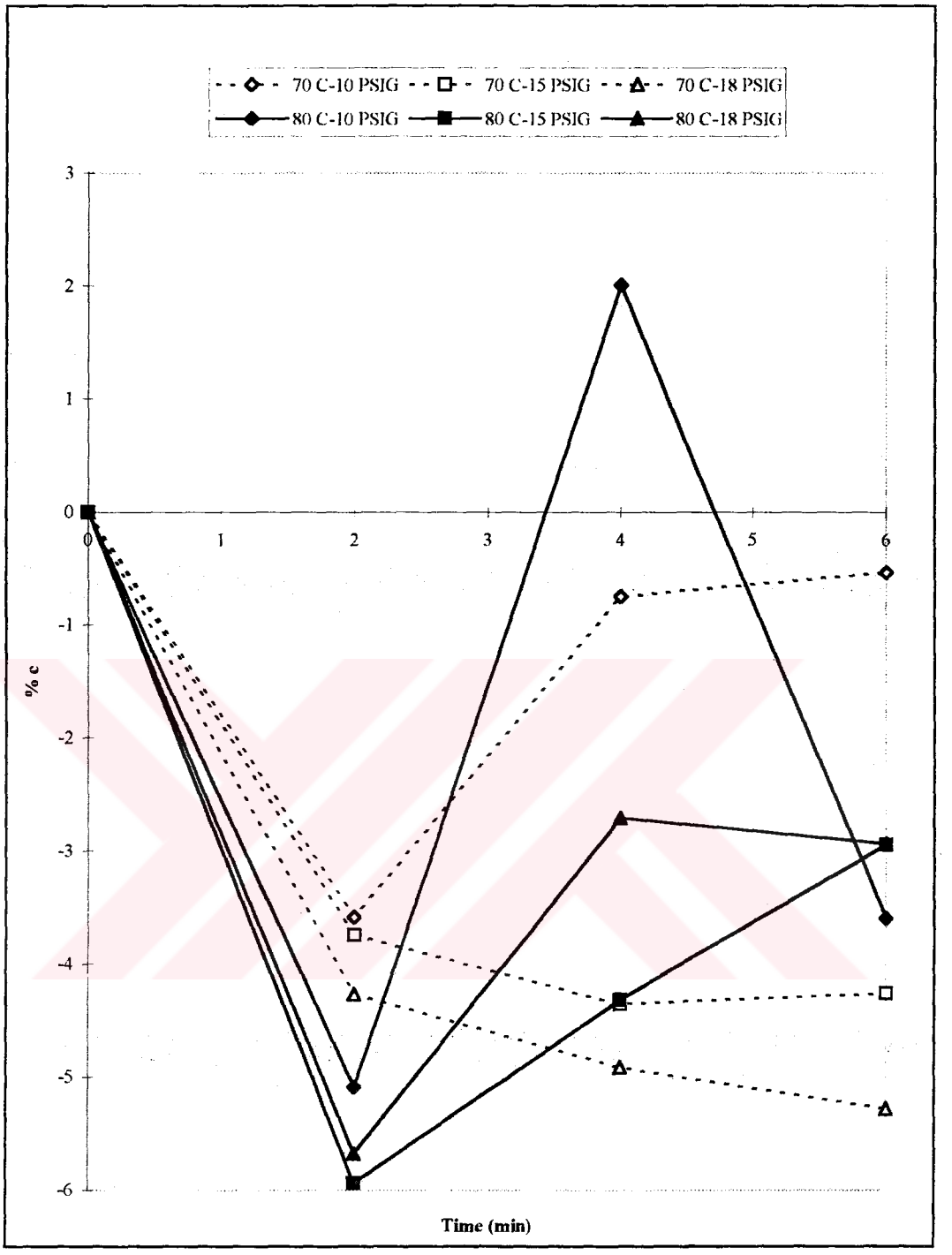

Figure C.3. Change (as percentage) in "c", average of Treatment I and II, of grain during Pressure Cooking

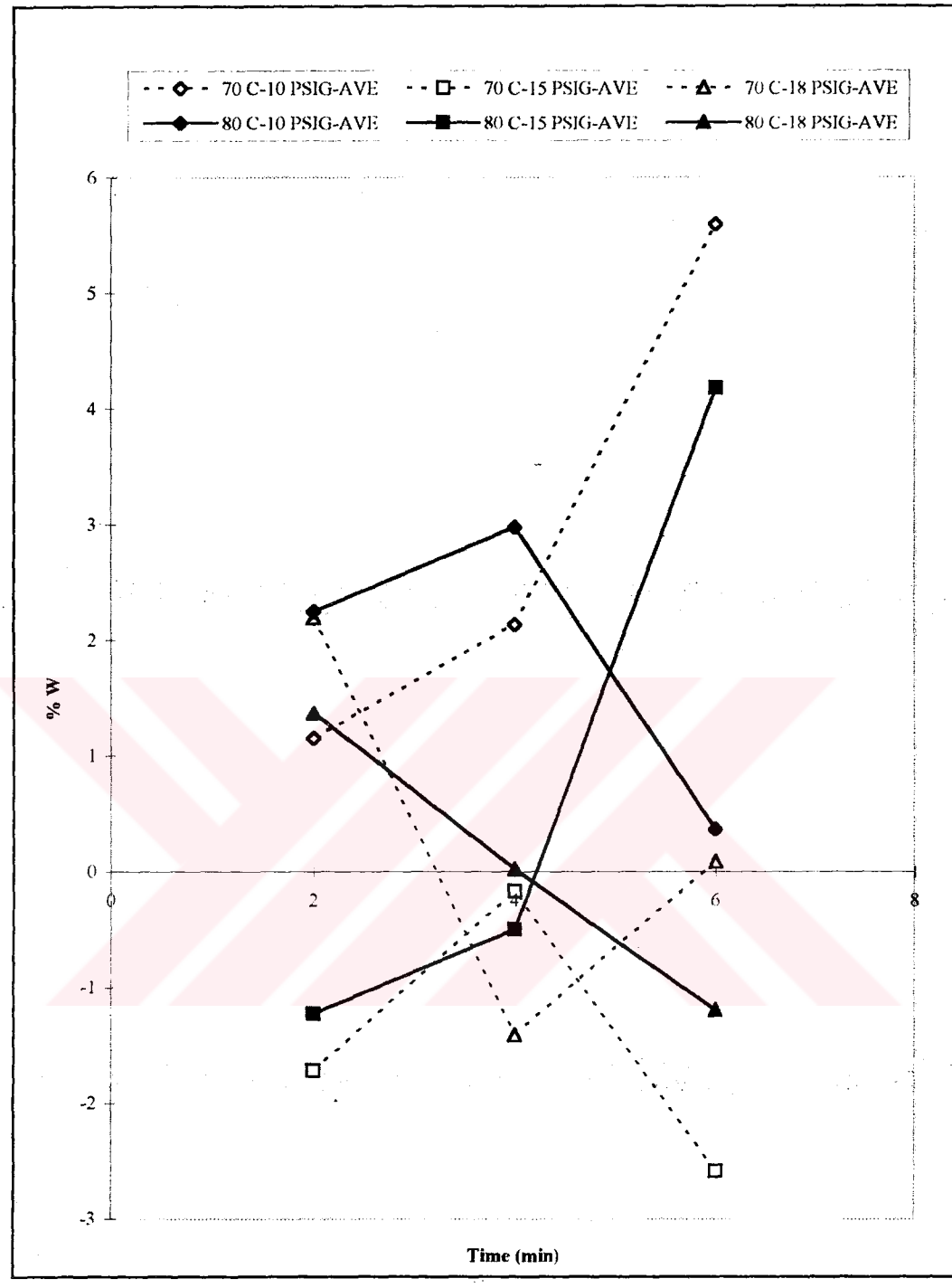

Figure C.4. Change (as percentage) in "W", average of Treatment I and II, of grain during Pressure Cooking

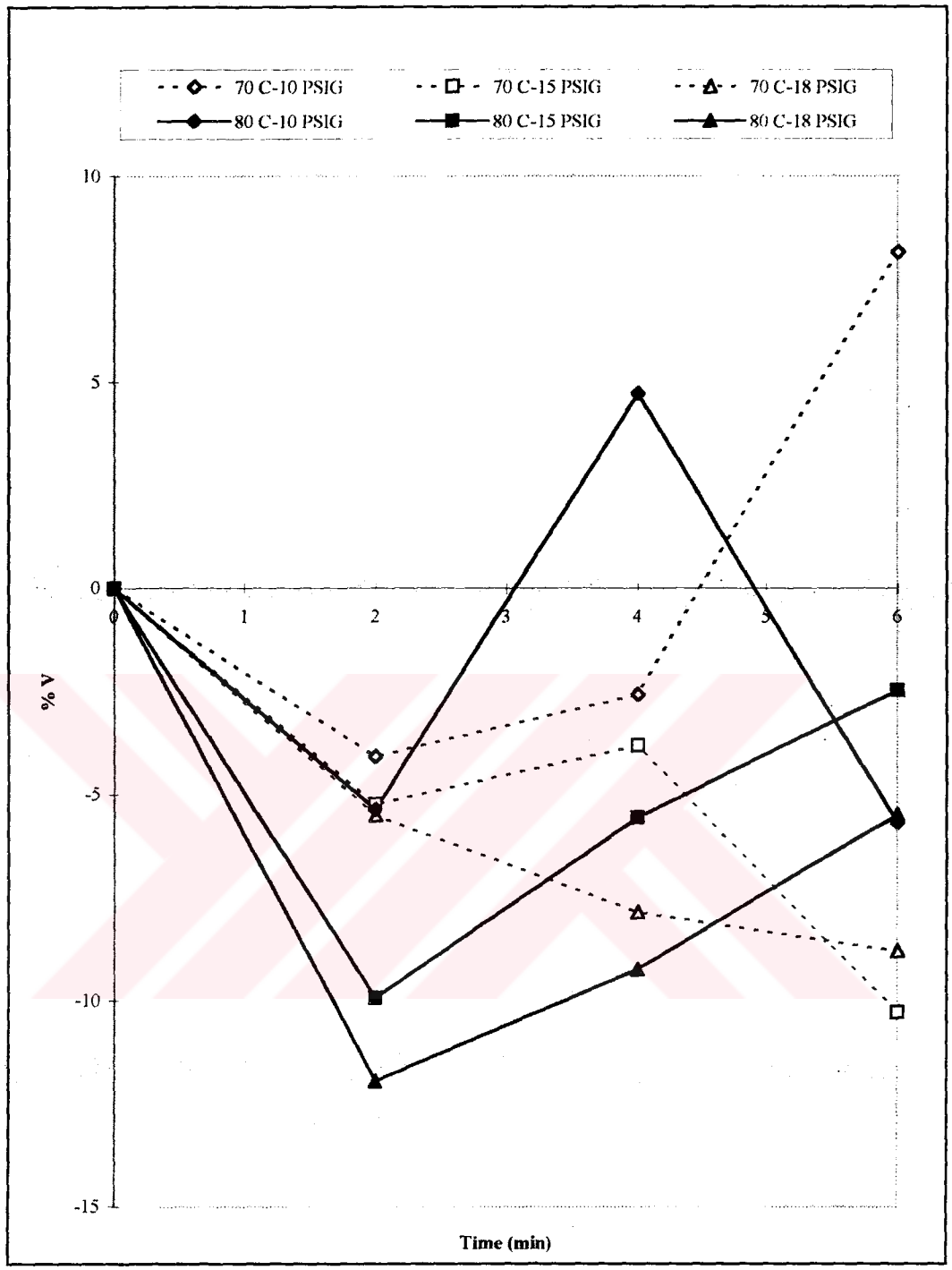

Figure C.5. Change (as percentage) in "V", average of Treatment I and II, of grain during Pressure Cooking

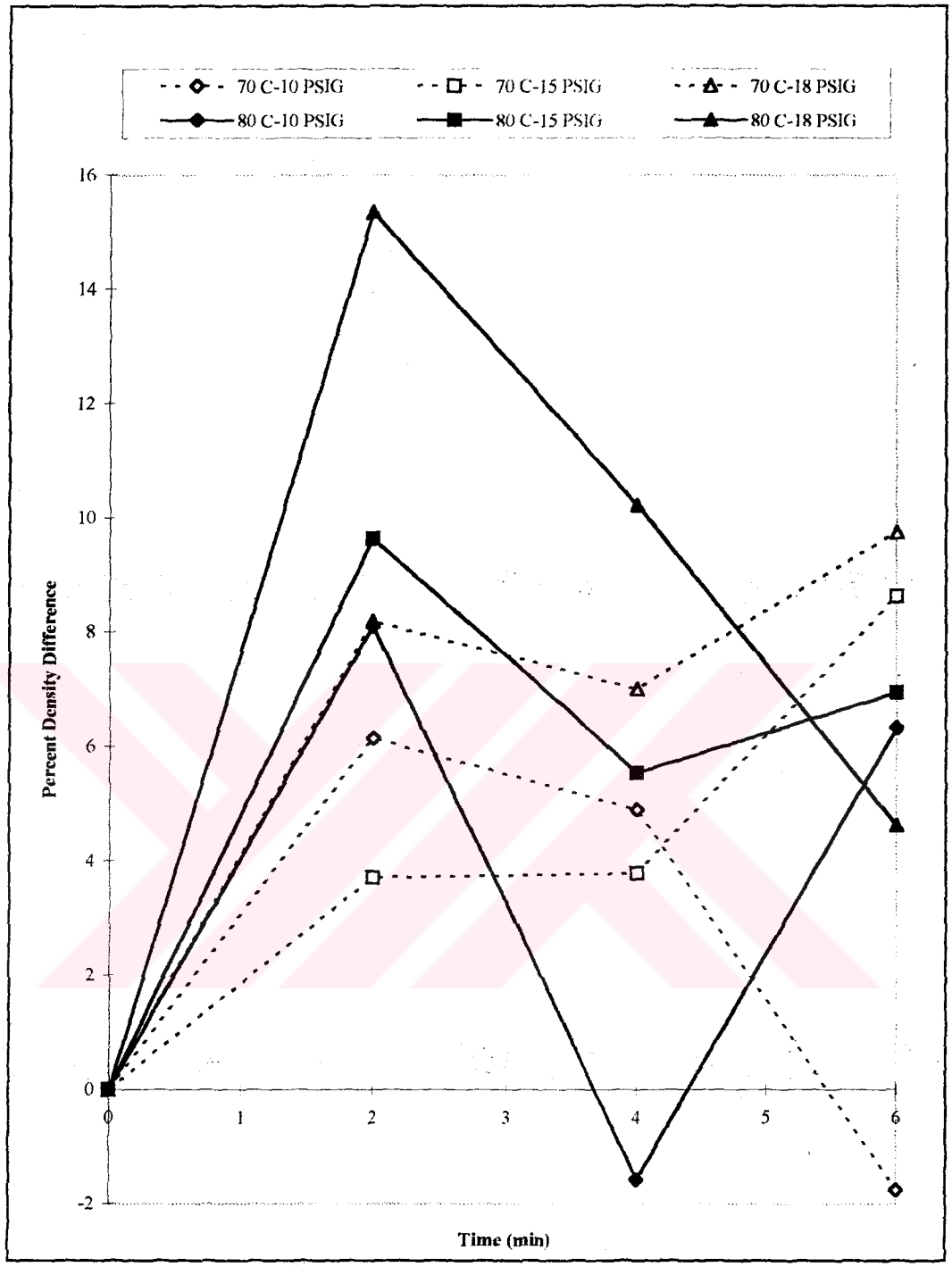

Figure C.6. Change (as percentage) in "ρ", average of Treatment I and II, of grain during Pressure Cooking

APPENDIX D. TABLES AND FIGURES OF DRYING

Table D.1. Data of Fluidized Bed Drying at 70 °C (Treatment I)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0	0.500	0.695000	0.643626	0.000000	-	-
1	0.498	0.688646	0.637272	-0.381236	0.640449	0.002364
2	0.494	0.673103	0.621729	-0.932557	0.629501	0.005782
3	0.489	0.656288	0.604914	-1.008948	0.613322	0.006255
4	0.483	0.637770	0.586396	-1.111055	0.595655	0.006888
5	0.478	0.619252	0.567878	-1.111105	0.577137	0.006889
6	0.472	0.600734	0.549360	-1.111055	0.558619	0.006888
7	0.467	0.582216	0.530842	-1.111055	0.540101	0.006888
8	0.461	0.563699	0.512325	-1.111055	0.521584	0.006888
9	0.456	0.545181	0.493807	-1.111055	0.503066	0.006888
10	0.450	0.526663	0.475289	-1.111105	0.484548	0.006889
12	0.439	0.489626	0.438252	-1.111105	0.456770	0.006889
14	0.430	0.458762	0.407388	-0.925909	0.422820	0.005740
16	0.422	0.430986	0.379612	-0.833291	0.393500	0.005166
18	0.415	0.406296	0.354922	-0.740703	0.367267	0.004592
20	0.408	0.381606	0.330232	-0.740703	0.342577	0.004592
25	0.393	0.332226	0.280852	-0.592563	0.305542	0.003674
30	0.379	0.285932	0.234558	-0.555528	0.257705	0.003444
35	0.368	0.248896	0.197522	-0.444422	0.216040	0.002755
40	0.359	0.218028	0.166654	-0.370426	0.182088	0.002297
45	0.351	0.190256	0.138882	-0.333262	0.152768	0.002066
50	0.346	0.171738	0.120364	-0.222211	0.129623	0.001378
55	0.340	0.153221	0.101847	-0.222211	0.111105	0.001378
65	0.333	0.128530	0.077156	-0.148141	0.089501	0.000918
70	0.330	0.119272	0.067898	-0.111106	0.072527	0.000689
75	0.327	0.110013	0.058639	-0.111106	0.063268	0.000689
80	0.326	0.103840	0.052466	-0.074070	0.055553	0.000459
85	0.324	0.097668	0.046294	-0.074070	0.049380	0.000459
90	0.322	0.091488	0.040114	-0.074154	0.043204	0.000460
95	0.320	0.085316	0.033942	-0.074070	0.037028	0.000459
100	0.318	0.079143	0.027769	-0.074070	0.030855	0.000459
105	0.317	0.076061	0.024687	-0.036991	0.026228	0.000229
110	0.317	0.072974	0.021600	-0.037035	0.023144	0.000230
115	0.316	0.069888	0.018514	-0.037035	0.020057	0.000230
120	0.315	0.066802	0.015428	-0.037035	0.016971	0.000230
125	0.314	0.063716	0.012342	-0.037035	0.013885	0.000230
130	0.313	0.060629	0.009255	-0.037035	0.010798	0.000230
135	0.312	0.057543	0.006169	-0.037035	0.007712	0.000230
140	0.311	0.054460	0.003086	-0.036991	0.004628	0.000229
145	0.310	0.051374	0.000000	-0.037038	0.001543	0.000230
150	0.310	0.051374	0.000000	0.000000	0.000000	0.000000
155	0.310	0.051374	0.000000	0.000000	0.000000	0.000000
160	0.310	0.051374	0.000000	0.000000	0.000000	0.000000
165	0.310	0.051374	0.000000	0.000000	0.000000	0.000000
170	0.310	0.051374	0.000000	0.000000	0.000000	0.000000
175	0.310	0.051374	0.000000	0.000000	0.000000	0.000000
180	0.310	0.051374	0.000000	0.000000	0.000000	0.000000

Table D.2. Data of Fluidized Bed Drying at 70 °C (Treatment II)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0	0.500	0.695000	0.642343	0.000000	-	-
1	0.499	0.692853	0.640196	-0.128813	0.641270	0.000799
2	0.495	0.679521	0.626864	-0.799911	0.633530	0.004959
3	0.491	0.663447	0.610790	-0.964429	0.618827	0.005979
4	0.486	0.645811	0.593154	-1.058196	0.601972	0.006561
5	0.480	0.628175	0.575518	-1.058161	0.584336	0.006560
6	0.475	0.610538	0.557881	-1.058196	0.566700	0.006561
7	0.470	0.592902	0.540245	-1.058161	0.549063	0.006560
8	0.465	0.575266	0.522609	-1.058161	0.531427	0.006560
9	0.460	0.557630	0.504973	-1.058161	0.513791	0.006560
10	0.454	0.539994	0.487337	-1.058196	0.496155	0.006561
12	0.444	0.504720	0.452063	-1.058196	0.469700	0.006561
14	0.433	0.469447	0.416790	-1.058196	0.434427	0.006561
16	0.424	0.437116	0.384459	-0.969947	0.400624	0.006013
18	0.415	0.407721	0.355064	-0.881851	0.369761	0.005467
20	0.408	0.384206	0.331549	-0.705440	0.343306	0.004374
25	0.393	0.331298	0.278641	-0.634896	0.305095	0.003936
30	0.380	0.287208	0.234551	-0.529080	0.256596	0.003280
35	0.369	0.251936	0.199279	-0.423264	0.216915	0.002624
45	0.353	0.196088	0.143431	-0.335084	0.171355	0.002077
50	0.346	0.173195	0.120538	-0.274726	0.131985	0.001703
55	0.341	0.155559	0.102902	-0.211632	0.111720	0.001312
60	0.337	0.142295	0.089638	-0.159162	0.096270	0.000987
70	0.330	0.118780	0.066123	-0.141088	0.077881	0.000875
75	0.327	0.108923	0.056266	-0.118287	0.061195	0.000733
80	0.325	0.100809	0.048152	-0.097375	0.052209	0.000604
85	0.323	0.093625	0.040968	-0.086201	0.044560	0.000534
90	0.321	0.087747	0.035090	-0.070544	0.038029	0.000437
95	0.320	0.083889	0.031232	-0.046293	0.033161	0.000287
100	0.319	0.080031	0.027374	-0.046293	0.029303	0.000287
105	0.317	0.076173	0.023516	-0.046293	0.025445	0.000287
110	0.317	0.073234	0.020577	-0.035272	0.022047	0.000219
115	0.316	0.070295	0.017638	-0.035272	0.019107	0.000219
120	0.315	0.067355	0.014698	-0.035272	0.016168	0.000219
125	0.314	0.064416	0.011759	-0.035272	0.013229	0.000219
130	0.313	0.061477	0.008820	-0.035272	0.010289	0.000219
135	0.312	0.058537	0.005880	-0.035279	0.007350	0.000219
140	0.311	0.055597	0.002940	-0.035279	0.004410	0.000219
145	0.311	0.052657	0.000000	-0.035278	0.001470	0.000219
150	0.311	0.052657	0.000000	0.000000	0.000000	0.000000
155	0.311	0.052657	0.000000	0.000000	0.000000	0.000000
160	0.311	0.052657	0.000000	0.000000	0.000000	0.000000
165	0.311	0.052657	0.000000	0.000000	0.000000	0.000000
170	0.311	0.052657	0.000000	0.000000	0.000000	0.000000
175	0.311	0.052657	0.000000	0.000000	0.000000	0.000000
180	0.311	0.052657	0.000000	0.000000	0.000000	0.000000

Table D.3. Data of Fluidized Bed Drying at 80 °C (Treatment I)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0	0.500	0.695000	0.648267	0.000000	-	-
1	0.496	0.681577	0.634844	-0.805363	0.641556	0.004993
2	0.491	0.662985	0.616252	-1.115520	0.625548	0.006916
3	0.484	0.641022	0.594289	-1.317784	0.605271	0.008170
4	0.477	0.617025	0.570292	-1.439826	0.582291	0.008927
5	0.470	0.593028	0.546295	-1.439826	0.558294	0.008927
6	0.463	0.569031	0.522298	-1.439826	0.534296	0.008927
7	0.456	0.545034	0.498301	-1.439826	0.510299	0.008927
8	0.449	0.521037	0.474304	-1.439826	0.486302	0.008927
9	0.442	0.497041	0.450308	-1.439754	0.462306	0.008926
10	0.436	0.476472	0.429739	-1.234136	0.440023	0.007651
12	0.424	0.438762	0.392029	-1.131292	0.410884	0.007014
14	0.415	0.407909	0.361176	-0.925602	0.376602	0.005738
16	0.407	0.380484	0.333751	-0.822757	0.347463	0.005101
18	0.399	0.353058	0.306325	-0.822757	0.320038	0.005101
20	0.393	0.332489	0.285756	-0.617068	0.296041	0.003826
25	0.380	0.288365	0.241632	-0.529491	0.263694	0.003283
30	0.368	0.247227	0.200494	-0.493654	0.221063	0.003061
35	0.358	0.212946	0.166213	-0.411379	0.183353	0.002550
40	0.349	0.182092	0.135359	-0.370241	0.150786	0.002295
45	0.343	0.161523	0.114790	-0.246827	0.125075	0.001530
50	0.338	0.144383	0.097650	-0.205689	0.106220	0.001275
55	0.334	0.130663	0.083930	-0.164637	0.090790	0.001021
60	0.331	0.120381	0.073648	-0.123387	0.078789	0.000765
65	0.327	0.110096	0.063363	-0.123414	0.068505	0.000765
70	0.325	0.101449	0.054716	-0.103761	0.059040	0.000643
75	0.323	0.093938	0.047205	-0.090132	0.050961	0.000559
80	0.321	0.087079	0.040346	-0.082318	0.043775	0.000510
85	0.319	0.080222	0.033489	-0.082276	0.036917	0.000510
90	0.317	0.073362	0.026629	-0.082318	0.030059	0.000510
95	0.315	0.067290	0.020557	-0.072869	0.023593	0.000452
100	0.314	0.063862	0.017129	-0.041138	0.018843	0.000255
105	0.313	0.060434	0.013701	-0.041138	0.015415	0.000255
110	0.312	0.057005	0.010272	-0.041138	0.011987	0.000255
115	0.311	0.053577	0.006844	-0.041138	0.008558	0.000255
120	0.310	0.050155	0.003422	-0.041068	0.005133	0.000255
125	0.309	0.046733	0.000000	-0.041063	0.001711	0.000255
130	0.309	0.046733	0.000000	0.000000	0.000000	0.000000
135	0.309	0.046733	0.000000	0.000000	0.000000	0.000000
140	0.309	0.046733	0.000000	0.000000	0.000000	0.000000
145	0.309	0.046733	0.000000	0.000000	0.000000	0.000000
150	0.309	0.046733	0.000000	0.000000	0.000000	0.000000

Table D.4. Data of Fluidized Bed Drying at 80 °C (Treatment II)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0	0.500	0.695000	0.647040	0.000000	-	-
1	0.496	0.682652	0.634692	-0.740900	0.640866	0.004593
2	0.491	0.664024	0.616064	-1.117687	0.625378	0.006929
3	0.484	0.642291	0.594331	-1.303969	0.605197	0.008084
4	0.478	0.620558	0.572598	-1.303969	0.583464	0.008084
5	0.472	0.598825	0.550865	-1.303969	0.561732	0.008084
6	0.465	0.577092	0.529132	-1.303958	0.539999	0.008084
7	0.459	0.555360	0.507400	-1.303958	0.518266	0.008084
8	0.452	0.533627	0.485667	-1.303969	0.496533	0.008084
10	0.440	0.490162	0.442202	-1.303958	0.463934	0.008084
12	0.430	0.456010	0.408050	-1.024547	0.425126	0.006352
14	0.421	0.428068	0.380108	-0.838266	0.394079	0.005197
16	0.413	0.400126	0.352166	-0.838266	0.366137	0.005197
18	0.406	0.375288	0.327328	-0.745125	0.339747	0.004620
20	0.399	0.353556	0.305596	-0.651984	0.316462	0.004042
25	0.386	0.306985	0.259025	-0.558844	0.282310	0.003465
30	0.374	0.266624	0.218664	-0.484331	0.238845	0.003003
35	0.365	0.238682	0.190722	-0.335306	0.204693	0.002079
40	0.358	0.213848	0.165888	-0.298012	0.178305	0.001848
42	0.355	0.204534	0.156574	-0.279422	0.161231	0.001732
45	0.352	0.192828	0.144868	-0.234108	0.150721	0.001451
50	0.346	0.174200	0.126240	-0.223537	0.135554	0.001386
55	0.341	0.157380	0.109420	-0.201844	0.117830	0.001251
60	0.337	0.141858	0.093898	-0.186258	0.101659	0.001155
65	0.332	0.126335	0.078375	-0.186281	0.086137	0.001155
70	0.329	0.114502	0.066542	-0.141992	0.072459	0.000880
75	0.326	0.103852	0.055892	-0.127808	0.061217	0.000792
80	0.323	0.094538	0.046578	-0.111769	0.051235	0.000693
85	0.320	0.085225	0.037265	-0.111755	0.041921	0.000693
90	0.318	0.076782	0.028822	-0.101312	0.033043	0.000628
95	0.316	0.070132	0.022172	-0.079802	0.025497	0.000495
100	0.314	0.063482	0.015522	-0.079802	0.018847	0.000495
105	0.313	0.060377	0.012417	-0.037252	0.013969	0.000231
110	0.312	0.057273	0.009313	-0.037252	0.010865	0.000231
115	0.311	0.054169	0.006209	-0.037252	0.007761	0.000231
120	0.310	0.051064	0.003104	-0.037252	0.004657	0.000231
125	0.309	0.047960	0.000000	-0.037253	0.001552	0.000231
130	0.309	0.047960	0.000000	0.000000	0.000000	0.000000
135	0.309	0.047960	0.000000	0.000000	0.000000	0.000000
140	0.309	0.047960	0.000000	0.000000	0.000000	0.000000
145	0.309	0.047960	0.000000	0.000000	0.000000	0.000000
150	0.309	0.047960	0.000000	0.000000	0.000000	0.000000

Table D.5. Data of Fluidized Bed Drying at 90 °C (Treatment I)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0	0.500	0.695000	0.651165	0.000000	-	-
1	0.489	0.656909	0.613074	-2.285484	0.632119	0.014169
2	0.476	0.614232	0.570397	-2.560570	0.591736	0.015875
3	0.464	0.571556	0.527721	-2.560570	0.549059	0.015875
4	0.451	0.528880	0.485045	-2.560570	0.506383	0.015875
5	0.438	0.486204	0.442369	-2.560570	0.463707	0.015875
6	0.429	0.454197	0.410362	-1.920428	0.426365	0.011906
7	0.422	0.429302	0.385467	-1.493666	0.397915	0.009260
8	0.416	0.408601	0.364766	-1.242111	0.375116	0.007701
9	0.410	0.391459	0.347624	-1.028468	0.356195	0.006376
10	0.405	0.374318	0.330483	-1.028468	0.339054	0.006376
12	0.396	0.342311	0.298476	-0.960214	0.314480	0.005953
14	0.388	0.313860	0.270025	-0.853523	0.284251	0.005292
16	0.380	0.287417	0.243582	-0.793295	0.256804	0.004918
18	0.372	0.262523	0.218688	-0.746833	0.231135	0.004630
20	0.366	0.241185	0.197350	-0.640143	0.208019	0.003969
25	0.353	0.194952	0.151117	-0.554790	0.174233	0.003440
30	0.343	0.162945	0.119110	-0.384086	0.135114	0.002381
35	0.337	0.141607	0.097772	-0.256057	0.108441	0.001587
40	0.330	0.120269	0.076434	-0.256057	0.087103	0.001587
45	0.327	0.109600	0.065765	-0.128029	0.071099	0.000794
50	0.324	0.099525	0.055690	-0.120899	0.060727	0.000750
55	0.322	0.090126	0.046291	-0.112784	0.050991	0.000699
60	0.319	0.080795	0.036960	-0.111979	0.041625	0.000694
65	0.316	0.072345	0.028510	-0.101401	0.032735	0.000629
70	0.314	0.065237	0.021402	-0.085292	0.024956	0.000529
75	0.312	0.058124	0.014289	-0.085352	0.017846	0.000529
80	0.311	0.054568	0.010733	-0.042676	0.012511	0.000265
85	0.310	0.051012	0.007177	-0.042676	0.008955	0.000265
90	0.309	0.047455	0.003620	-0.042676	0.005398	0.000265
95	0.308	0.043835	0.000000	-0.043442	0.001810	0.000269
100	0.308	0.043835	0.000000	0.000000	0.000000	0.000000
105	0.308	0.043835	0.000000	0.000000	0.000000	0.000000
110	0.308	0.043835	0.000000	0.000000	0.000000	0.000000
115	0.308	0.043835	0.000000	0.000000	0.000000	0.000000
120	0.308	0.043835	0.000000	0.000000	0.000000	0.000000

Table D.6. Data of Fluidized Bed Drying at 90 °C (Treatment II)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0	0.500	0.695000	0.651761	0.000000	-	-
1	0.492	0.668826	0.625587	-1.570432	0.638674	0.009736
2	0.484	0.640530	0.597291	-1.697791	0.611439	0.010526
3	0.475	0.609403	0.566164	-1.867570	0.581728	0.011578
4	0.466	0.578277	0.535038	-1.867570	0.550601	0.011578
5	0.456	0.547151	0.503912	-1.867570	0.519475	0.011578
6	0.447	0.516025	0.472786	-1.867570	0.488349	0.011578
7	0.438	0.484899	0.441660	-1.867570	0.457223	0.011578
8	0.430	0.456602	0.413363	-1.697791	0.427512	0.010526
9	0.422	0.431137	0.387898	-1.527899	0.400631	0.009473
10	0.416	0.408500	0.365261	-1.358211	0.376580	0.008421
12	0.405	0.374545	0.331306	-1.018658	0.348284	0.006315
14	0.397	0.346249	0.303010	-0.848882	0.317158	0.005263
16	0.389	0.318990	0.275751	-0.817779	0.289381	0.005070
18	0.382	0.293523	0.250284	-0.763994	0.263018	0.004737
20	0.375	0.270887	0.227648	-0.679105	0.238966	0.004210
25	0.359	0.217126	0.173887	-0.645130	0.200767	0.004000
30	0.346	0.172945	0.129706	-0.530175	0.151796	0.003287
35	0.337	0.141816	0.098577	-0.373545	0.114141	0.002316
40	0.331	0.122009	0.078770	-0.237687	0.088673	0.001474
45	0.327	0.108527	0.065288	-0.161773	0.072029	0.001003
50	0.325	0.100039	0.056800	-0.101866	0.061044	0.000632
55	0.322	0.092474	0.049235	-0.090780	0.053017	0.000563
60	0.320	0.086155	0.042916	-0.075826	0.046075	0.000470
65	0.317	0.074614	0.031375	-0.138490	0.037145	0.000859
70	0.314	0.065878	0.022639	-0.104834	0.027007	0.000650
75	0.313	0.060219	0.016980	-0.067911	0.019809	0.000421
80	0.311	0.054559	0.011320	-0.067911	0.014150	0.000421
85	0.310	0.051730	0.008491	-0.033955	0.009906	0.000211
90	0.309	0.048898	0.005659	-0.033978	0.007075	0.000211
95	0.309	0.046069	0.002830	-0.033955	0.004244	0.000211
100	0.308	0.043239	0.000000	-0.033955	0.001415	0.000211
105	0.308	0.043239	0.000000	0.000000	0.000000	0.000000

Table D.7. Data of Tray Drying at 70 °C (Treatment I)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0.0	0.500	0.695000	0.61942	0.00000	-	-
2.0	0.500	0.695000	0.61942	0.00000	0.619419	0.000000
5.0	0.499	0.691525	0.61594	-0.06950	0.617682	0.201499
7.5	0.498	0.688050	0.61247	-0.08340	0.614207	0.241798
9.5	0.497	0.684575	0.60899	-0.10425	0.610732	0.302248
10.0	0.497	0.683706	0.60813	-0.10425	0.608560	0.302248
12.0	0.496	0.680231	0.60465	-0.10425	0.606388	0.302248
14.0	0.495	0.676756	0.60118	-0.10425	0.602913	0.302248
16.0	0.494	0.673281	0.59770	-0.10425	0.599438	0.302248
18.0	0.493	0.669806	0.59423	-0.10425	0.595963	0.302248
20.0	0.492	0.666331	0.59075	-0.10425	0.592488	0.302248
25.0	0.487	0.652431	0.57685	-0.16680	0.583800	0.483597
30.0	0.483	0.638531	0.56295	-0.16680	0.569900	0.483597
35.0	0.479	0.624631	0.54905	-0.16680	0.556000	0.483597
40.0	0.475	0.610731	0.53515	-0.16680	0.542100	0.483597
45.0	0.471	0.596831	0.52125	-0.16680	0.528200	0.483597
50.0	0.467	0.582931	0.50735	-0.16680	0.514300	0.483597
55.0	0.463	0.569031	0.49345	-0.16680	0.500400	0.483597
60.0	0.459	0.555131	0.47955	-0.16680	0.486500	0.483597
65.0	0.455	0.541231	0.46565	-0.16680	0.472600	0.483597
70.0	0.451	0.527331	0.45175	-0.16680	0.458700	0.483597
75.0	0.446	0.513431	0.43785	-0.16680	0.444800	0.483597
80.0	0.442	0.499531	0.42395	-0.16680	0.430900	0.483597
86.0	0.437	0.482851	0.40727	-0.16680	0.415610	0.483597
90.0	0.434	0.471731	0.39615	-0.16680	0.401710	0.483597
95.0	0.430	0.457831	0.38225	-0.16680	0.389200	0.483597
100.0	0.426	0.443931	0.36835	-0.16680	0.375300	0.483597
105.0	0.422	0.430031	0.35445	-0.16680	0.361400	0.483597
110.0	0.418	0.416131	0.34055	-0.16680	0.347500	0.483597
115.0	0.414	0.402231	0.32665	-0.16680	0.333600	0.483597
125.0	0.405	0.374431	0.29885	-0.16680	0.312750	0.483597
130.0	0.401	0.360531	0.28495	-0.16680	0.291900	0.483597
135.0	0.397	0.346631	0.27105	-0.16680	0.278000	0.483597
140.0	0.394	0.336206	0.26063	-0.12510	0.265838	0.362698
147.0	0.390	0.321611	0.24603	-0.12510	0.253328	0.362697
150.0	0.388	0.315356	0.23978	-0.12510	0.242903	0.362697
155.0	0.385	0.304931	0.22935	-0.12510	0.234563	0.362697
160.0	0.382	0.294506	0.21893	-0.12510	0.224138	0.362697
165.0	0.379	0.284081	0.20850	-0.12510	0.213713	0.362698
170.0	0.376	0.273656	0.19808	-0.12510	0.203288	0.362698
175.0	0.373	0.263231	0.18765	-0.12510	0.192863	0.362698
185.0	0.368	0.245856	0.17028	-0.10425	0.178963	0.302248
191.0	0.364	0.235431	0.15985	-0.10425	0.165063	0.302248
195.0	0.362	0.228481	0.15290	-0.10425	0.156375	0.302248
200.0	0.360	0.221531	0.14595	-0.08340	0.149425	0.241798
205.0	0.358	0.214581	0.13900	-0.08340	0.142475	0.241798
210.0	0.356	0.207631	0.13205	-0.08340	0.135525	0.241798
215.0	0.354	0.200681	0.12510	-0.08340	0.128575	0.241798
220.0	0.352	0.193731	0.11815	-0.08340	0.121625	0.241798
225.0	0.350	0.186781	0.11120	-0.08340	0.114675	0.241798
230.0	0.348	0.179831	0.10425	-0.08340	0.107725	0.241798
235.0	0.346	0.172881	0.09730	-0.08340	0.100775	0.241798
240.0	0.344	0.165931	0.09035	-0.08340	0.093825	0.241798
245.0	0.342	0.158981	0.08340	-0.08340	0.086875	0.241798
250.0	0.340	0.152031	0.07645	-0.08340	0.079925	0.241798
255.0	0.338	0.145081	0.06950	-0.08340	0.072975	0.241798
260.0	0.336	0.138131	0.06255	-0.08340	0.066025	0.241798
265.0	0.334	0.131181	0.05560	-0.08340	0.059075	0.241798

Table D.7. (cont'd)

270.0	0.332	0.124231	0.04865	-0.08340	0.052125	0.241798
275.0	0.330	0.117281	0.04170	-0.08340	0.045175	0.241798
280.0	0.329	0.113806	0.03823	-0.04170	0.039963	0.120899
285.0	0.328	0.110331	0.03475	-0.04170	0.036488	0.120899
290.0	0.327	0.106856	0.03128	-0.04170	0.033013	0.120899
295.0	0.325	0.103381	0.02780	-0.04170	0.029538	0.120899
300.0	0.324	0.099906	0.02433	-0.04170	0.026063	0.120899
305.0	0.323	0.096431	0.02085	-0.04170	0.022588	0.120899
310.0	0.322	0.092956	0.01738	-0.04170	0.019113	0.120899
315.0	0.321	0.089481	0.01390	-0.04170	0.015638	0.120899
320.0	0.320	0.086006	0.01043	-0.04170	0.012163	0.120899
325.0	0.319	0.082531	0.00695	-0.04170	0.008688	0.120899
330.0	0.318	0.079056	0.00348	-0.04170	0.005213	0.120899
335.0	0.317	0.075581	0.00000	-0.04171	0.001738	0.120916
340.0	0.317	0.075581	0.00000	0.00000	0.000000	0.000000

Table D.8. Data of Tray Drying at 70 °C (Treatment II)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0.0	0.500	0.69500	0.62108	0.00000	-	-
1.5	0.499	0.69163	0.61771	-0.13486	0.61940	0.390988
5.5	0.498	0.68826	0.61434	-0.05058	0.61603	0.146635
8.0	0.497	0.68489	0.61097	-0.08092	0.61265	0.234617
10.0	0.496	0.68151	0.60760	-0.10115	0.60928	0.293271
12.0	0.495	0.67814	0.60422	-0.10115	0.60591	0.293271
14.0	0.494	0.67477	0.60085	-0.10115	0.60254	0.293271
16.0	0.493	0.67140	0.59748	-0.10115	0.59917	0.293271
20.0	0.490	0.66061	0.58669	-0.16185	0.59209	0.469233
25.0	0.486	0.64712	0.57320	-0.16185	0.57995	0.469233
30.0	0.482	0.63363	0.55972	-0.16185	0.56646	0.469233
35.0	0.478	0.62015	0.54623	-0.16185	0.55297	0.469233
40.0	0.474	0.60666	0.53274	-0.16185	0.53949	0.469233
50.0	0.466	0.57969	0.50577	-0.16185	0.51925	0.469233
55.0	0.462	0.56620	0.49228	-0.16185	0.49902	0.469233
60.0	0.458	0.55271	0.47879	-0.16185	0.48554	0.469233
65.0	0.454	0.53922	0.46531	-0.16185	0.47205	0.469233
70.0	0.450	0.52574	0.45182	-0.16185	0.45856	0.469233
75.0	0.446	0.51225	0.43833	-0.16185	0.44508	0.469233
85.0	0.438	0.48528	0.41136	-0.16185	0.42485	0.469233
90.0	0.434	0.47179	0.39787	-0.16185	0.40461	0.469233
95.0	0.430	0.45830	0.38438	-0.16185	0.39113	0.469233
108.0	0.420	0.42324	0.34932	-0.16185	0.36685	0.469233
110.0	0.418	0.41784	0.34392	-0.16185	0.34662	0.469233
125.0	0.406	0.37738	0.30346	-0.16185	0.32369	0.469233
130.0	0.402	0.36389	0.28997	-0.16185	0.29672	0.469233
135.0	0.398	0.35040	0.27649	-0.16185	0.28323	0.469233
140.0	0.394	0.33692	0.26300	-0.16185	0.26974	0.469233
145.0	0.391	0.32680	0.25288	-0.12138	0.25794	0.351925
150.0	0.388	0.31669	0.24277	-0.12138	0.24783	0.351925
155.0	0.385	0.30657	0.23265	-0.12138	0.23771	0.351925
160.0	0.382	0.29646	0.22254	-0.12138	0.22760	0.351925
165.0	0.379	0.28634	0.21242	-0.12138	0.21748	0.351925
170.0	0.376	0.27623	0.20231	-0.12138	0.20737	0.351925
175.0	0.374	0.26611	0.19219	-0.12138	0.19725	0.351925
180.0	0.371	0.25599	0.18208	-0.12138	0.18713	0.351925
185.0	0.368	0.24588	0.17196	-0.12138	0.17702	0.351925
190.0	0.365	0.23576	0.16185	-0.12138	0.16690	0.351925
195.0	0.362	0.22565	0.15173	-0.12138	0.15679	0.351925
200.0	0.360	0.21891	0.14499	-0.08092	0.14836	0.234617
205.0	0.358	0.21216	0.13824	-0.08092	0.14162	0.234617
210.0	0.356	0.20542	0.13150	-0.08092	0.13487	0.234617
215.0	0.354	0.19867	0.12476	-0.08092	0.12813	0.234617
220.0	0.352	0.19193	0.11801	-0.08092	0.12138	0.234617
225.0	0.350	0.18519	0.11127	-0.08092	0.11464	0.234617
230.0	0.348	0.17844	0.10453	-0.08092	0.10790	0.234617
235.0	0.346	0.17170	0.09778	-0.08092	0.10115	0.234617
240.0	0.344	0.16496	0.09104	-0.08092	0.09441	0.234617
245.0	0.342	0.15821	0.08429	-0.08092	0.08767	0.234617
250.0	0.340	0.15147	0.07755	-0.08092	0.08092	0.234617
255.0	0.338	0.14473	0.07081	-0.08092	0.07418	0.234617
260.0	0.336	0.13798	0.06406	-0.08092	0.06744	0.234617
265.0	0.334	0.13124	0.05732	-0.08092	0.06069	0.234617
270.0	0.332	0.12450	0.05058	-0.08092	0.05395	0.234617
275.0	0.330	0.11775	0.04383	-0.08092	0.04721	0.234617
280.0	0.329	0.11438	0.04046	-0.04046	0.04215	0.117308
285.0	0.328	0.11101	0.03709	-0.04046	0.03878	0.117308
290.0	0.327	0.10764	0.03372	-0.04046	0.03540	0.117308

Table D.8. (cont'd)

295.0	0.326	0.10426	0.03035	-0.04046	0.03203	0.117308
300.0	0.325	0.10089	0.02697	-0.04046	0.02866	0.117308
305.0	0.324	0.09752	0.02360	-0.04046	0.02529	0.117308
310.0	0.323	0.09415	0.02023	-0.04046	0.02192	0.117308
315.0	0.322	0.09078	0.01686	-0.04046	0.01855	0.117308
320.0	0.321	0.08741	0.01349	-0.04046	0.01517	0.117308
325.0	0.320	0.08403	0.01012	-0.04046	0.01180	0.117308
330.0	0.319	0.08066	0.00674	-0.04046	0.00843	0.117308
335.0	0.318	0.07729	0.00337	-0.04046	0.00506	0.117308
340.0	0.317	0.07392	0.00000	-0.04046	0.00169	0.117303
345.0	0.317	0.07392	0.00000	0.00000	0.00000	0.000000

Table D.9. Data of Tray Drying at 80 °C (Treatment I)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	P
0.0	0.500	0.69500	0.62839	0.00000	-	-
1.5	0.499	0.69208	0.62547	-0.11664	0.62693	0.33816
3.0	0.498	0.68917	0.62256	-0.11663	0.62402	0.33815
4.5	0.497	0.68625	0.61964	-0.11663	0.62110	0.33815
5.5	0.497	0.68334	0.61673	-0.17495	0.61818	0.50723
6.5	0.496	0.68042	0.61381	-0.17495	0.61527	0.50723
7.5	0.495	0.67751	0.61090	-0.17495	0.61235	0.50723
8.5	0.494	0.67459	0.60798	-0.17495	0.60944	0.50723
9.5	0.493	0.67167	0.60506	-0.17495	0.60652	0.50723
10.0	0.493	0.66998	0.60337	-0.20349	0.60422	0.58998
12.0	0.491	0.66319	0.59658	-0.20349	0.59998	0.58998
16.0	0.487	0.64920	0.58259	-0.20994	0.58959	0.60868
18.0	0.484	0.64220	0.57559	-0.20994	0.57909	0.60868
20.0	0.482	0.63520	0.56859	-0.20994	0.57209	0.60868
25.0	0.477	0.61771	0.55110	-0.20994	0.55984	0.60868
30.0	0.472	0.60021	0.53360	-0.20994	0.54235	0.60868
35.0	0.467	0.58272	0.51611	-0.20994	0.52485	0.60868
40.0	0.462	0.56522	0.49861	-0.20994	0.50736	0.60868
45.0	0.457	0.54773	0.48112	-0.20994	0.48986	0.60868
50.0	0.451	0.53023	0.46362	-0.20994	0.47237	0.60868
55.0	0.446	0.51274	0.44613	-0.20994	0.45487	0.60868
60.0	0.441	0.49524	0.42863	-0.20994	0.43738	0.60868
65.0	0.436	0.47775	0.41114	-0.20994	0.41988	0.60868
70.0	0.431	0.46025	0.39364	-0.20994	0.40239	0.60868
75.0	0.426	0.44276	0.37615	-0.20994	0.38489	0.60868
80.0	0.420	0.42526	0.35865	-0.20994	0.36740	0.60868
85.0	0.415	0.40777	0.34116	-0.20994	0.34990	0.60868
90.0	0.411	0.39319	0.32658	-0.17495	0.33387	0.50723
95.0	0.407	0.37861	0.31200	-0.17495	0.31929	0.50723
100.0	0.402	0.36403	0.29742	-0.17495	0.30471	0.50723
105.0	0.398	0.34945	0.28284	-0.17495	0.29013	0.50723
110.0	0.394	0.33487	0.26826	-0.17495	0.27555	0.50723
115.0	0.389	0.32029	0.25368	-0.17495	0.26097	0.50723
120.0	0.385	0.30571	0.23910	-0.17495	0.24639	0.50723
125.0	0.382	0.29405	0.22744	-0.13996	0.23327	0.40578
130.0	0.378	0.28238	0.21577	-0.13996	0.22161	0.40578
135.0	0.375	0.27072	0.20411	-0.13996	0.20994	0.40578
140.0	0.371	0.25906	0.19245	-0.13996	0.19828	0.40578
145.0	0.368	0.24739	0.18078	-0.13996	0.18662	0.40578
150.0	0.365	0.23573	0.16912	-0.13996	0.17495	0.40578
155.0	0.361	0.22407	0.15746	-0.13996	0.16329	0.40578
160.0	0.358	0.21240	0.14579	-0.13996	0.15163	0.40578
165.0	0.354	0.20074	0.13413	-0.13996	0.13996	0.40578
170.0	0.351	0.18908	0.12247	-0.13996	0.12830	0.40578
175.0	0.348	0.18033	0.11372	-0.10497	0.11809	0.30434
180.0	0.346	0.17158	0.10497	-0.10497	0.10935	0.30434
185.0	0.343	0.16283	0.09622	-0.10497	0.10060	0.30434
190.0	0.340	0.15409	0.08748	-0.10497	0.09185	0.30434
195.0	0.338	0.14534	0.07873	-0.10497	0.08310	0.30434
200.0	0.335	0.13659	0.06998	-0.10497	0.07436	0.30434
205.0	0.333	0.12784	0.06123	-0.10497	0.06561	0.30434
210.0	0.331	0.12201	0.05540	-0.06998	0.05832	0.20289
215.0	0.329	0.11618	0.04957	-0.06998	0.05249	0.20289
220.0	0.328	0.11035	0.04374	-0.06998	0.04665	0.20289
225.0	0.326	0.10452	0.03791	-0.06998	0.04082	0.20289
230.0	0.325	0.10160	0.03499	-0.03499	0.03645	0.10145
235.0	0.324	0.09869	0.03208	-0.03499	0.03353	0.10145
240.0	0.323	0.09577	0.02916	-0.03499	0.03062	0.10145

Table D.9. (cont'd)

245.0	0.322	0.09285	0.02624	-0.03499	0.02770	0.10145
250.0	0.322	0.08994	0.02333	-0.03499	0.02479	0.10145
255.0	0.321	0.08702	0.02041	-0.03499	0.02187	0.10145
260.0	0.320	0.08411	0.01750	-0.03499	0.01895	0.10145
265.0	0.319	0.08119	0.01458	-0.03499	0.01604	0.10145
270.0	0.318	0.07827	0.01166	-0.03499	0.01312	0.10145
275.0	0.317	0.07536	0.00875	-0.03499	0.01021	0.10145
280.0	0.316	0.07244	0.00583	-0.03499	0.00729	0.10145
285.0	0.316	0.06953	0.00292	-0.03499	0.00437	0.10145
290.0	0.315	0.06661	0.00000	-0.03499	0.00146	0.10145
295.0	0.315	0.06661	0.00000	0.00000	0.00000	0.00000

Table D.10. Data of Tray Drying at 80 °C (Treatment II)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	ρ
0.0	0.500	0.69500	0.63003	0.00000	-	-
1.5	0.499	0.69286	0.62789	-0.08555	0.62896	0.24802
3.0	0.499	0.69072	0.62576	-0.08555	0.62682	0.24802
4.5	0.498	0.68697	0.62200	-0.15019	0.62388	0.43543
5.5	0.497	0.68447	0.61950	-0.15019	0.62075	0.43542
6.5	0.496	0.68196	0.61699	-0.15019	0.61825	0.43543
7.5	0.495	0.67852	0.61356	-0.20630	0.61528	0.59811
8.5	0.494	0.67509	0.61012	-0.20630	0.61184	0.59811
9.0	0.494	0.67337	0.60840	-0.20630	0.60926	0.59811
9.5	0.493	0.67165	0.60668	-0.20630	0.60754	0.59811
10.0	0.493	0.66984	0.60487	-0.21725	0.60577	0.62986
12.0	0.490	0.66260	0.59763	-0.21725	0.60125	0.62986
14.0	0.488	0.65509	0.59012	-0.22528	0.59387	0.65314
16.0	0.486	0.64758	0.58261	-0.22528	0.58636	0.65314
18.0	0.484	0.64007	0.57510	-0.22528	0.57885	0.65314
20.0	0.482	0.63256	0.56759	-0.22528	0.57135	0.65314
25.0	0.476	0.61379	0.54882	-0.22528	0.55820	0.65314
30.0	0.471	0.59501	0.53004	-0.22528	0.53943	0.65314
35.0	0.465	0.57624	0.51127	-0.22528	0.52066	0.65314
40.0	0.459	0.55747	0.49250	-0.22528	0.50188	0.65314
45.0	0.454	0.53869	0.47373	-0.22528	0.48311	0.65314
50.0	0.448	0.51992	0.45495	-0.22528	0.46434	0.65314
55.0	0.443	0.50115	0.43618	-0.22528	0.44557	0.65314
60.0	0.437	0.48237	0.41741	-0.22528	0.42679	0.65314
65.0	0.432	0.46360	0.39863	-0.22528	0.40802	0.65314
70.0	0.426	0.44483	0.37986	-0.22528	0.38925	0.65314
75.0	0.421	0.42605	0.36109	-0.22528	0.37047	0.65314
80.0	0.415	0.40728	0.34231	-0.22528	0.35170	0.65314
85.0	0.410	0.38851	0.32354	-0.22528	0.33293	0.65314
90.0	0.405	0.37349	0.30852	-0.18022	0.31603	0.52251
95.0	0.401	0.35847	0.29350	-0.18022	0.30101	0.52251
100.0	0.396	0.34345	0.27849	-0.18022	0.28599	0.52251
105.0	0.392	0.32843	0.26347	-0.18022	0.27098	0.52251
110.0	0.387	0.31342	0.24845	-0.18022	0.25596	0.52251
115.0	0.383	0.29840	0.23343	-0.18022	0.24094	0.52251
120.0	0.379	0.28338	0.21841	-0.18022	0.22592	0.52251
125.0	0.375	0.27212	0.20715	-0.13517	0.21278	0.39188
130.0	0.372	0.26085	0.19588	-0.13517	0.20152	0.39188
135.0	0.369	0.24959	0.18462	-0.13517	0.19025	0.39188
140.0	0.366	0.24154	0.17657	-0.09655	0.18060	0.27992
145.0	0.364	0.23350	0.16853	-0.09655	0.17255	0.27992
152.0	0.361	0.22223	0.15727	-0.09655	0.16290	0.27992
155.0	0.359	0.21741	0.15244	-0.09655	0.15485	0.27992
166.0	0.354	0.19971	0.13474	-0.09655	0.14359	0.27992
170.0	0.352	0.19370	0.12873	-0.09011	0.13173	0.26126
176.0	0.349	0.18469	0.11972	-0.09011	0.12422	0.26126
180.0	0.348	0.17868	0.11371	-0.09011	0.11672	0.26126
185.0	0.345	0.17117	0.10620	-0.09011	0.10996	0.26126
190.0	0.343	0.16366	0.09869	-0.09011	0.10245	0.26126
197.0	0.341	0.15490	0.08993	-0.07509	0.09431	0.21771
200.0	0.340	0.15115	0.08618	-0.07509	0.08806	0.21771
205.0	0.338	0.14489	0.07992	-0.07509	0.08305	0.21771
210.0	0.336	0.13863	0.07366	-0.07509	0.07679	0.21771
215.0	0.334	0.13237	0.06740	-0.07509	0.07053	0.21771
220.0	0.332	0.12611	0.06115	-0.07509	0.06428	0.21771
225.0	0.331	0.12075	0.05578	-0.06437	0.05847	0.18661
232.0	0.328	0.11324	0.04827	-0.06437	0.05203	0.18661
235.0	0.327	0.11002	0.04506	-0.06437	0.04666	0.18661

Table D.10. (cont'd)

240.0	0.326	0.10627	0.04130	-0.04506	0.04318	0.13063
245.0	0.325	0.10251	0.03755	-0.04506	0.03942	0.13063
250.0	0.324	0.09876	0.03379	-0.04506	0.03567	0.13063
256.0	0.323	0.09425	0.02929	-0.04506	0.03154	0.13063
260.0	0.322	0.09125	0.02628	-0.04506	0.02778	0.13063
265.0	0.321	0.08750	0.02253	-0.04506	0.02441	0.13063
270.0	0.320	0.08374	0.01877	-0.04506	0.02065	0.13063
275.0	0.319	0.07999	0.01502	-0.04506	0.01690	0.13063
280.0	0.317	0.07623	0.01126	-0.04506	0.01314	0.13063
290.0	0.315	0.06872	0.00375	-0.04506	0.00751	0.13063
295.0	0.314	0.06497	0.00000	-0.04505	0.00188	0.13062
300.0	0.314	0.06497	0.00000	0.00000	0.00000	0.00000

Table D.11. Data of Tray Drying at 90 °C (Treatment I)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0.0	0.50000	0.69500	0.64163	0.00000	-	-
0.5	0.49900	0.69268	0.63931	-0.27819	0.64047	0.80654
1.0	0.49900	0.69020	0.63683	-0.29806	0.63807	0.86415
1.5	0.49800	0.68771	0.63434	-0.29806	0.63559	0.86415
2.0	0.49700	0.68464	0.63127	-0.36845	0.63281	1.06824
2.5	0.49600	0.68130	0.62793	-0.40081	0.62960	1.16205
3.0	0.49500	0.67796	0.62459	-0.40081	0.62626	1.16205
3.5	0.49400	0.67462	0.62125	-0.40081	0.62292	1.16205
4.0	0.49300	0.67128	0.61791	-0.40081	0.61958	1.16205
4.5	0.49200	0.66794	0.61457	-0.40081	0.61624	1.16205
5.0	0.49100	0.66460	0.61123	-0.40081	0.61290	1.16205
5.5	0.49000	0.66126	0.60789	-0.40081	0.60956	1.16205
6.0	0.48900	0.65792	0.60455	-0.40081	0.60622	1.16205
6.5	0.48800	0.65458	0.60121	-0.40081	0.60288	1.16205
7.0	0.48700	0.65124	0.59787	-0.40081	0.59954	1.16205
7.5	0.48600	0.64790	0.59453	-0.40081	0.59620	1.16205
8.0	0.48500	0.64456	0.59119	-0.40081	0.59286	1.16205
8.5	0.48400	0.64122	0.58785	-0.40081	0.58952	1.16205
9.0	0.48300	0.63788	0.58451	-0.40081	0.58618	1.16205
9.5	0.48200	0.63454	0.58117	-0.40081	0.58284	1.16205
10.0	0.48100	0.63120	0.57783	-0.40081	0.57950	1.16205
12.0	0.47700	0.61784	0.56447	-0.40081	0.57115	1.16205
14.0	0.47300	0.60448	0.55111	-0.40081	0.55779	1.16205
16.0	0.46900	0.59112	0.53775	-0.40081	0.54443	1.16205
18.0	0.46500	0.57776	0.52439	-0.40081	0.53107	1.16205
20.0	0.46100	0.56440	0.51103	-0.40081	0.51771	1.16205
25.0	0.45200	0.53100	0.47763	-0.40081	0.49433	1.16205
30.0	0.44400	0.50428	0.45091	-0.32065	0.46427	0.92964
35.0	0.43600	0.47756	0.42419	-0.32065	0.43755	0.92964
40.0	0.42800	0.45084	0.39747	-0.32065	0.41083	0.92964
45.0	0.42000	0.42412	0.37075	-0.32065	0.38411	0.92964
50.0	0.41300	0.40074	0.34737	-0.28057	0.35906	0.81344
55.0	0.40600	0.37736	0.32399	-0.28057	0.33568	0.81344
60.0	0.39900	0.35398	0.30061	-0.28057	0.31230	0.81344
65.0	0.39400	0.33394	0.28057	-0.24049	0.29059	0.69723
70.0	0.38800	0.31390	0.26053	-0.24049	0.27055	0.69723
75.0	0.38200	0.29386	0.24049	-0.24049	0.25051	0.69723
80.0	0.37600	0.27382	0.22045	-0.24049	0.23047	0.69723
85.0	0.37000	0.25377	0.20040	-0.24049	0.21042	0.69723
90.0	0.36500	0.23707	0.18370	-0.20040	0.19205	0.58103
95.0	0.36000	0.22037	0.16700	-0.20040	0.17535	0.58103
100.0	0.35600	0.20701	0.15364	-0.16032	0.16032	0.46482
105.0	0.35200	0.19365	0.14028	-0.16032	0.14696	0.46482
110.0	0.34800	0.18029	0.12692	-0.16032	0.13360	0.46482
115.0	0.34500	0.17027	0.11690	-0.12024	0.12191	0.34862
120.0	0.34200	0.16025	0.10688	-0.12024	0.11189	0.34862
125.0	0.33900	0.15023	0.09686	-0.12024	0.10187	0.34862
130.0	0.33600	0.14021	0.08684	-0.12024	0.09185	0.34862
135.0	0.33300	0.13019	0.07682	-0.12024	0.08183	0.34862
140.0	0.33100	0.12351	0.07014	-0.08016	0.07348	0.23241
145.0	0.32900	0.11683	0.06346	-0.08016	0.06680	0.23241
150.0	0.32700	0.11015	0.05678	-0.08016	0.06012	0.23241
155.0	0.32600	0.10347	0.05010	-0.08016	0.05344	0.23241
160.0	0.32400	0.09679	0.04342	-0.08016	0.04676	0.23241
165.0	0.32300	0.09345	0.04008	-0.04008	0.04175	0.11621
170.0	0.32200	0.09011	0.03674	-0.04008	0.03841	0.11621

Table D.11. (cont'd)

175.0	0.32100	0.08677	0.03340	-0.04008	0.03507	0.11621
180.0	0.32000	0.08343	0.03006	-0.04008	0.03173	0.11621
185.0	0.31900	0.08009	0.02672	-0.04008	0.02839	0.11621
190.0	0.31800	0.07675	0.02338	-0.04008	0.02505	0.11621
195.0	0.31700	0.07341	0.02004	-0.04008	0.02171	0.11621
200.0	0.31600	0.07007	0.01670	-0.04008	0.01837	0.11621
205.0	0.31500	0.06673	0.01336	-0.04008	0.01503	0.11621
210.0	0.31400	0.06339	0.01002	-0.04008	0.01169	0.11621
215.0	0.31300	0.06005	0.00668	-0.04008	0.00835	0.11621
220.0	0.31200	0.05671	0.00334	-0.04008	0.00501	0.11621
225.0	0.31100	0.05337	0.00000	-0.04008	0.00167	0.11620
230.0	0.31100	0.05337	0.00000	0.00000	0.00000	0.00000

Table D.12.. Data of Tray Drying at 90 °C (Treatment II)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0.0	0.50000	0.69500	0.64219	0.00000	-	-
0.5	0.49900	0.69308	0.64027	-0.23071	0.64123	0.66887
1.0	0.49900	0.69088	0.63807	-0.26360	0.63917	0.76423
1.5	0.49800	0.68853	0.63572	-0.28268	0.63689	0.81956
2.0	0.49700	0.68617	0.63336	-0.28268	0.63454	0.81956
2.5	0.49700	0.68366	0.63085	-0.30152	0.63210	0.87419
3.0	0.49600	0.68049	0.62768	-0.38012	0.62926	1.10208
3.5	0.49500	0.67732	0.62451	-0.38012	0.62610	1.10208
4.0	0.49400	0.67415	0.62135	-0.38012	0.62293	1.10208
4.5	0.49300	0.67099	0.61818	-0.38012	0.61976	1.10208
5.0	0.49200	0.66782	0.61501	-0.38012	0.61659	1.10208
5.5	0.49100	0.66465	0.61184	-0.38012	0.61343	1.10208
6.0	0.49000	0.66148	0.60867	-0.38012	0.61026	1.10208
6.5	0.48900	0.65832	0.60551	-0.38012	0.60709	1.10208
7.5	0.48700	0.65198	0.59917	-0.38012	0.60234	1.10208
8.0	0.48600	0.64881	0.59600	-0.38012	0.59759	1.10208
8.5	0.48500	0.64564	0.59284	-0.38012	0.59442	1.10208
9.0	0.48500	0.64248	0.58967	-0.38012	0.59125	1.10208
9.5	0.48400	0.63931	0.58650	-0.38012	0.58808	1.10208
10.0	0.48300	0.63614	0.58333	-0.38012	0.58492	1.10208
12.0	0.47900	0.62347	0.57066	-0.38012	0.57700	1.10208
14.0	0.47500	0.61080	0.55799	-0.38012	0.56433	1.10208
16.0	0.47100	0.59813	0.54532	-0.38012	0.55166	1.10208
18.0	0.46800	0.58546	0.53265	-0.38012	0.53898	1.10208
20.0	0.46400	0.57279	0.51998	-0.38012	0.52631	1.10208
25.0	0.45500	0.54111	0.48830	-0.38012	0.50414	1.10208
30.0	0.44500	0.50943	0.45662	-0.38012	0.47246	1.10208
35.0	0.43800	0.48409	0.43128	-0.30410	0.44395	0.88166
40.0	0.43100	0.46192	0.40911	-0.26609	0.42020	0.77146
45.0	0.42500	0.43974	0.38694	-0.26609	0.39802	0.77146
50.0	0.41800	0.41757	0.36476	-0.26609	0.37585	0.77146
55.0	0.41300	0.39856	0.34576	-0.22807	0.35526	0.66125
60.0	0.40700	0.37956	0.32675	-0.22807	0.33625	0.66125
65.0	0.40100	0.36055	0.30774	-0.22807	0.31725	0.66125
70.0	0.39600	0.34155	0.28874	-0.22807	0.29824	0.66125
75.0	0.39000	0.32254	0.26973	-0.22807	0.27923	0.66125
80.0	0.38500	0.30353	0.25072	-0.22807	0.26023	0.66125
85.0	0.37900	0.28453	0.23172	-0.22807	0.24122	0.66125
90.0	0.37400	0.26869	0.21588	-0.19006	0.22380	0.55104
95.0	0.37000	0.25285	0.20004	-0.19006	0.20796	0.55104
100.0	0.36500	0.23701	0.18420	-0.19006	0.19212	0.55104
105.0	0.36000	0.22117	0.16836	-0.19006	0.17628	0.55104
110.0	0.35700	0.20850	0.15569	-0.15205	0.16203	0.44083
115.0	0.35300	0.19583	0.14302	-0.15205	0.14936	0.44083
120.0	0.34900	0.18316	0.13035	-0.15205	0.13669	0.44083
125.0	0.34500	0.17049	0.11768	-0.15205	0.12402	0.44083
130.0	0.34200	0.15782	0.10501	-0.15205	0.11135	0.44083
135.0	0.33900	0.14832	0.09551	-0.11404	0.10026	0.33062
140.0	0.33600	0.13881	0.08600	-0.11404	0.09076	0.33062
145.0	0.33300	0.12931	0.07650	-0.11404	0.08125	0.33062
150.0	0.33100	0.12297	0.07017	-0.07603	0.07333	0.22042
155.0	0.32900	0.11664	0.06383	-0.07603	0.06700	0.22042
160.0	0.32800	0.11030	0.05749	-0.07603	0.06066	0.22042
165.0	0.32600	0.10397	0.05116	-0.07603	0.05433	0.22042
170.0	0.32400	0.09763	0.04482	-0.07603	0.04799	0.22042
175.0	0.32200	0.09130	0.03849	-0.07603	0.04166	0.22042
180.0	0.32000	0.08496	0.03215	-0.07603	0.03532	0.22042
185.0	0.31900	0.07997	0.02716	-0.05987	0.02966	0.17359

Table D.12. (cont'd)

190.0	0.31700	0.07498	0.02217	-0.05987	0.02467	0.17359
195.0	0.31600	0.07182	0.01901	-0.03801	0.02059	0.11021
200.0	0.31500	0.06865	0.01584	-0.03801	0.01742	0.11021
205.0	0.31400	0.06548	0.01267	-0.03801	0.01425	0.11021
210.0	0.31300	0.06231	0.00950	-0.03801	0.01109	0.11021
215.0	0.31200	0.05914	0.00634	-0.03801	0.00792	0.11021
220.0	0.31200	0.05598	0.00317	-0.03801	0.00475	0.11021
225.0	0.31100	0.05281	0.00000	-0.03801	0.00158	0.11020
230.0	0.31100	0.05281	0.00000	0.00000	0.00000	0.00000

Table D.13. Data of Conductional Drying at 70 °C (Treatment I)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0.0	0.02400	0.69500	0.63422	0.00000	-	-
0.5	0.02400	0.69500	0.63422	0.00000	0.63422	0.00000
1.0	0.02398	0.69353	0.63275	-0.17700	0.63348	0.22155
1.5	0.02396	0.69205	0.63127	-0.17700	0.63201	0.22155
2.0	0.02394	0.69058	0.62980	-0.17700	0.63053	0.22155
2.5	0.02392	0.68910	0.62832	-0.17700	0.62906	0.22155
3.0	0.02390	0.68763	0.62685	-0.17700	0.62758	0.22155
3.5	0.02386	0.68468	0.62390	-0.35390	0.62537	0.44310
4.0	0.02381	0.68173	0.62095	-0.35390	0.62242	0.44310
4.5	0.02377	0.67878	0.61800	-0.35390	0.61947	0.44310
5.0	0.02373	0.67583	0.61505	-0.35390	0.61653	0.44310
5.5	0.02369	0.67288	0.61210	-0.35390	0.61358	0.44310
6.0	0.02365	0.66993	0.60915	-0.35390	0.61063	0.44310
6.5	0.02360	0.66698	0.60620	-0.35390	0.60768	0.44310
7.0	0.02356	0.66403	0.60325	-0.35390	0.60473	0.44310
7.5	0.02352	0.66108	0.60030	-0.35390	0.60178	0.44310
8.0	0.02348	0.65813	0.59735	-0.35390	0.59883	0.44310
8.5	0.02344	0.65519	0.59441	-0.35390	0.59588	0.44310
9.0	0.02340	0.65224	0.59146	-0.35390	0.59293	0.44310
9.5	0.02335	0.64929	0.58851	-0.35390	0.58998	0.44310
10.0	0.02331	0.64634	0.58556	-0.35390	0.58703	0.44310
12.0	0.02315	0.63454	0.57376	-0.35390	0.57966	0.44310
14.0	0.02298	0.62274	0.56196	-0.35390	0.56786	0.44310
16.0	0.02281	0.61095	0.55017	-0.35390	0.55607	0.44310
18.0	0.02264	0.59915	0.53837	-0.35390	0.54427	0.44310
20.0	0.02248	0.58735	0.52657	-0.35390	0.53247	0.44310
25.0	0.02206	0.55786	0.49708	-0.35390	0.51183	0.44310
30.0	0.02164	0.52837	0.46759	-0.35390	0.48233	0.44310
35.0	0.02122	0.49888	0.43810	-0.35390	0.45284	0.44310
40.0	0.02081	0.46938	0.40860	-0.35390	0.42335	0.44310
45.0	0.02039	0.43989	0.37911	-0.35390	0.39386	0.44310
50.0	0.02005	0.41630	0.35552	-0.28310	0.36731	0.35448
55.0	0.01974	0.39418	0.33340	-0.26540	0.34446	0.33232
60.0	0.01943	0.37206	0.31128	-0.26540	0.32234	0.33232
65.0	0.01916	0.35289	0.29211	-0.23000	0.30169	0.28801
70.0	0.01889	0.33372	0.27294	-0.23000	0.28252	0.28801
75.0	0.01863	0.31602	0.25524	-0.21230	0.26409	0.26586
80.0	0.01838	0.29833	0.23755	-0.21230	0.24640	0.26586
85.0	0.01815	0.28211	0.22133	-0.19460	0.22944	0.24370
90.0	0.01792	0.26589	0.20511	-0.19460	0.21322	0.24370
95.0	0.01772	0.25114	0.19036	-0.17700	0.19773	0.22155
100.0	0.01755	0.23934	0.17856	-0.14160	0.18446	0.17724
105.0	0.01738	0.22755	0.16677	-0.14160	0.17266	0.17724
110.0	0.01722	0.21575	0.15497	-0.14160	0.16087	0.17724
115.0	0.01707	0.20543	0.14465	-0.12390	0.14981	0.15508
120.0	0.01694	0.19658	0.13580	-0.10620	0.14022	0.13293
125.0	0.01682	0.18773	0.12695	-0.10620	0.13138	0.13293
130.0	0.01671	0.18036	0.11958	-0.08850	0.12327	0.11077
136.0	0.01659	0.17151	0.11073	-0.08850	0.11515	0.11077
141.0	0.01651	0.16561	0.10483	-0.07080	0.10778	0.08862
145.0	0.01644	0.16089	0.10011	-0.07080	0.10247	0.08862
150.0	0.01636	0.15536	0.09458	-0.06640	0.09735	0.08308
155.0	0.01628	0.14983	0.08905	-0.06640	0.09182	0.08308
160.0	0.01620	0.14430	0.08352	-0.06640	0.08629	0.08308
170.0	0.01608	0.13546	0.07468	-0.05310	0.07910	0.06646
175.0	0.01602	0.13103	0.07025	-0.05310	0.07246	0.06646
180.0	0.01596	0.12682	0.06604	-0.05060	0.06815	0.06330
187.0	0.01587	0.12092	0.06014	-0.05060	0.06309	0.06330
190.0	0.01584	0.11861	0.05783	-0.04630	0.05898	0.05791

Table D.13. (cont'd)

195.0	0.01578	0.11475	0.05397	-0.04630	0.05590	0.05791
200.0	0.01573	0.11090	0.05012	-0.04630	0.05205	0.05791
205.0	0.01569	0.10795	0.04717	-0.03540	0.04864	0.04431
210.0	0.01565	0.10500	0.04422	-0.03540	0.04569	0.04431
215.0	0.01561	0.10205	0.04127	-0.03540	0.04275	0.04431
220.0	0.01556	0.09910	0.03832	-0.03540	0.03980	0.04431
225.0	0.01552	0.09615	0.03537	-0.03540	0.03685	0.04431
230.0	0.01548	0.09320	0.03242	-0.03540	0.03390	0.04431
235.0	0.01544	0.09025	0.02947	-0.03540	0.03095	0.04431
240.0	0.01540	0.08730	0.02652	-0.03540	0.02800	0.04431
245.0	0.01535	0.08435	0.02357	-0.03540	0.02505	0.04431
250.0	0.01532	0.08190	0.02112	-0.02950	0.02235	0.03692
257.0	0.01527	0.07846	0.01768	-0.02950	0.01940	0.03692
260.0	0.01525	0.07698	0.01620	-0.02950	0.01694	0.03692
265.0	0.01523	0.07551	0.01473	-0.01770	0.01546	0.02215
270.0	0.01521	0.07403	0.01325	-0.01770	0.01399	0.02215
275.0	0.01519	0.07256	0.01178	-0.01770	0.01252	0.02215
280.0	0.01517	0.07108	0.01030	-0.01770	0.01104	0.02215
285.0	0.01515	0.06961	0.00883	-0.01770	0.00957	0.02215
290.0	0.01512	0.06813	0.00735	-0.01770	0.00809	0.02215
295.0	0.01510	0.06666	0.00588	-0.01770	0.00662	0.02215
300.0	0.01508	0.06518	0.00440	-0.01770	0.00514	0.02215
305.0	0.01506	0.06371	0.00293	-0.01770	0.00367	0.02215
310.0	0.01504	0.06224	0.00146	-0.01770	0.00219	0.02215
315.0	0.01502	0.06078	0.00000	-0.01750	0.00073	0.02187
320.0	0.01502	0.06078	0.00000	0.00000	0.00000	0.00000

Table D.14. Data of Conductional Drying at 70 °C (Treatment II)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0.0	0.02400	0.69500	0.63248	0.00000	-	-
0.5	0.02400	0.69500	0.63248	0.00000	0.63248	0.00000
1.0	0.02398	0.69357	0.63105	-0.17190	0.63176	0.21520
1.5	0.02396	0.69214	0.62962	-0.17190	0.63033	0.21520
2.0	0.02394	0.69070	0.62818	-0.17190	0.62890	0.21520
2.5	0.02390	0.68798	0.62546	-0.32660	0.62682	0.40888
3.0	0.02386	0.68512	0.62260	-0.34380	0.62403	0.43040
3.5	0.02382	0.68225	0.61973	-0.34380	0.62116	0.43040
4.0	0.02378	0.67939	0.61687	-0.34380	0.61830	0.43040
4.5	0.02374	0.67652	0.61400	-0.34380	0.61544	0.43040
5.0	0.02370	0.67366	0.61114	-0.34380	0.61257	0.43040
5.5	0.02366	0.67079	0.60827	-0.34380	0.60971	0.43040
6.0	0.02362	0.66793	0.60541	-0.34380	0.60684	0.43040
6.5	0.02358	0.66506	0.60254	-0.34380	0.60398	0.43040
7.0	0.02354	0.66220	0.59968	-0.34380	0.60111	0.43040
7.5	0.02350	0.65933	0.59681	-0.34380	0.59825	0.43040
8.0	0.02346	0.65647	0.59395	-0.34380	0.59538	0.43040
8.5	0.02342	0.65361	0.59109	-0.34380	0.59252	0.43040
9.0	0.02337	0.65074	0.58822	-0.34380	0.58965	0.43040
9.5	0.02333	0.64788	0.58536	-0.34380	0.58679	0.43040
10.0	0.02329	0.64501	0.58249	-0.34380	0.58392	0.43040
12.0	0.02313	0.63355	0.57103	-0.34380	0.57676	0.43040
14.0	0.02297	0.62209	0.55957	-0.34380	0.56530	0.43040
16.0	0.02281	0.61063	0.54811	-0.34380	0.55384	0.43040
18.0	0.02264	0.59918	0.53666	-0.34380	0.54239	0.43040
20.0	0.02248	0.58772	0.52520	-0.34380	0.53093	0.43040
25.0	0.02208	0.55907	0.49655	-0.34380	0.51087	0.43040
30.0	0.02167	0.53042	0.46790	-0.34380	0.48223	0.43040
35.0	0.02127	0.50178	0.43926	-0.34380	0.45358	0.43040
40.0	0.02086	0.47313	0.41061	-0.34380	0.42493	0.43040
45.0	0.02045	0.44448	0.38196	-0.34380	0.39629	0.43040
50.0	0.02009	0.41870	0.35618	-0.30940	0.36907	0.38736
55.0	0.01976	0.39578	0.33326	-0.27500	0.34472	0.34432
65.0	0.01914	0.35138	0.28886	-0.26640	0.31106	0.33356
70.0	0.01883	0.32989	0.26737	-0.25780	0.27812	0.32280
75.0	0.01855	0.30984	0.24732	-0.24060	0.25735	0.30128
80.0	0.01828	0.29122	0.22870	-0.22340	0.23801	0.27976
85.0	0.01804	0.27403	0.21151	-0.20630	0.22011	0.25824
90.0	0.01780	0.25684	0.19432	-0.20630	0.20292	0.25824
95.0	0.01757	0.24109	0.17857	-0.18910	0.18645	0.23672
100.0	0.01737	0.22677	0.16425	-0.17190	0.17141	0.21520
105.0	0.01719	0.21387	0.15135	-0.15470	0.15780	0.19368
123.0	0.01664	0.17520	0.11268	-0.12890	0.13202	0.16140
125.0	0.01658	0.17090	0.10838	-0.12890	0.11053	0.16140
130.0	0.01648	0.16374	0.10122	-0.08590	0.10480	0.10760
135.0	0.01640	0.15801	0.09549	-0.06880	0.09836	0.08608
140.0	0.01632	0.15228	0.08976	-0.06880	0.09263	0.08608
145.0	0.01624	0.14655	0.08403	-0.06880	0.08690	0.08608
150.0	0.01615	0.14082	0.07830	-0.06880	0.08117	0.08608
155.0	0.01609	0.13653	0.07401	-0.05160	0.07616	0.06456
160.0	0.01603	0.13223	0.06971	-0.05160	0.07186	0.06456
165.0	0.01597	0.12793	0.06541	-0.05160	0.06756	0.06456
170.0	0.01591	0.12364	0.06112	-0.05160	0.06326	0.06456
175.0	0.01587	0.12077	0.05825	-0.03440	0.05968	0.04304
180.0	0.01583	0.11791	0.05539	-0.03440	0.05682	0.04304
185.0	0.01579	0.11504	0.05252	-0.03440	0.05395	0.04304
190.0	0.01575	0.11218	0.04966	-0.03440	0.05109	0.04304
195.0	0.01571	0.10931	0.04679	-0.03440	0.04823	0.04304
200.0	0.01567	0.10645	0.04393	-0.03440	0.04536	0.04304

Table D.14. (cont'd)

205.0	0.01563	0.10358	0.04106	-0.03440	0.04250	0.04304
210.0	0.01559	0.10072	0.03820	-0.03440	0.03963	0.04304
215.0	0.01555	0.09833	0.03581	-0.02860	0.03701	0.03587
220.0	0.01552	0.09594	0.03342	-0.02860	0.03462	0.03587
226.0	0.01548	0.09308	0.03056	-0.02860	0.03199	0.03587
230.0	0.01545	0.09117	0.02865	-0.02860	0.02960	0.03587
235.0	0.01542	0.08878	0.02626	-0.02860	0.02746	0.03587
240.0	0.01538	0.08639	0.02387	-0.02860	0.02507	0.03587
245.0	0.01535	0.08401	0.02149	-0.02860	0.02268	0.03587
250.0	0.01533	0.08258	0.02006	-0.01720	0.02077	0.02152
255.0	0.01531	0.08114	0.01862	-0.01720	0.01934	0.02152
260.0	0.01529	0.07971	0.01719	-0.01720	0.01791	0.02152
265.0	0.01527	0.07828	0.01576	-0.01720	0.01647	0.02152
270.0	0.01525	0.07685	0.01433	-0.01720	0.01504	0.02152
275.0	0.01523	0.07541	0.01289	-0.01720	0.01361	0.02152
280.0	0.01521	0.07398	0.01146	-0.01720	0.01218	0.02152
285.0	0.01519	0.07255	0.01003	-0.01720	0.01075	0.02152
290.0	0.01517	0.07112	0.00860	-0.01720	0.00931	0.02152
295.0	0.01515	0.06968	0.00716	-0.01720	0.00788	0.02152
300.0	0.01513	0.06825	0.00573	-0.01720	0.00645	0.02152
305.0	0.01511	0.06682	0.00430	-0.01720	0.00502	0.02152
310.0	0.01509	0.06539	0.00287	-0.01720	0.00358	0.02152
315.0	0.01507	0.06395	0.00143	-0.01720	0.00215	0.02152
320.0	0.01505	0.06252	0.00000	-0.01720	0.00072	0.02156

Table D.15. Data of Conductional Drying at 80 °C (Treatment I)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	ρ
0.0	0.02400	0.69500	0.64707	0.00000		
0.5	0.02400	0.69500	0.64707	0.00000	0.64707	0.00000
1.0	0.02398	0.69341	0.64548	-0.19110	0.64627	0.23931
1.5	0.02396	0.69181	0.64388	-0.19110	0.64468	0.23931
2.0	0.02392	0.68927	0.64134	-0.30580	0.64261	0.38289
2.5	0.02388	0.68672	0.63879	-0.30580	0.64006	0.38289
3.0	0.02384	0.68353	0.63560	-0.38230	0.63720	0.47862
3.5	0.02379	0.68035	0.63242	-0.38230	0.63401	0.47862
4.0	0.02375	0.67716	0.62923	-0.38230	0.63082	0.47862
4.5	0.02368	0.67256	0.62463	-0.55160	0.62693	0.69060
5.0	0.02362	0.66797	0.62004	-0.55160	0.62234	0.69060
5.5	0.02355	0.66337	0.61544	-0.55160	0.61774	0.69060
6.0	0.02349	0.65877	0.61084	-0.55160	0.61314	0.69060
6.5	0.02342	0.65418	0.60625	-0.55160	0.60855	0.69060
7.0	0.02336	0.64958	0.60165	-0.55160	0.60395	0.69060
7.5	0.02329	0.64498	0.59705	-0.55160	0.59935	0.69060
8.0	0.02323	0.64039	0.59246	-0.55160	0.59476	0.69060
8.5	0.02316	0.63579	0.58786	-0.55160	0.59016	0.69060
9.0	0.02310	0.63119	0.58326	-0.55160	0.58556	0.69060
9.5	0.02303	0.62660	0.57867	-0.55160	0.58097	0.69060
10.0	0.02297	0.62200	0.57407	-0.55160	0.57637	0.69060
12.0	0.02271	0.60361	0.55568	-0.55160	0.56488	0.69060
14.0	0.02245	0.58523	0.53730	-0.55160	0.54649	0.69060
16.0	0.02219	0.56684	0.51891	-0.55160	0.52811	0.69060
18.0	0.02193	0.54846	0.50053	-0.55160	0.50972	0.69060
20.0	0.02167	0.53007	0.48214	-0.55160	0.49133	0.69060
25.0	0.02101	0.48410	0.43617	-0.55160	0.45916	0.69060
30.0	0.02036	0.43814	0.39021	-0.55160	0.41319	0.69060
35.0	0.01971	0.39217	0.34424	-0.55160	0.36722	0.69060
40.0	0.01924	0.35872	0.31079	-0.40140	0.32752	0.50255
45.0	0.01883	0.33005	0.28212	-0.34400	0.29646	0.43075
50.0	0.01843	0.30138	0.25345	-0.34400	0.26779	0.43075
55.0	0.01807	0.27590	0.22797	-0.30580	0.24071	0.38289
60.0	0.01771	0.25041	0.20248	-0.30580	0.21522	0.38289
65.0	0.01741	0.22970	0.18177	-0.24850	0.19213	0.31110
70.0	0.01714	0.21059	0.16266	-0.22940	0.17222	0.28717
75.0	0.01689	0.19307	0.14514	-0.21030	0.15390	0.26324
80.0	0.01665	0.17555	0.12762	-0.21030	0.13638	0.26324
85.0	0.01647	0.16281	0.11488	-0.15290	0.12125	0.19145
90.0	0.01628	0.15006	0.10213	-0.15290	0.10850	0.19145
95.0	0.01613	0.13891	0.09098	-0.13380	0.09656	0.16752
100.0	0.01599	0.12936	0.08143	-0.11470	0.08620	0.14358
105.0	0.01586	0.11980	0.07187	-0.11470	0.07665	0.14358
110.0	0.01574	0.11183	0.06390	-0.09560	0.06789	0.11965
115.0	0.01565	0.10546	0.05753	-0.07650	0.06072	0.09572
120.0	0.01556	0.09909	0.05116	-0.07650	0.05435	0.09572
125.0	0.01550	0.09431	0.04638	-0.05730	0.04877	0.07179
130.0	0.01543	0.08954	0.04161	-0.05730	0.04399	0.07179
135.0	0.01536	0.08476	0.03683	-0.05730	0.03922	0.07179
140.0	0.01529	0.07998	0.03205	-0.05730	0.03444	0.07179
145.0	0.01525	0.07679	0.02886	-0.03820	0.03046	0.04786
150.0	0.01520	0.07361	0.02568	-0.03820	0.02727	0.04786
155.0	0.01518	0.07201	0.02408	-0.01910	0.02488	0.02393
160.0	0.01516	0.07042	0.02249	-0.01910	0.02329	0.02393
165.0	0.01513	0.06883	0.02090	-0.01910	0.02170	0.02393
170.0	0.01511	0.06724	0.01931	-0.01910	0.02010	0.02393
175.0	0.01509	0.06564	0.01771	-0.01910	0.01851	0.02393
180.0	0.01507	0.06405	0.01612	-0.01910	0.01692	0.02393
185.0	0.01504	0.06246	0.01453	-0.01910	0.01532	0.02393

Table D.15. (cont'd)

190.0	0.01502	0.06086	0.01293	-0.01910	0.01373	0.02393
195.0	0.01500	0.05927	0.01134	-0.01910	0.01214	0.02393
200.0	0.01498	0.05768	0.00975	-0.01910	0.01055	0.02393
205.0	0.01495	0.05609	0.00816	-0.01910	0.00895	0.02393
210.0	0.01493	0.05449	0.00656	-0.01910	0.00736	0.02393
215.0	0.01491	0.05290	0.00497	-0.01910	0.00577	0.02393
220.0	0.01490	0.05191	0.00398	-0.01190	0.00447	0.01492
225.0	0.01488	0.05091	0.00298	-0.01190	0.00348	0.01492
230.0	0.01487	0.04992	0.00199	-0.01190	0.00249	0.01492
235.0	0.01485	0.04893	0.00100	-0.01190	0.00149	0.01492
240.0	0.01484	0.04793	0.00000	-0.01200	0.00050	0.01499
245.0	0.01484	0.04793	0.00000	0.00000	0.00000	0.00000

Table D.16. Data of Conductional Drying at 80 °C (Treatment II)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0.0	0.02400	0.69500	0.64847	0.00000		
0.5	0.02400	0.69500	0.64847	0.00000	0.64847	0.00000
1.0	0.02398	0.69372	0.64718	-0.15409	0.64782	0.19293
1.5	0.02395	0.69115	0.64461	-0.30819	0.64590	0.38586
2.0	0.02391	0.68858	0.64205	-0.30819	0.64333	0.38586
2.5	0.02387	0.68601	0.63948	-0.30819	0.64076	0.38586
3.0	0.02384	0.68344	0.63691	-0.30819	0.63819	0.38586
3.5	0.02380	0.68088	0.63434	-0.30819	0.63563	0.38586
4.0	0.02374	0.67674	0.63021	-0.49584	0.63228	0.62080
4.5	0.02368	0.67261	0.62608	-0.49584	0.62814	0.62080
5.0	0.02363	0.66848	0.62195	-0.49584	0.62401	0.62080
5.5	0.02357	0.66435	0.61781	-0.49584	0.61988	0.62080
6.0	0.02351	0.66022	0.61368	-0.49584	0.61575	0.62080
6.5	0.02345	0.65608	0.60955	-0.49584	0.61162	0.62080
7.0	0.02339	0.65195	0.60542	-0.49584	0.60748	0.62080
7.5	0.02333	0.64782	0.60128	-0.49584	0.60335	0.62080
8.0	0.02327	0.64369	0.59715	-0.49584	0.59922	0.62080
8.5	0.02322	0.63955	0.59302	-0.49584	0.59509	0.62080
9.0	0.02316	0.63542	0.58889	-0.49584	0.59095	0.62080
9.5	0.02310	0.63129	0.58476	-0.49584	0.58682	0.62080
10.0	0.02304	0.62716	0.58062	-0.49584	0.58269	0.62080
12.0	0.02281	0.61063	0.56410	-0.49584	0.57236	0.62080
14.0	0.02257	0.59410	0.54757	-0.49584	0.55583	0.62080
16.0	0.02234	0.57757	0.53104	-0.49584	0.53930	0.62080
18.0	0.02210	0.56105	0.51451	-0.49584	0.52278	0.62080
20.0	0.02187	0.54452	0.49798	-0.49584	0.50625	0.62080
25.0	0.02129	0.50320	0.45666	-0.49584	0.47732	0.62080
30.0	0.02070	0.46188	0.41534	-0.49584	0.43600	0.62080
35.0	0.02012	0.42056	0.37402	-0.49584	0.39468	0.62080
40.0	0.01953	0.37924	0.33270	-0.49584	0.35336	0.62080
45.0	0.01894	0.33792	0.29138	-0.49584	0.31204	0.62080
50.0	0.01836	0.29660	0.25006	-0.49584	0.27072	0.62080
55.0	0.01792	0.26578	0.21924	-0.36983	0.23465	0.46303
60.0	0.01757	0.24058	0.19404	-0.30243	0.20664	0.37864
65.0	0.01724	0.21732	0.17079	-0.27904	0.18241	0.34936
70.0	0.01695	0.19678	0.15024	-0.24655	0.16052	0.30868
75.0	0.01667	0.17751	0.13098	-0.23114	0.14061	0.28939
80.0	0.01644	0.16082	0.11429	-0.20032	0.12263	0.25081
85.0	0.01627	0.14926	0.10273	-0.13869	0.10851	0.17364
90.0	0.01613	0.13899	0.09246	-0.12328	0.09759	0.15434
95.0	0.01598	0.12872	0.08218	-0.12328	0.08732	0.15434
100.0	0.01586	0.11973	0.07320	-0.10787	0.07769	0.13505
105.0	0.01575	0.11202	0.06549	-0.09246	0.06934	0.11576
110.0	0.01564	0.10432	0.05779	-0.09246	0.06164	0.11576
115.0	0.01556	0.09918	0.05265	-0.06164	0.05522	0.07717
120.0	0.01551	0.09533	0.04880	-0.04623	0.05072	0.05788
125.0	0.01546	0.09148	0.04494	-0.04623	0.04687	0.05788
130.0	0.01540	0.08763	0.04109	-0.04623	0.04302	0.05788
135.0	0.01535	0.08377	0.03724	-0.04623	0.03917	0.05788
140.0	0.01531	0.08121	0.03467	-0.03082	0.03596	0.03859
145.0	0.01527	0.07864	0.03210	-0.03082	0.03339	0.03859
150.0	0.01524	0.07607	0.02954	-0.03082	0.03082	0.03859
155.0	0.01520	0.07350	0.02697	-0.03082	0.02825	0.03859
160.0	0.01516	0.07093	0.02440	-0.03082	0.02568	0.03859
165.0	0.01513	0.06836	0.02183	-0.03082	0.02311	0.03859
170.0	0.01509	0.06580	0.01926	-0.03082	0.02055	0.03859
175.0	0.01507	0.06451	0.01798	-0.01541	0.01862	0.01929
180.0	0.01506	0.06323	0.01669	-0.01541	0.01734	0.01929
185.0	0.01504	0.06194	0.01541	-0.01541	0.01605	0.01929

Table D.16. (cont'd)

190.0	0.01502	0.06066	0.01413	-0.01541	0.01477	0.01929
195.0	0.01500	0.05938	0.01284	-0.01541	0.01348	0.01929
200.0	0.01498	0.05809	0.01156	-0.01541	0.01220	0.01929
205.0	0.01496	0.05681	0.01027	-0.01541	0.01092	0.01929
210.0	0.01495	0.05552	0.00899	-0.01541	0.00963	0.01929
215.0	0.01493	0.05424	0.00771	-0.01541	0.00835	0.01929
220.0	0.01491	0.05296	0.00642	-0.01541	0.00706	0.01929
225.0	0.01489	0.05167	0.00514	-0.01541	0.00578	0.01929
230.0	0.01487	0.05039	0.00385	-0.01541	0.00449	0.01929
235.0	0.01486	0.04910	0.00257	-0.01541	0.00321	0.01929
240.0	0.01484	0.04782	0.00128	-0.01541	0.00193	0.01929
245.0	0.01482	0.04653	0.00000	-0.01541	0.00064	0.01929
250.0	0.01482	0.04653	0.00000	0.00000	0.00000	0.00000

Table D.17. Data of Conductional Drying at 90 °C (Treatment I)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0.0	0.02400	0.69500	0.65295	0.00000	-	-
0.5	0.02398	0.69374	0.65169	-0.15164	0.65232	0.18986
1.0	0.02394	0.69058	0.64853	-0.37910	0.65011	0.47464
1.5	0.02389	0.68742	0.64537	-0.37910	0.64695	0.47464
2.0	0.02385	0.68426	0.64221	-0.37910	0.64379	0.47464
2.5	0.02378	0.67952	0.63747	-0.56866	0.63984	0.71196
3.0	0.02371	0.67478	0.63273	-0.56866	0.63510	0.71196
3.5	0.02363	0.66846	0.62641	-0.75821	0.62957	0.94928
4.0	0.02354	0.66214	0.62009	-0.75821	0.62325	0.94928
4.5	0.02345	0.65583	0.61378	-0.75821	0.61693	0.94928
5.0	0.02336	0.64951	0.60746	-0.75821	0.61062	0.94928
5.5	0.02327	0.64319	0.60114	-0.75821	0.60430	0.94928
6.0	0.02318	0.63687	0.59482	-0.75821	0.59798	0.94928
6.5	0.02309	0.63055	0.58850	-0.75821	0.59166	0.94928
7.0	0.02300	0.62423	0.58218	-0.75821	0.58534	0.94928
7.5	0.02291	0.61792	0.57587	-0.75821	0.57902	0.94928
8.0	0.02282	0.61160	0.56955	-0.75821	0.57271	0.94928
8.5	0.02273	0.60528	0.56323	-0.75821	0.56639	0.94928
9.0	0.02264	0.59896	0.55691	-0.75821	0.56007	0.94928
9.5	0.02255	0.59264	0.55059	-0.75821	0.55375	0.94928
10.0	0.02246	0.58632	0.54427	-0.75821	0.54743	0.94928
12.0	0.02210	0.56105	0.51900	-0.75821	0.53164	0.94928
14.0	0.02177	0.53736	0.49531	-0.71082	0.50715	0.88995
16.0	0.02146	0.51524	0.47319	-0.66343	0.48425	0.83062
18.0	0.02117	0.49471	0.45266	-0.61604	0.46292	0.77129
20.0	0.02087	0.47417	0.43212	-0.61604	0.44239	0.77129
25.0	0.02018	0.42521	0.38315	-0.58761	0.40764	0.73570
30.0	0.01951	0.37782	0.33577	-0.56866	0.35946	0.71196
35.0	0.01893	0.33675	0.29470	-0.49283	0.31523	0.61703
40.0	0.01839	0.29884	0.25679	-0.45492	0.27574	0.56957
45.0	0.01790	0.26409	0.22204	-0.41701	0.23941	0.52211
50.0	0.01747	0.23407	0.19202	-0.36015	0.20703	0.45091
55.0	0.01709	0.20722	0.16517	-0.32224	0.17860	0.40345
60.0	0.01680	0.18669	0.14463	-0.24642	0.15490	0.30852
65.0	0.01651	0.16615	0.12410	-0.24642	0.13437	0.30852
70.0	0.01624	0.14720	0.10515	-0.22746	0.11462	0.28479
75.0	0.01607	0.13456	0.09251	-0.15164	0.09883	0.18986
80.0	0.01589	0.12192	0.07987	-0.15164	0.08619	0.18986
85.0	0.01575	0.11244	0.07039	-0.11373	0.07513	0.14239
90.0	0.01564	0.10455	0.06250	-0.09478	0.06644	0.11866
95.0	0.01553	0.09665	0.05460	-0.09478	0.05855	0.11866
100.0	0.01544	0.09033	0.04828	-0.07582	0.05144	0.09493
105.0	0.01535	0.08401	0.04196	-0.07582	0.04512	0.09493
110.0	0.01528	0.07927	0.03722	-0.05687	0.03959	0.07120
115.0	0.01522	0.07453	0.03248	-0.05687	0.03485	0.07120
120.0	0.01515	0.06980	0.02774	-0.05687	0.03011	0.07120
125.0	0.01508	0.06506	0.02301	-0.05687	0.02538	0.07120
130.0	0.01501	0.06032	0.01827	-0.05687	0.02064	0.07120
135.0	0.01497	0.05716	0.01511	-0.03791	0.01669	0.04746
140.0	0.01494	0.05513	0.01308	-0.02430	0.01410	0.03043
145.0	0.01491	0.05311	0.01106	-0.02430	0.01207	0.03043
150.0	0.01489	0.05153	0.00948	-0.01896	0.01027	0.02373
155.0	0.01487	0.04995	0.00790	-0.01896	0.00869	0.02373
160.0	0.01484	0.04837	0.00632	-0.01896	0.00711	0.02373
165.0	0.01482	0.04679	0.00474	-0.01896	0.00553	0.02373
170.0	0.01480	0.04521	0.00316	-0.01896	0.00395	0.02373
175.0	0.01478	0.04363	0.00158	-0.01896	0.00237	0.02373
180.0	0.01476	0.04205	0.00000	-0.01895	0.00079	0.02373
185.0	0.01476	0.04205	0.00000	0.00000	0.00000	0.00000

Table D.18. Data of Conductional Drying at 90 °C (Treatment II)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0.0	0.02400	0.69500	0.65981	0.00000	-	-
0.5	0.02348	0.65833	0.62314	-4.40059	0.64148	5.50958
1.0	0.02345	0.65606	0.62087	-0.27207	0.62201	0.34064
1.5	0.02340	0.65266	0.61747	-0.40811	0.61917	0.51095
2.0	0.02335	0.64926	0.61407	-0.40811	0.61577	0.51095
2.5	0.02329	0.64473	0.60954	-0.54414	0.61180	0.68127
3.0	0.02323	0.64019	0.60500	-0.54414	0.60727	0.68127
3.5	0.02315	0.63487	0.59969	-0.63808	0.60234	0.79889
4.0	0.02307	0.62956	0.59437	-0.63808	0.59703	0.79889
4.5	0.02300	0.62424	0.58905	-0.63808	0.59171	0.79889
5.0	0.02292	0.61892	0.58373	-0.63808	0.58639	0.79889
5.5	0.02285	0.61360	0.57842	-0.63808	0.58107	0.79889
6.0	0.02277	0.60829	0.57310	-0.63808	0.57576	0.79889
6.5	0.02270	0.60297	0.56778	-0.63808	0.57044	0.79889
7.0	0.02262	0.59765	0.56246	-0.63808	0.56512	0.79889
7.5	0.02255	0.59233	0.55715	-0.63808	0.55981	0.79889
8.0	0.02247	0.58702	0.55183	-0.63808	0.55449	0.79889
8.5	0.02240	0.58170	0.54651	-0.63808	0.54917	0.79889
9.0	0.02232	0.57638	0.54119	-0.63808	0.54385	0.79889
9.5	0.02225	0.57107	0.53588	-0.63808	0.53854	0.79889
10.0	0.02217	0.56575	0.53056	-0.63808	0.53322	0.79889
12.0	0.02187	0.54448	0.50929	-0.63808	0.51993	0.79889
14.0	0.02157	0.52321	0.48802	-0.63808	0.49866	0.79889
16.0	0.02127	0.50194	0.46675	-0.63808	0.47739	0.79889
18.0	0.02097	0.48067	0.44548	-0.63808	0.45612	0.79889
20.0	0.02071	0.46253	0.42734	-0.54414	0.43641	0.68127
25.0	0.02010	0.41945	0.38427	-0.51694	0.40580	0.64721
30.0	0.01954	0.37978	0.34459	-0.47612	0.36443	0.59611
35.0	0.01902	0.34350	0.30831	-0.43531	0.32645	0.54502
40.0	0.01851	0.30722	0.27204	-0.43531	0.29017	0.54502
45.0	0.01803	0.27322	0.23803	-0.40811	0.25503	0.51095
50.0	0.01761	0.24399	0.20880	-0.35069	0.22342	0.43907
55.0	0.01725	0.21792	0.18273	-0.31288	0.19577	0.39173
60.0	0.01689	0.19298	0.15779	-0.29928	0.17026	0.37470
65.0	0.01657	0.17031	0.13512	-0.27207	0.14645	0.34064
70.0	0.01628	0.14990	0.11471	-0.24486	0.12492	0.30657
75.0	0.01604	0.13290	0.09771	-0.20405	0.10621	0.25548
80.0	0.01583	0.11816	0.08297	-0.17685	0.09034	0.22141
85.0	0.01564	0.10456	0.06937	-0.16324	0.07617	0.20438
90.0	0.01550	0.09435	0.05916	-0.12243	0.06427	0.15329
95.0	0.01535	0.08415	0.04896	-0.12243	0.05406	0.15329
100.0	0.01527	0.07848	0.04329	-0.06802	0.04613	0.08516
105.0	0.01519	0.07281	0.03763	-0.06802	0.04046	0.08516
110.0	0.01511	0.06715	0.03196	-0.06802	0.03479	0.08516
115.0	0.01505	0.06261	0.02742	-0.05441	0.02969	0.06813
120.0	0.01500	0.05921	0.02402	-0.04081	0.02572	0.05110
125.0	0.01495	0.05581	0.02062	-0.04081	0.02232	0.05110
130.0	0.01490	0.05241	0.01722	-0.04081	0.01892	0.05110
135.0	0.01485	0.04901	0.01382	-0.04081	0.01552	0.05110
140.0	0.01482	0.04674	0.01155	-0.02721	0.01269	0.03406
145.0	0.01479	0.04447	0.00928	-0.02721	0.01042	0.03406
150.0	0.01476	0.04221	0.00702	-0.02721	0.00815	0.03406
155.0	0.01474	0.04086	0.00567	-0.01618	0.00634	0.02026
160.0	0.01472	0.03972	0.00454	-0.01360	0.00510	0.01703
165.0	0.01471	0.03859	0.00340	-0.01360	0.00397	0.01703
170.0	0.01469	0.03746	0.00227	-0.01360	0.00283	0.01703
175.0	0.01467	0.03632	0.00113	-0.01360	0.00170	0.01703
180.0	0.01466	0.03519	0.00000	-0.01361	0.00057	0.01704
185.0	0.01466	0.03519	0.00000	0.00000	0.00000	0.00000

Table D.19. Data of Infrared Drying at 70 °C (Treatment I)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0.0	0.02400	0.69492	0.66179	0.00000	-	-
0.5	0.02397	0.69251	0.65939	-0.28800	0.66060	0.36070
1.0	0.02382	0.68227	0.64915	-1.22900	0.65430	1.53850
1.5	0.02365	0.67034	0.63722	-1.43200	0.64320	1.79310
2.0	0.02352	0.66109	0.62797	-1.11000	0.63260	1.38990
2.5	0.02342	0.65417	0.62105	-0.83100	0.62450	1.03980
3.0	0.02334	0.64859	0.61547	-0.66900	0.61830	0.83820
3.5	0.02326	0.64280	0.60968	-0.69500	0.61260	0.87000
4.0	0.02316	0.63588	0.60276	-0.83100	0.60620	1.03980
4.5	0.02307	0.62945	0.59633	-0.77100	0.59950	0.96550
5.0	0.02297	0.62225	0.58913	-0.86400	0.59270	1.08220
5.5	0.02289	0.61624	0.58312	-0.72000	0.58610	0.90190
6.0	0.02279	0.60946	0.57634	-0.81400	0.57970	1.01860
6.5	0.02270	0.60275	0.56963	-0.80500	0.57300	1.00800
7.0	0.02261	0.59640	0.56328	-0.76300	0.56650	0.95490
7.5	0.02252	0.59011	0.55699	-0.75400	0.56010	0.94430
8.0	0.02242	0.58312	0.55000	-0.83900	0.55350	1.05040
8.5	0.02232	0.57648	0.54336	-0.79700	0.54670	0.99740
9.0	0.02223	0.56985	0.53672	-0.79700	0.54000	0.99740
9.5	0.02214	0.56384	0.53072	-0.72000	0.53370	0.90190
10.0	0.02205	0.55706	0.52394	-0.81400	0.52730	1.01860
12.0	0.02169	0.53171	0.49859	-0.76100	0.51130	0.95230
14.0	0.02134	0.50685	0.47373	-0.74600	0.48620	0.93370
16.0	0.02100	0.48305	0.44993	-0.71400	0.46180	0.89390
18.0	0.02068	0.46010	0.42698	-0.68900	0.43850	0.86210
20.0	0.02036	0.43785	0.40473	-0.66700	0.41590	0.83560
26.0	0.01945	0.37323	0.34011	-0.64600	0.37240	0.80900
30.0	0.01887	0.33291	0.29979	-0.60500	0.32000	0.75730
35.0	0.01823	0.28757	0.25445	-0.54400	0.27710	0.68120
40.0	0.01768	0.24866	0.21554	-0.46700	0.23500	0.58460
46.0	0.01707	0.20572	0.17260	-0.42900	0.19410	0.53760
50.0	0.01672	0.18107	0.14795	-0.37000	0.16030	0.46290
55.0	0.01634	0.15388	0.12076	-0.32600	0.13440	0.40850
60.0	0.01603	0.13206	0.09894	-0.26200	0.10990	0.32790
66.0	0.01569	0.10833	0.07521	-0.23700	0.08710	0.29710
70.0	0.01551	0.09527	0.06215	-0.19600	0.06870	0.24540
75.0	0.01532	0.08157	0.04845	-0.16400	0.05530	0.20580
80.0	0.01515	0.06977	0.03665	-0.14200	0.04250	0.17720
85.0	0.01501	0.06010	0.02698	-0.11600	0.03180	0.14540
90.0	0.01489	0.05170	0.01857	-0.10100	0.02280	0.12630
96.0	0.01477	0.04336	0.01024	-0.08300	0.01440	0.10430
105.0	0.01463	0.03312	0.00000	-0.06800	0.00510	0.08550

Table D.20. Data of Infrared Drying at 70 °C (Treatment II)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	ρ
0.0	0.02400	0.69492	0.69131	0.00000	-	-
0.5	0.02398	0.69322	0.68962	-0.20300	0.69050	0.25460
1.0	0.02388	0.68651	0.68291	-0.80500	0.68630	1.00800
1.5	0.02377	0.67874	0.67514	-0.93200	0.67900	1.16710
2.0	0.02370	0.67352	0.66992	-0.62700	0.67250	0.78520
2.5	0.02364	0.66914	0.66554	-0.52500	0.66770	0.65780
3.0	0.02357	0.66441	0.66081	-0.56800	0.66320	0.71090
3.5	0.02349	0.65904	0.65544	-0.64400	0.65810	0.80640
4.0	0.02341	0.65339	0.64979	-0.67800	0.65260	0.84880
4.5	0.02333	0.64732	0.64371	-0.72900	0.64680	0.91250
5.0	0.02324	0.64110	0.63750	-0.74600	0.64060	0.93370
5.5	0.02315	0.63475	0.63114	-0.76300	0.63430	0.95490
6.0	0.02306	0.62825	0.62465	-0.78000	0.62790	0.97610
6.5	0.02296	0.62133	0.61773	-0.83100	0.62120	1.03980
7.0	0.02286	0.61462	0.61102	-0.80500	0.61440	1.00800
7.5	0.02277	0.60777	0.60417	-0.82200	0.60760	1.02920
8.0	0.02267	0.60071	0.59710	-0.84700	0.60060	1.06100
9.0	0.02247	0.58694	0.58333	-0.82600	0.59020	1.03450
9.5	0.02238	0.58023	0.57662	-0.80500	0.58000	1.00800
10.0	0.02228	0.57309	0.56949	-0.85600	0.57310	1.07160
12.0	0.02189	0.54583	0.54223	-0.81800	0.55590	1.02390
14.0	0.02151	0.51907	0.51547	-0.80300	0.52880	1.00530
16.0	0.02114	0.49294	0.48934	-0.78400	0.50240	0.98140
18.0	0.02078	0.46773	0.46412	-0.75600	0.47670	0.94700
20.0	0.02044	0.44322	0.43962	-0.73500	0.45190	0.92040
26.0	0.01943	0.37225	0.36864	-0.71000	0.40410	0.88860
31.0	0.01864	0.31667	0.31307	-0.66700	0.34090	0.83500
35.0	0.01809	0.27726	0.27366	-0.59100	0.29340	0.74010
40.0	0.01745	0.23206	0.22846	-0.54200	0.25110	0.67910
45.0	0.01688	0.19174	0.18814	-0.48400	0.20830	0.60580
50.0	0.01638	0.15678	0.15318	-0.41900	0.17070	0.52520
55.0	0.01598	0.12881	0.12521	-0.33600	0.13920	0.42020
60.0	0.01566	0.10600	0.10240	-0.27400	0.11380	0.34270
65.0	0.01535	0.08390	0.08030	-0.26500	0.09130	0.33210
70.0	0.01506	0.06370	0.06010	-0.24200	0.07020	0.30350
75.0	0.01484	0.04767	0.04407	-0.19200	0.05210	0.24090
80.0	0.01464	0.03411	0.03051	-0.16300	0.03730	0.20370
85.0	0.01448	0.02246	0.01886	-0.14000	0.02470	0.17510
92.0	0.01429	0.00911	0.00551	-0.11400	0.01220	0.14320
95.0	0.01423	0.00459	0.00099	-0.09000	0.00320	0.11320
96.0	0.01421	0.00360	0.00000	-0.05900	0.00050	0.07420

Table D.21. Data of Infrared Drying at 80 °C (Treatment I)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0.0	0.02400	0.69492	0.64739	0.00000	-	-
0.5	0.02398	0.69329	0.64576	-0.19500	0.64660	0.24400
1.5	0.02370	0.67394	0.62641	-1.16100	0.63610	1.45360
2.0	0.02353	0.66179	0.61427	-1.45800	0.62030	1.82500
2.5	0.02341	0.65339	0.60586	-1.00800	0.61010	1.26260
3.0	0.02332	0.64675	0.59922	-0.79700	0.60250	0.99740
3.5	0.02322	0.63983	0.59230	-0.83100	0.59580	1.03980
4.0	0.02312	0.63242	0.58489	-0.89000	0.58860	1.11410
5.0	0.02289	0.61631	0.56879	-0.96600	0.57680	1.20960
5.5	0.02277	0.60819	0.56066	-0.97500	0.56470	1.22020
6.0	0.02265	0.59965	0.55212	-1.02500	0.55640	1.28380
6.5	0.02253	0.59138	0.54386	-0.99200	0.54800	1.24140
7.0	0.02242	0.58298	0.53545	-1.00800	0.53970	1.26260
7.5	0.02230	0.57493	0.52740	-0.96600	0.53140	1.20960
8.0	0.02219	0.56688	0.51935	-0.96600	0.52340	1.20960
8.5	0.02207	0.55862	0.51109	-0.99200	0.51520	1.24140
9.0	0.02196	0.55064	0.50311	-0.95800	0.50710	1.19900
9.5	0.02184	0.54223	0.49470	-1.00800	0.49890	1.26260
10.0	0.02173	0.53461	0.48708	-0.91500	0.49090	1.14590
12.0	0.02129	0.50353	0.45600	-0.93200	0.47150	1.16710
14.0	0.02086	0.47302	0.42550	-0.91500	0.44070	1.14590
16.0	0.02044	0.44350	0.39598	-0.88600	0.41070	1.10880
18.0	0.02005	0.41575	0.36822	-0.83300	0.38210	1.04250
20.0	0.01967	0.38905	0.34153	-0.80100	0.35490	1.00270
25.0	0.01879	0.32684	0.27931	-0.74700	0.31040	0.93480
30.0	0.01802	0.27274	0.22521	-0.64900	0.25230	0.81270
36.0	0.01725	0.21794	0.17041	-0.54800	0.19780	0.68610
40.0	0.01681	0.18729	0.13976	-0.46000	0.15510	0.57560
45.0	0.01635	0.15480	0.10727	-0.39000	0.12350	0.48810
50.0	0.01598	0.12853	0.08100	-0.31500	0.09410	0.39470
55.0	0.01568	0.10706	0.05953	-0.25800	0.07030	0.32260
60.0	0.01543	0.08962	0.04209	-0.20900	0.05080	0.26210
65.0	0.01522	0.07500	0.02747	-0.17500	0.03480	0.21960
70.0	0.01506	0.06356	0.01603	-0.13700	0.02180	0.17190
75.0	0.01492	0.05381	0.00629	-0.11700	0.01120	0.14640
77.0	0.01488	0.05064	0.00311	-0.09500	0.00470	0.11940
79.0	0.01483	0.04753	0.00000	-0.09300	0.00160	0.11670

Table D.22. Data of Infrared Drying at 80 °C (Treatment II)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	R
0.0	0.02400	0.69490	0.64980	0.00000	-	-
0.5	0.02398	0.69340	0.64830	-0.18600	0.69410	0.23340
1.0	0.02387	0.68570	0.64060	-0.91500	0.68950	1.14590
1.5	0.02369	0.67270	0.62760	-1.55900	0.67920	1.95230
2.0	0.02352	0.66130	0.61620	-1.37300	0.66700	1.71890
2.5	0.02341	0.65350	0.60840	-0.94100	0.65740	1.17770
3.0	0.02332	0.64670	0.60160	-0.81400	0.65010	1.01860
3.5	0.02322	0.63950	0.59440	-0.86400	0.64310	1.08220
4.0	0.02311	0.63200	0.58690	-0.89800	0.63570	1.12470
4.5	0.02299	0.62380	0.57870	-0.98300	0.62790	1.23080
5.0	0.02287	0.61510	0.57000	-1.04200	0.61950	1.30510
6.0	0.02263	0.59790	0.55280	-1.03400	0.60650	1.29450
6.5	0.02251	0.58950	0.54440	-1.00800	0.59370	1.26260
7.0	0.02238	0.58030	0.53520	-1.10200	0.58490	1.37930
7.5	0.02226	0.57170	0.52660	-1.03400	0.57600	1.29450
8.5	0.02201	0.55400	0.50890	-1.05900	0.56290	1.32630
9.0	0.02188	0.54520	0.50010	-1.05900	0.54960	1.32630
10.0	0.02165	0.52870	0.48360	-0.99200	0.53690	1.24140
12.0	0.02117	0.49520	0.45010	-1.00400	0.51190	1.25730
14.0	0.02071	0.46240	0.41730	-0.98300	0.47880	1.23080
16.0	0.02026	0.43080	0.38570	-0.94900	0.44660	1.18830
20.0	0.01943	0.37240	0.32730	-0.87600	0.40160	1.09680
25.0	0.01851	0.30720	0.26210	-0.78200	0.33980	0.97930
30.0	0.01772	0.25150	0.20640	-0.66900	0.27930	0.83720
35.0	0.01706	0.20480	0.15970	-0.56000	0.22810	0.70130
40.0	0.01652	0.16680	0.12170	-0.45600	0.18580	0.57080
45.0	0.01608	0.13570	0.09060	-0.37300	0.15130	0.46690
56.0	0.01572	0.10990	0.06480	-0.14100	0.12280	0.17650
60.0	0.01517	0.07130	0.02620	-0.57900	0.09060	0.72550
65.0	0.01496	0.05660	0.01150	-0.17500	0.06390	0.21960
70.0	0.01480	0.04510	0.00000	-0.13900	0.05080	0.17400

Table D.23. Data of Infrared Drying at 90 °C (Treatment I)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	P
0.0	0.02400	0.69492	0.66914	0.00000	-	-
0.5	0.02398	0.69336	0.66759	-0.18600	0.66840	0.23340
1.5	0.02368	0.67232	0.64654	-1.26300	0.65710	1.58090
2.5	0.02333	0.64732	0.62154	-1.50000	0.63400	1.87800
3.0	0.02320	0.63870	0.61292	-1.03400	0.61720	1.29450
3.5	0.02308	0.63023	0.60445	-1.01700	0.60870	1.27320
4.0	0.02296	0.62112	0.59534	-1.09300	0.59990	1.36870
4.5	0.02282	0.61172	0.58595	-1.12700	0.59060	1.41120
5.0	0.02269	0.60212	0.57634	-1.15300	0.58110	1.44300
5.5	0.02254	0.59188	0.56610	-1.22900	0.57120	1.53850
6.0	0.02239	0.58150	0.55572	-1.24600	0.56090	1.55970
6.5	0.02226	0.57203	0.54626	-1.13600	0.55100	1.42180
7.0	0.02212	0.56236	0.53658	-1.16100	0.54140	1.45360
7.5	0.02198	0.55254	0.52677	-1.17800	0.53170	1.47480
8.0	0.02185	0.54308	0.51730	-1.13600	0.52200	1.42180
8.5	0.02171	0.53333	0.50756	-1.16900	0.51240	1.46420
9.0	0.02158	0.52387	0.49809	-1.13600	0.50280	1.42180
9.5	0.02144	0.51427	0.48849	-1.15300	0.49330	1.44300
10.0	0.02131	0.50501	0.47924	-1.11000	0.48390	1.38990
12.0	0.02079	0.46850	0.44273	-1.09500	0.46100	1.37140
14.0	0.02030	0.43326	0.40749	-1.05700	0.42510	1.32360
16.0	0.01982	0.39979	0.37401	-1.00400	0.39070	1.25730
18.0	0.01937	0.36773	0.34195	-0.96200	0.35800	1.20430
20.0	0.01894	0.33722	0.31144	-0.91500	0.32670	1.14590
25.0	0.01798	0.26949	0.24372	-0.81300	0.27760	1.01750
30.0	0.01719	0.21363	0.18785	-0.67000	0.21580	0.83930
35.0	0.01653	0.16737	0.14160	-0.55500	0.16470	0.69500
40.0	0.01599	0.12952	0.10374	-0.45400	0.12270	0.56870
45.0	0.01559	0.10127	0.07549	-0.33900	0.08960	0.42440
50.0	0.01527	0.07811	0.05233	-0.27800	0.06390	0.34800
55.0	0.01502	0.06073	0.03496	-0.20800	0.04360	0.26100
61.0	0.01479	0.04477	0.01900	-0.16000	0.02700	0.19980
65.0	0.01465	0.03439	0.00862	-0.15600	0.01380	0.19500
70.0	0.01455	0.02768	0.00191	-0.08100	0.00530	0.10080
71.0	0.01453	0.02578	0.00000	-0.11400	0.00100	0.14320

Table D.24. Data of Infrared Drying at 90 °C (Treatment II)

Time(min)	Weigth(kg)	Xt	X	dX/dt	X ave	ρ
0.0	0.02400	0.69492	0.68086	0.00000	-	-
0.5	0.02398	0.69357	0.67952	-0.16100	0.68020	0.20160
1.0	0.02388	0.68665	0.67260	-0.83100	0.67610	1.03980
1.5	0.02370	0.67366	0.65960	-1.55900	0.66610	1.95230
2.0	0.02345	0.65622	0.64216	-2.09300	0.65090	2.62070
2.5	0.02328	0.64379	0.62973	-1.49200	0.63590	1.86740
3.0	0.02314	0.63446	0.62041	-1.11900	0.62510	1.40060
3.5	0.02302	0.62571	0.61165	-1.05100	0.61600	1.31570
4.0	0.02289	0.61631	0.60226	-1.12700	0.60700	1.41120
4.5	0.02274	0.60600	0.59195	-1.23700	0.59710	1.54910
5.0	0.02260	0.59576	0.58171	-1.22900	0.58680	1.53850
5.5	0.02244	0.58503	0.57097	-1.28800	0.57630	1.61280
6.0	0.02230	0.57465	0.56059	-1.24600	0.56580	1.55970
6.5	0.02215	0.56427	0.55021	-1.24600	0.55540	1.55970
7.0	0.02200	0.55388	0.53983	-1.24600	0.54500	1.55970
7.5	0.02186	0.54350	0.52945	-1.24600	0.53460	1.55970
8.5	0.02157	0.52302	0.50897	-1.22900	0.51920	1.53850
9.0	0.02142	0.51299	0.49894	-1.20300	0.50400	1.50670
9.5	0.02128	0.50268	0.48863	-1.23700	0.49380	1.54910
10.0	0.02114	0.49280	0.47874	-1.18600	0.48370	1.48540
12.0	0.02059	0.45388	0.43983	-1.16700	0.45930	1.46160
14.0	0.02006	0.41688	0.40283	-1.11000	0.42130	1.38990
16.0	0.01958	0.38277	0.36871	-1.02300	0.38580	1.28120
18.0	0.01911	0.34936	0.33531	-1.00200	0.35200	1.25470
20.0	0.01865	0.31716	0.30311	-0.96600	0.31920	1.20960
25.0	0.01766	0.24746	0.23340	-0.83600	0.26830	1.04720
31.0	0.01668	0.17818	0.16412	-0.69300	0.19880	0.86740
35.0	0.01617	0.14188	0.12783	-0.54400	0.14600	0.68170
40.0	0.01567	0.10678	0.09273	-0.42100	0.11030	0.52730
46.0	0.01522	0.07507	0.06102	-0.31700	0.07690	0.39700
50.0	0.01499	0.05848	0.04442	-0.24900	0.05270	0.31170
55.0	0.01476	0.04202	0.02797	-0.19700	0.03620	0.24720
60.0	0.01458	0.02987	0.01582	-0.14600	0.02190	0.18250
65.0	0.01445	0.02041	0.00636	-0.11400	0.01110	0.14220
71.0	0.01436	0.01405	0.00000	-0.06400	0.00320	0.07960

Table D.25. Data of Microwave Drying at 30% Power supply (Treatment I)

Time (min)	Weigth(kg)	X
0.0	0.50000	0.69490
1.0	0.49900	0.69150
2.0	0.49800	0.68810
3.0	0.49700	0.68470
4.0	0.49500	0.67800
5.0	0.49400	0.67460
6.0	0.49200	0.66780
7.0	0.49000	0.66100
8.0	0.48800	0.65420
9.0	0.48600	0.64750
10.0	0.48400	0.64070
12.0	0.48000	0.62710
14.0	0.47500	0.61020
16.0	0.47000	0.59320
18.0	0.46500	0.57630
20.0	0.46000	0.55930
22.0	0.45400	0.53900
24.0	0.44900	0.52200
26.0	0.44400	0.50510
28.0	0.43900	0.48810
30.0	0.43300	0.46780
32.0	0.42800	0.45080
34.0	0.42000	0.42370
36.0	0.41800	0.41690
38.0	0.41300	0.40000
40.0	0.40900	0.38640
42.0	0.40400	0.36950
44.0	0.39900	0.35250
46.0	0.39500	0.33900
48.0	0.39100	0.32540
50.0	0.38700	0.31190
52.0	0.38300	0.29830
54.0	0.37800	0.28140
58.0	0.37300	0.26440
60.0	0.36900	0.25080
62.0	0.36500	0.23730
64.0	0.36000	0.22030
66.0	0.35500	0.20340
68.0	0.35000	0.18640
70.0	0.34700	0.17630
72.0	0.34300	0.16270
76.0	0.34000	0.15250
78.0	0.33700	0.14240
80.0	0.33300	0.12880
82.0	0.32800	0.11190
84.0	0.32500	0.10170
87.0	0.32300	0.09490
88.0	0.32000	0.08470
90.0	0.31800	0.07800
92.0	0.31400	0.06440
94.0	0.31300	0.06100
96.0	0.31000	0.05080
98.0	0.30700	0.04070
100.0	0.30500	0.03390
102.0	0.30300	0.02710
104.0	0.30100	0.02030
106.0	0.29900	0.01360
108.0	0.29800	0.01020
110.0	0.29700	0.00680
112.0	0.29600	0.00340
114.0	0.29500	0.00000
116.0	0.29500	0.00000

Table D.26. Data of Microwave Drying at 30% Power supply (Treatment II)

Time (min)	Weigth(kg)	X
0.0	0.50000	0.69490
1.0	0.49900	0.69150
2.0	0.49900	0.69150
3.0	0.49700	0.68470
4.0	0.49600	0.68140
5.0	0.49500	0.67800
6.0	0.49400	0.67460
7.0	0.49300	0.67120
8.0	0.49100	0.66440
9.0	0.48900	0.65760
10.0	0.48700	0.65080
12.0	0.48300	0.63730
14.0	0.47800	0.62030
16.0	0.47300	0.60340
18.0	0.46700	0.58310
20.0	0.46200	0.56610
22.0	0.45600	0.54580
24.0	0.45000	0.52540
26.0	0.44400	0.50510
28.0	0.43800	0.48470
30.0	0.43200	0.46440
32.0	0.42600	0.44410
34.0	0.42100	0.42710
36.0	0.41300	0.40000
38.0	0.40800	0.38310
40.0	0.40300	0.36610
42.0	0.39800	0.34920
44.0	0.39300	0.33220
46.0	0.38900	0.31860
48.0	0.38400	0.30170
50.0	0.38000	0.28810
53.0	0.37300	0.26440
54.0	0.37000	0.25420
58.0	0.36200	0.22710
60.0	0.35600	0.20680
62.0	0.35100	0.18980
64.0	0.34800	0.17970
66.0	0.34400	0.16610
68.0	0.34100	0.15590
70.0	0.33800	0.14580
72.0	0.33400	0.13220
76.0	0.32900	0.11530
78.0	0.32600	0.10510
80.0	0.32400	0.09830
82.0	0.32100	0.08810
84.0	0.31900	0.08140
87.0	0.31500	0.06780
88.0	0.31400	0.06440
90.0	0.31100	0.05420
92.0	0.30800	0.04410
94.0	0.30600	0.03730
96.0	0.30400	0.03050
98.0	0.30200	0.02370
100.0	0.30000	0.01690
102.0	0.29900	0.01360
104.0	0.29800	0.01020
106.0	0.29700	0.00680
108.0	0.29600	0.00340
110.0	0.29500	0.00000
112.0	0.29500	0.00000
114.0	0.29500	0.00000

Table D.27. Data of Microwave Drying at 50% Power supply (Treatment I)

Time (min)	Weigth(kg)	X
0.0	0.50000	0.69492
1.0	0.49900	0.69153
2.0	0.49700	0.68475
4.0	0.49300	0.67119
5.0	0.48900	0.65763
6.0	0.48500	0.64407
8.0	0.47700	0.61695
9.0	0.47200	0.60000
10.0	0.46700	0.58305
12.0	0.45600	0.54576
14.0	0.44500	0.50848
16.0	0.43400	0.47119
18.0	0.42300	0.43390
20.0	0.41200	0.39661
22.0	0.40300	0.36610
26.0	0.38400	0.30170
28.0	0.37500	0.27119
30.0	0.36600	0.24068
32.0	0.35700	0.21017
34.0	0.34800	0.17966
36.0	0.34000	0.15254
40.0	0.32600	0.10509
44.0	0.31300	0.06102

Table D.28. Data of Microwave Drying at 50% Power supply (Treatment II)

Time (min)	Weigth(kg)	X
0.0	0.50000	0.69492
1.0	0.49900	0.69153
2.0	0.49800	0.68814
4.0	0.49400	0.67458
5.0	0.49000	0.66102
6.0	0.48600	0.64746
8.0	0.47800	0.62034
9.0	0.47100	0.59661
10.0	0.46600	0.57966
12.0	0.45500	0.54237
14.0	0.44400	0.50509
16.0	0.43300	0.46780
18.0	0.42200	0.43051
20.0	0.41100	0.39322
22.0	0.40400	0.36949
26.0	0.38500	0.30509
28.0	0.37600	0.27458
30.0	0.36700	0.24407
32.0	0.35800	0.21356
34.0	0.34900	0.18305
36.0	0.34100	0.15593
40.0	0.32800	0.11186
44.0	0.31500	0.06780
45.0	0.30000	0.01695

Table D.29. Data of Microwave Drying at 100% Power supply (Treatment I)

Time (min)	Weigth(kg)	X
0.0	0.50000	0.69492
1.0	0.49684	0.68420
2.0	0.49169	0.66675
3.0	0.48355	0.63915
4.0	0.47324	0.60420
5.0	0.46190	0.56576
6.0	0.44990	0.52509
7.0	0.43860	0.48678
8.0	0.42760	0.44949
9.0	0.41646	0.41173
10.0	0.40691	0.37936
12.0	0.38776	0.31444
14.0	0.36818	0.24807
16.0	0.34693	0.17603
18.0	0.33387	0.13176
20.0	0.32053	0.08654
22.0	0.30860	0.04610
24.0	0.30180	0.02305
26.5	0.29388	-0.00380
28.5	0.28800	-0.02373
31.0	0.28055	-0.04898
33.0	0.27702	-0.06095
36.0	0.27181	-0.07861

Table D.30. Data of Microwave Drying at 100% Power supply (Treatment II)

Time (min)	Weigth(kg)	X
0.0	0.50000	0.69492
1.0	0.49735	0.68593
2.0	0.49215	0.66831
3.0	0.48523	0.64485
4.0	0.47576	0.61275
5.0	0.46497	0.57617
6.0	0.45319	0.53624
7.0	0.44151	0.49664
8.0	0.43047	0.45922
10.0	0.40958	0.38841
12.0	0.48938	0.65892
14.0	0.37012	0.25464
16.0	0.35316	0.19715
18.0	0.33705	0.14254
20.0	0.32465	0.10051
22.0	0.31371	0.06342
24.0	0.30553	0.03570
26.0	0.29845	0.01170

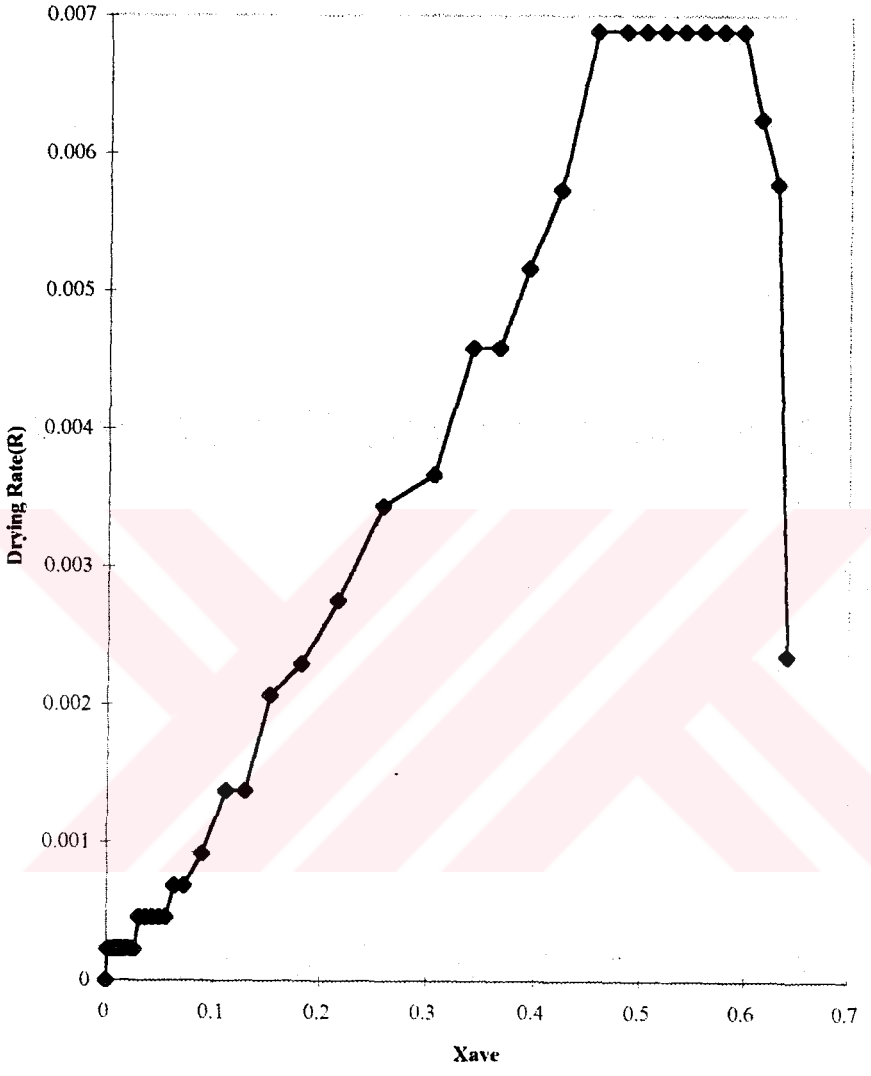

Figure D.1. Drying Rate Graph for Fluidized Bed Drying at 70 C (Treatment I)

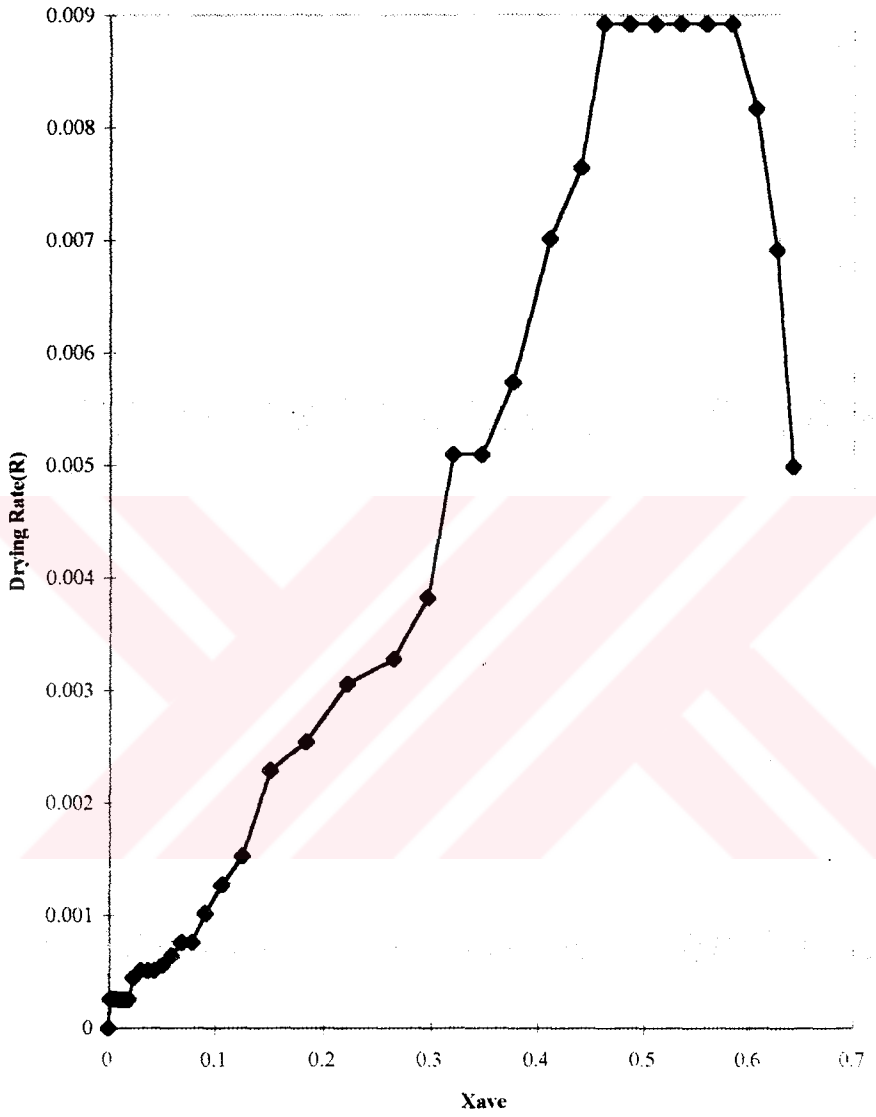

Figure D.2. Drying Rate Graph for Fluidized Bed Drying at 80 C (Treatment I)

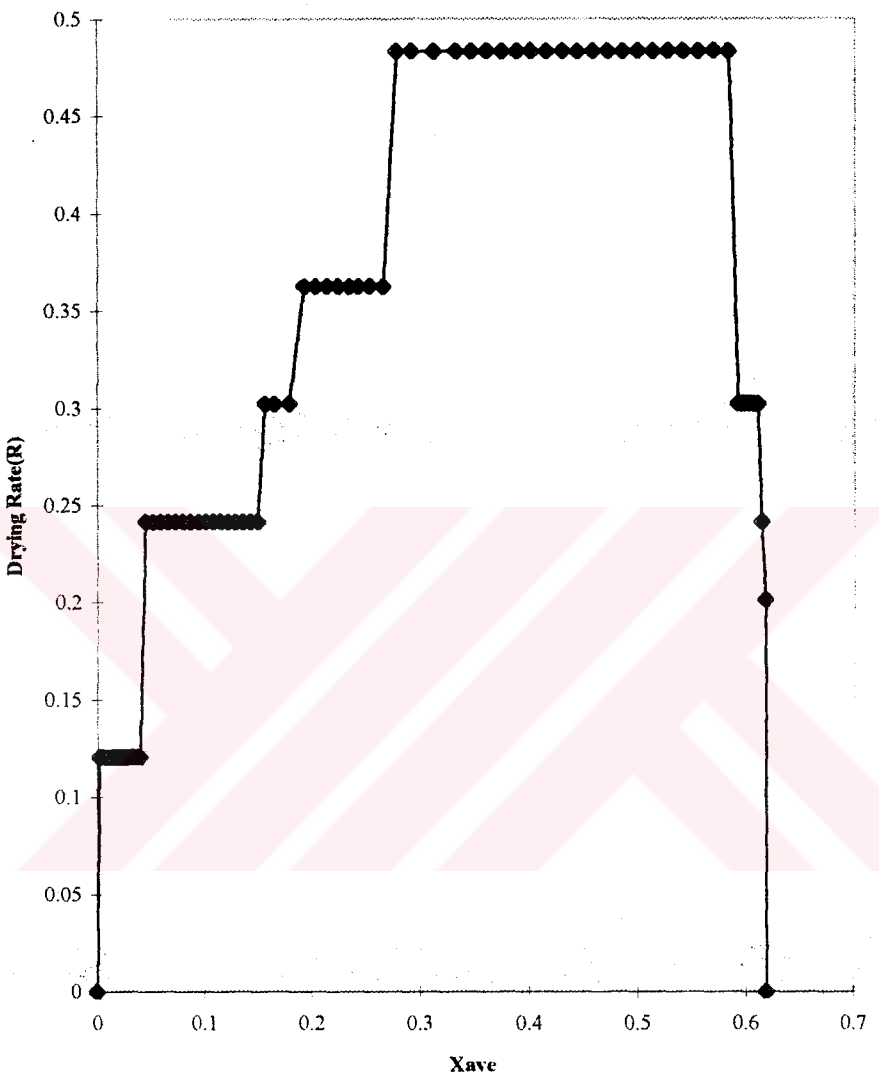

Figure D.3. Drying Rate Graph for Tray Drying at 70 C (Treatment I)

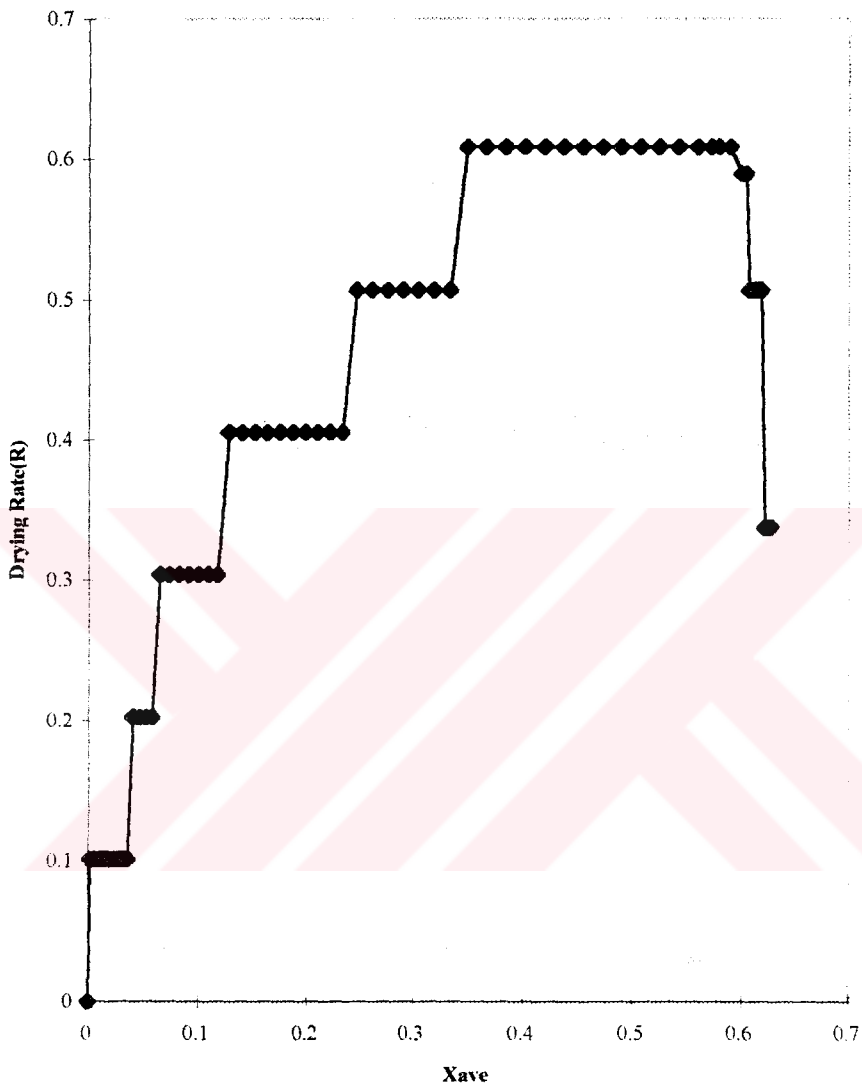

Figure D.4. Drying Rate Graph for Tray Drying at 80 C (Treatment I)

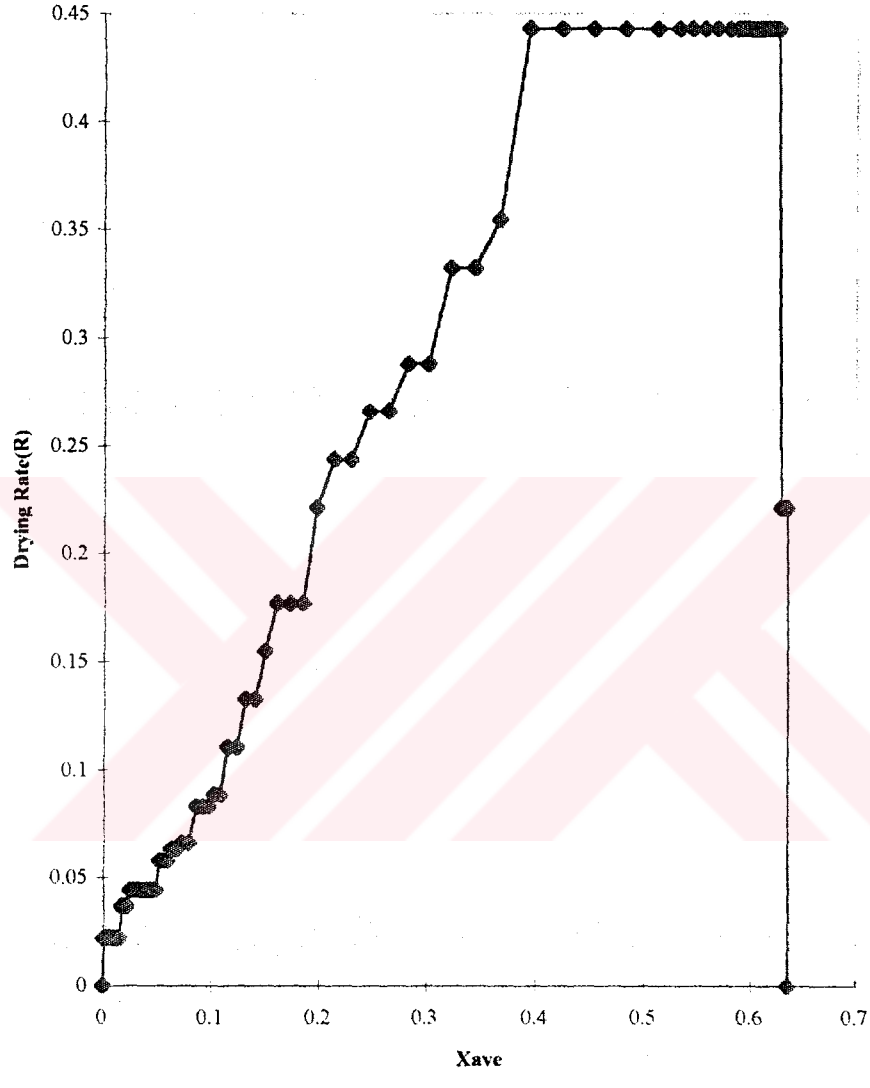

Figure D.5. Drying Rate Graph for Conductional Drying at 70 C (Treatment I)

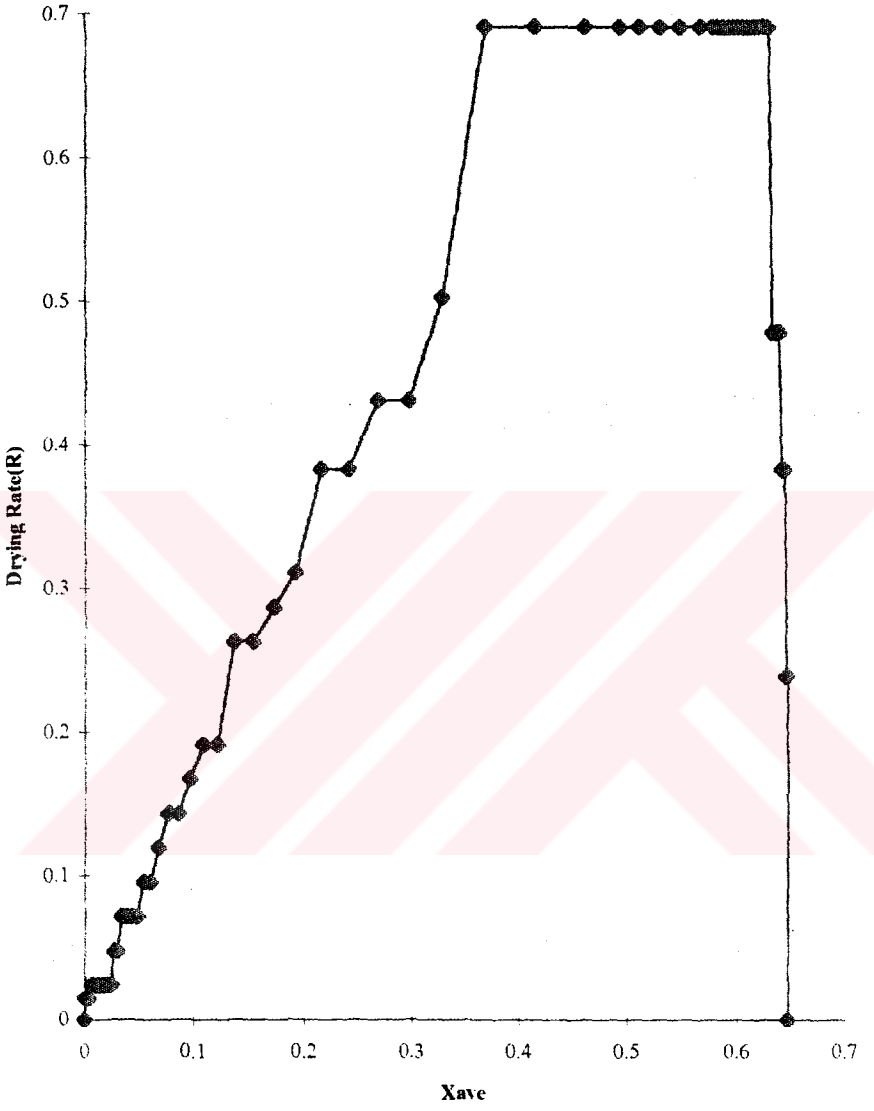

Figure D.6. Drying Rate Graph for Conductional Drying at 80 C (Treatment I)

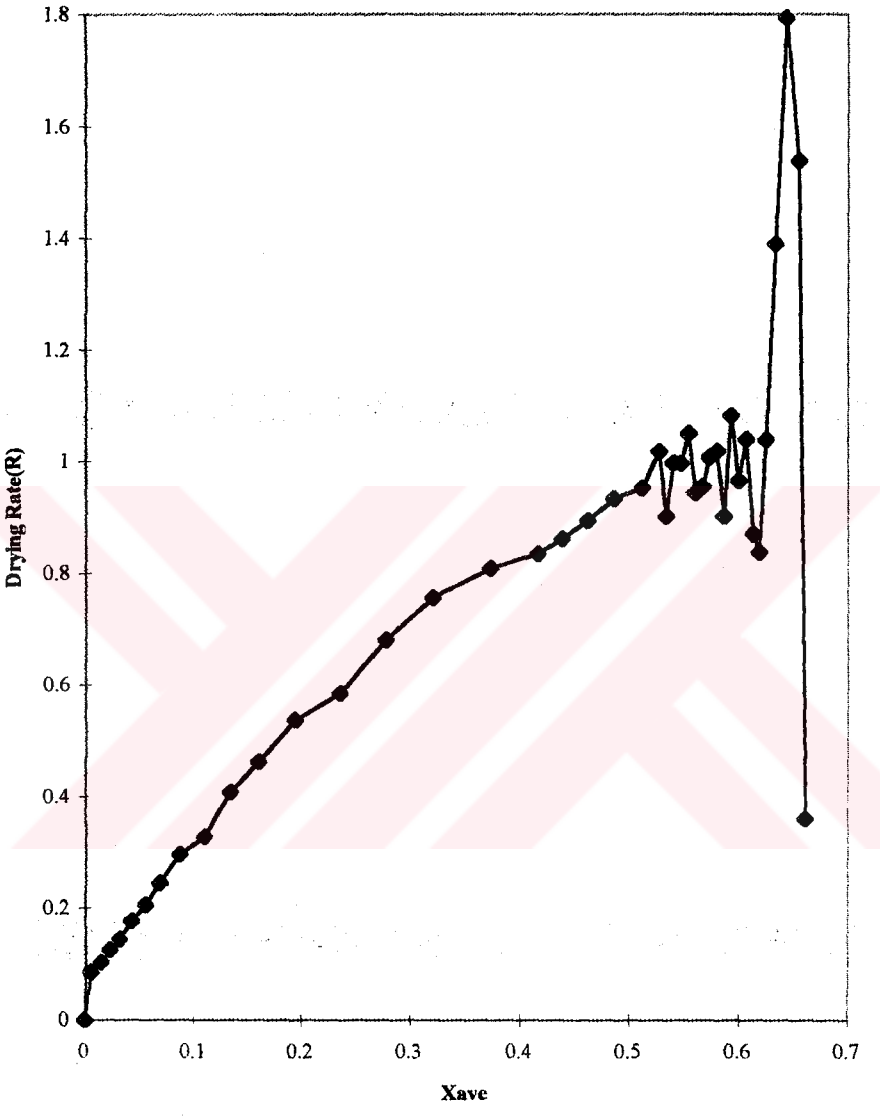

Figure D.7. Drying Rate Graph for Infrared Drying at 70 C (Treatment I)

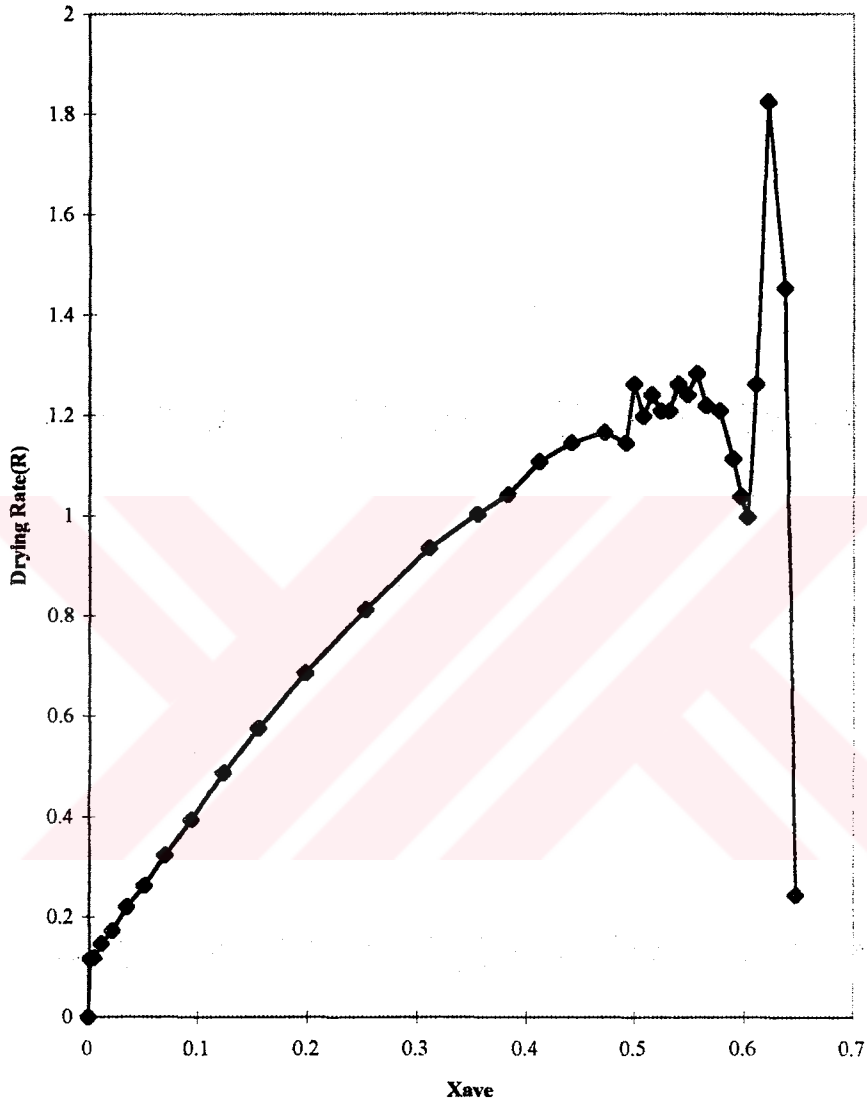

Figure D.8. Drying Rate Graph for Infrared Drying at 80 C (Treatment I)