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The Development of a Reduced Glycemic Load/ High Fiber Pasta Using Pulses

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THE DEVELOPMENT OF A REDUCED GLYCEMIC LOAD/HIGH FIBER PASTA USING PULSES

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This work is dedicated to my Lord Jesus Christ for giving me the enduring strength throughout this journey. I would also like dedicate this research to my beautiful wife, for her love and support while perusing this Master's Degree. Without her help, guidance, and dedication, I would not be as advanced in science as I am today.

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ABSTRACT

The use of beans in the human diet provides an excellent source of dietary fiber and has potential for lowering glycemic load. Prepared meals with high levels of dietary fiber and low glycemic loads were found to be rare in a market survey of nine stores with various price points in the greater Baton Rouge area. The majority of the prepared meals found fell into low or medium fiber categories with medium to high glycemic loads. This indicates a need to increase the fiber level and decrease the glycemic load in popular foods. The purpose of this research is to accomplish these changes in prepared meals by substituting a portion of the standard pasta flour with bean flour.

Various mixtures of pinto bean, navy bean, black bean, enriched semolina, and "00" flours (a high-gluten red spring wheat flour) were tested using a standard Rapid Visco Analysis method and the visco-elastic properties were compared with the control flour. The addition of navy bean four to the control flour was found to produce a composite flour with a similar texture at 25%, 30%, and 50% substitution levels. A calculated proximate analysis was performed on three ravioli produced: a control, a 50%, and a 75% navy bean ravioli. A 14% DV and a 21% DV increase in dietary fiber were predicted for the 50% and 75% navy bean ravioli, respectively. A seven and a ten gram decrease in glycemic load were predicted for the 50% and the 75% navy bean ravioli.

The three ravioli types were also subjected to a sensory study with 103 participants. It was found that the color, texture, aroma, appearance, and liking preferences were not significantly changed by the substitution of navy bean flour at a 50% substitution level ($\alpha = 0.05$). These characteristics of commercially available frozen pasta meals were also measured with a blind consumer survey of consumers ages 65 and older. The predominant unsatisfactory characteristics found were texture and color. In comparison, the texture and color were not significantly altered by the 50% substitution of navy bean flour in the ravioli sensory study.

CHAPTER 1: INTRODUCTION AND JUSTIFICATION

1.1: INTRODUCTION

The purpose of this research is to increase the fiber content of frozen pasta meals by replacing a portion of the standard pasta flour with bean flour. Chapter 1 is an introduction to the structure of the document and justifies the importance of the given purpose. Chapter 2 presents a review of the literature available concerning the health benefits of a diet high in dietary fiber and glycemic load. The third chapter describes the methodology of the experimental process, while the analysis of the data collected is discussed in Chapter 4. A summary of the research and suggestions for further research are also included in the last chapter.

This first chapter presents a brief description of the research and its justification. The topics of each chapter are summarized, providing an introduction to the overall field. A specific range of options were chosen to test. Justification for these choices is provided in the second section of this chapter. A basic background of the pertinent topics is also included in the discussion of these choices.

The second chapter discusses various aspects of using beans to fortify foods. The nutritional structure of beans provides a balance of soluble and insoluble dietary fiber, resulting in a food that is high in fiber and low in glycemic load (Appendix A). Combining beans with whole grains also improves the protein quality of the food (Pulse Canada, 2011). The benefits of a diet that is high in dietary fiber, high in protein, and low in glycemic load are also discussed, with a focus on the diets of consumers ages 65 and older. A few examples are given of experiments done to fortify pasta with various bean flours. The various analysis methods used in this experiment are also discussed in Chapter Two.

In the third chapter of this thesis, the materials and methods used in the experiment are described in detail. The experiment was performed in three stages. The first stage consisted of two market surveys and a blind consumer survey. Next, various mixtures of enriched semolina flour, “00” flour, navy bean flour, black bean flour, and pinto bean flour were tested for compatibility. Based on the results of these tests, three mixtures were chosen for formulation into cheese-stuffed ravioli in the final stage of the research. A consumer sensory study was then executed with these ravioli blends, thus concluding the research.

In Chapter Four, the results of the various tests are presented and discussed. The structure of the analysis of the market surveys is given and discussed. The results of the blind consumer survey and flour mixture testing are also presented. The results of a calculated proximate analysis of the three ravioli blends chosen for the sensory study are outlined, and the statistical analysis of the results from the sensory study is discussed. In conclusion, implications of the results presented are explained and suggestions for further research are given.

Based on the research in the following pages, it is recommended that further research use beans and legume flour in the development of new pastas. The superior nutritional profile of milled bean flour presents an opportunity to improve the nutritional content of the pasta products currently available in the market. The benefits of a diet high in fiber and low in glycemic load also justify the modification of these products. The development of high fiber low glycemic load foods will raise the standard of tomorrow’s recipes.

1.2: JUSTIFICATION

The creation of new healthy types of food as well as the improvement of existing foods has been become a popular trend over the past years. One of the questions that is asked when looking at food options is, “What are some ways to make food healthier?” When the consumer is looking for a healthier alternative in a food product, one of the variables that is often considered is the amount of dietary fiber that is contained in the food. In various societies today, there are diets that emphasize foods that are higher in fiber or lower in glycemic load (GL). One particular diet that focuses on higher fiber levels is the beans-only diet. Beans-only diets, such as the baked bean diet, pair vegetables and grains like whole grain breads, brown rice or barley with a number of different legume types. Beans are now thought to help both improve nutrition, such as increase the protein and dietary fiber, while encouraging healthy weight loss (Kerns, 2015).

Another question that is asked is, “How is one particular food product of choice lower in glycemic load or higher in fiber than the alternative?” As theses terms are defined, this question will be explained. Glycemic load is interpreted as the product of the average glycemic index (GI) of carbohydrate foods consumed and the total carbohydrate intake over a specified time period (Monro and Shaw, 2008). In conjunction with this definition, glycemic index can be defined as a numeric value based on the blood sugar response caused by the carbohydrate consumed (Mendosa, 2008).

According to the Food and Drug Administration (FDA), nutrients are classified as either high or low based on percent daily value of the prescribed consumption. If the percent daily value (%DV) is greater than or equal to twenty percent of the total prescribed consumption (%DV ≥ 20), the amount of the nutrient is considered to be “high” in that product (FDA 2015). In comparison, it is defined that a value less than or equal to five percent of the DV (%DV ≤ 5), the product would be considered “low” in value (FDA.gov). In accordance with these definitions, fiber levels have high (%DV ≥ 20) and low (%DV ≤ 5) values. For the purpose of this research, we define a medium fiber level to be between 6 - 19 %DV.

Current literature defines a low glycemic load to be below 11 grams per serving and a high glycemic load as greater than 20 grams per serving. This research is concerned with increasing the fiber content of pasta products while decreasing the glycemic load by substituting beans for a portion of the pasta flour. Although the fiber content of a product is used to calculate the glycemic load of the same product, these two characteristics are considered independently in the data analysis reported in Chapter 4.

With the advancement of different diets, both low glycemic load and high fiber content have shown to help manage the risk of diseases. According to the World Health Organization, more than half the deaths in the world are due to non-communicable disease (NCD). Diseases such as cardiovascular disease, type 1 and type 2 diabetes, Hypercholesterolemia, and increased body weight have fallen into the category of NCDs (Siddiq and Uebersax, 2012). With a rise in deaths due to NCDs, human nutrition plays a critical role the health of individuals. The use of dry beans in the diet can help individuals manage blood glucose levels, assist with fiber deficiencies, and present an individual with a good source of protein.

The target demographic for this thesis is centered on consumers ages 65 and older. It also included “baby boomers”, one of the largest population segments who are susceptible to age related conditions. The reason for this range is the significant increase in NCDs in the population suffering from high cholesterol, type two diabetes, and obesity. Research also shows decreased risks of cardiovascular disease, obesity, and other non-communicable diseases in individuals who followed a low glycemic and or high fiber diet. Demographics show that individuals 65 years of age and older are the fastest-growing segment of the population and contribute for the majority of cardiovascular disease (CVD), morbidity, mortality, and health care expenditures (Mozaffarian, 2003). Although the youth of today will be the next individuals who need to maintain a balanced diet, the focus for this research is directed to seniors because of the risk of diabetes, CVD, cancer, and the lack of necessary fiber in their diets.

Beans and legumes in the human diet have been shown to be an excellent source of dietary fiber and a factor in lowering glycemic load (Messina, 1999). Beans, correctly referred to as *Phaseolous vulgaris* L., are the major type of ingredient within the heart of this research (Hangen and Bennink, 2002). There are many different types of beans and legumes that qualify as low glycemic high fiber ingredient. Lentils have shown to be both a good source of fiber and have a low glycemic load. Pinto beans, as well as navy beans, have also been shown to be a good sources of fiber (Geila and Anderson, 2013). Pinto beans in the raw state contain 21.04 %DV fiber and 23.8 %DV of protein per serving. The fiber level of navy beans is higher by 2.56%, totaling approximately 19.1 grams of fiber per serving, with a slightly lower level of protein (Appendix A).

In this research, the focus is on higher levels of fiber, not protein, although protein in the diet is also important to seniors (Health.gov, 2010). The focus of this work is partially justified based on a study completed with two groups of subjects with type two diabetes, where each group was fed different amounts of fiber. One group ate a diabetic type of diet with a total of 24 grams of fiber/day, while the other group ate a diet consisting of 50 grams of fiber/day. The group of people who ate the diet higher in fiber had lower levels of both plasma glucose (blood sugar) and insulin (the hormone that helps blood sugar get into cells). The individuals with the higher fiber diet also reduced their total cholesterol by nearly 7%, their triglyceride levels by 10.2%, and their Very Low Density Lipoprotein (VLDL – the most dangerous form of cholesterol) levels by 12.5% (Mateljan, 2008). By simply increasing fiber intake, the experimental group received several health benefits.

The development of a legume based pasta product was chosen based on the large consumption of pasta products in the U.S and the lack of high fiber pasta choices in the market. In today's market there are many different types of dried and frozen pastas on the shelf. Most of the pasta products that are sold in the market today are made from blends of semolina and durum wheat flour. Some dried pasta choices include vegetables, including carrots, spinach and beets. Some specialty products on the store shelf, such as the gluten free section of the market, included dried bean pasta and rice pasta options. There are virtually no frozen products with beans or vegetables as shown in the market survey in Chapter 3. There also do not appear to be any pasta products that are both high in fiber and low in glycemic load. The goal of this research was to fortify the pasta with a percentage of milled bean flour.

Flour from milled beans provides several advantages over pre-gelatinized bean flour. One of the benefits of milled bean flour is that there is less loss in micronutrients and fiber levels because the beans are milled from the raw/dried state. Some nutrients are lost in the cooking process to produce pre-gelatinized bean flour.

One of the most common forms of pasta in the market is ravioli. Most of the options for ravioli can be found in the frozen section with some choices in the refrigerator section and one or two options in a dry form. The market survey illustrates that ravioli pasta only contained a traditional blend of durum wheat and semolina or a vegetable and wheat blend. Thus, an alternative type of frozen ravioli offers new product opportunity.

The composition of pasta products in general is not complicated. Most formulas for ravioli include five basic ingredients; flour, oil, egg as a binder, and salt to taste. An important factor in pasta production is the formation of an elastic dough from the two proteins within wheat gluten. When gluten is hydrated and blended in pasta dough, a complex matrix is formed. Studies show that when the gluten proteins interact with the starch in the wheat flour, a continuous proteinaceous matrix is formed (Shewry et al, 2002) The downside to pasta made from traditional flours such as enriched semolina flour and unbleached white wheat flour is that the product is generally high in total carbohydrates and low in dietary fiber. Bob’s Red Mill Semolina Flour contains 31 grams of total carbohydrates and 2 grams of dietary fiber per ¼ cup serving (42 grams). In comparison, Antimo Caputo "00" Chef's Flour, a soft wheat flour, contains 23 grams of total carbohydrates and less than 1 gram of fiber per ¼ cup serving (30 grams). Most pasta on the store shelf that is available for the consumer contains both types of flour. Traditional pasta is has a medium to high glycemic load and low to medium fiber content. However, there are companies similar to Best Cooking Pulses that offer flours, produced from beans and legumes, as an alternative to traditional flour. The reasons that most people remove traditional wheat flour would either be for personal health choices or the individual might be faced with an intolerance to gluten. The analysis of the flours used in this work is based on their total carbohydrates, dietary fiber, protein content, and gelatinization profile.

The types of beans studied in this thesis are pinto beans, navy beans, and black beans. In each analysis shown, these beans are introduced in the form of milled flour. As described before, digestible carbohydrates are defined as the difference between the total carbohydrates and the dietary fiber. Although bean flours are high in fiber, they are also high in fermentable carbohydrates resulting in a low glycemic load (low digestible carbohydrate) level. The question posed is how to develop a pasta product with a percentage of the bean flour and a mixture of gluten flours that delivers a medium to high fiber content and a low glycemic load.

The bean flours tested in this experiment were pinto bean, navy bean and black bean. Most types of pasta have a yellow to light brown color. Black bean pasta was eliminated in favor of the lighter color pinto and navy bean flours. Various levels of substitution of the bean flours were tested with standard methods, as described in Chapter 3.

Part of the first phase of this research project took place in a descriptive market setting, where the products observed are classified by fiber content and glycemic level based solely on their nutrition labels. Within this first phase, a sample of the target population was also surveyed based on the availability of frozen pasta meals in the market setting. The second phase of this research began with testing the moisture and starch properties of different wheat and bean flour mixtures. The testing of these different flour mixtures lead to the formulation of various pasta doughs, each containing a substitution with these flours. In the third and final phase of the project, the final formulations were produced. A consumer sensory test was then conducted using college students and faculty representing a sample of the population. In order to determine the best pasta dough to use in the construction of the bean ravioli product, the results of the consumer survey were analyzed. This process completes phase III and is discussed in Chapter 4.

In summary, it is common among this new generation to try various types of diets to obtain the goal of a healthy living. Through research, it has been shown that a diet with low glycemic load and medium to high fiber levels reduces the risk of different types of diseases. It has also been shown that beans like navy beans and other legumes can be used in different ways to facilitate more fiber in the diet. When an individual incorporates more fiber into their diet from beans, the glycemic load will also decrease due to the fermentable carbohydrates that are provided by the bean itself. Knowing that beans provide such a benefit, the challenge will be to develop a food product that is both familiar and appealing to individuals, but will also help with the health concerns. This proposed research will demonstrate the development of bean ravioli using navy bean flour.

CHAPTER 2: LITERATURE REVIEW

2.1: NUTRITIONAL ASPECTS OF HEALTHY FOODS FOR THE OLDER GENERATION

2.1.1 Overview

Individuals ages 65 years and older may consume a lower calorie diet due to limited mobility and decreased appetite; however, they require adjusted levels of essential nutrients. Higher quality meal choices become important for this population as they age. This need is in line with recent trends in food research emphasizing the production and availability of healthier foods in the market, as evidenced by the increasing variety of alternative food choices. Pasta is one of the food types in the market that is consumed in the most varied locations. Pasta is considered unhealthy due to its generally high carbohydrate, low fiber, and low protein content. This nutritional profile can be improved by fortifying the pasta with pulses such as chickpea, pinto bean, and navy bean flours.

2.1.2 Recommended Dietary Intakes for the Senior Citizens

The older generation is diverse, ranging in activity levels, health condition, and lifestyle coming from all walks of life. One overall trend observed with this group is the desire to live an enjoyable life without unmanageable health issues. Seniors increasingly see the importance of food choices and the effects on their quality of life (Costa and Jongen, 2010). However, seniors also face increasing nutritional challenges. As these individuals pass the age of 50, the recommended dietary intakes change for several food categories, making it more difficult to get the correct balance of nutrition described below. Consequently, the gap between these recommended consumptions and the actual intakes is large (Blumberg, 1997).

Many older individuals also note a decrease in appetite due to medications, a change in taste or smell, or problems with dentures (National Institute on Aging, 2016). Others may simply note a decrease in appetite with no apparent medical reason. In addition, they face the challenge of maintaining a healthy level of exercise and daily activity with possibly decreasing ranges of motion, which is necessary to maintain a healthy lifestyle (Lichtenstein et al, 2006). Another complication is a decrease in expendable income. In light of these issues, the older generation faces the challenge of eating higher quality food on restricted budgets and with increasing health issues.

The recommended calorie intake for seniors decreases by 200 calories between the ages of 51 and 61, depending on the activity level and the gender (USDA, 2016b). This decrease corresponds to excluding three medium eggs, 16 ounces of coca-cola, or one ounce of butter per day. This change is not large, but additional decreases in calorie intake are recommended for individuals who would benefit from weight loss. Moderate weight loss due to low calorie intake levels has been shown to improve hyperinsulinemia, cardiovascular risk factors, and a myriad of other improvements (Numata et al, 1993; Wing et al, 2011; Wadden and Stunkard, 1986).

Many older individuals are considered at risk for cardiovascular disease. Another way to decrease this risk is to decrease the intake of dietary cholesterol to less than 200 milligrams per day, instead of the normal limit of 300 milligrams. This decrease of 100 milligrams is approximately equivalent to three medium blueberry muffins, two-fifths of a stick of butter, or one piece of fried chicken. Not only is the amount of cholesterol intake a factor in heart health, but also the source. Whole grains are the recommended source of dietary cholesterol to protect against coronary heart disease, the leading cause of mortality in America (Hu and Willett, 2002).

As individuals pass the age of 50, the recommended fiber intake decreases from 38 grams of fiber to 30 grams of fiber per day (USDA, 2016a). The amount of dietary fiber consumed is closely associated with the glycemic load of the food product and the rate of digestion. Research has shown that a diet high in dietary glycemic load is associated with an increased risk of cardiovascular disease (Linus Pauling Institute, 2016). Similarly, a diet low in dietary fiber has been positively correlated with an increase in coronary heart disease (Pereira et al, 2004). This leads to the recommendation to follow a diet with a decreased glycemic load and increased dietary fiber content for the older population.

However, it does not follow that foods should be considered simply by their glycemic load. Other factors, such as the individual's insulin resistance, total carbohydrate content, fiber, and other nutrients should also be considered when selecting foods for a healthy diet (Hu and Willett, 2002; Committee on Diet and Health, 1989). For example, it is also recommended that individuals ages 50 and older increase their intake of vitamin B_{12} (Health.gov, 2010). Also, older individuals have the same recommended dietary fat intake as younger adults, but are recommended to receive this dietary fat in the non-hydrogenated unsaturated form to decrease risk of coronary heart disease (Hu and Willet, 2002). The recommended protein intake for older individuals remains an unsettled issue.

As a population at increased risk for cardiovascular diseases, the older generation faces a myriad of recommendations and limitations on their diets. These include decreasing calorie, sodium, and dietary cholesterol intake, decreasing glycemic load, and choosing non-hydrogenated unsaturated fats. Combined with possible pre-existing medical conditions, these dietary changes can make a healthy lifestyle seem difficult at best. In an effort to educate the industrialized population in these areas, several new visual methods have been studied to portray the health of various types of foods.

2.1.3 Nutritional Aspects of Healthy Foods

Several nutritional metrics have been developed in an effort to help the industrialized population choose healthy foods to include in their diets (Food and Drug Administration, 2008). The nutrition facts label, nutritional target map, caloric ratio pyramid, nutrient balance indicator, and other nutritional aids portray different aspects of the nutritional quality of that item. There has also been an effort in research to further identify unhealthy components of foods and unsafe preparation practices. These informational metrics and research efforts can increase the quality of life for older individuals.

The Food and Drug Administration (FDA) maintains the standardization of the Nutrition Facts Label required on all processed foods in the market (Figure 2.1a). This label gives the serving size and the nutritional profile for each serving. This profile includes the calorie, total fat, fat components, cholesterol, sodium, total carbohydrate, dietary fiber, sugars, protein, and vitamin content as required by the FDA. Percent daily values of each nutritional component are calculated based on a 2000 calorie diet (Health.gov, 2010). Although this label is the standard of nutrition labels in the market, it can be difficult for consumer to make decisions based on the information it provides. Spatial representations of this information tend to increase the ease of decision-making processes.

The Nutritional Target Map was developed and copyrighted by nutritiondata.self.com to provide additional nutritional indices to consumers in a spatial context (Figure 2.1b). One of these indices gives a numerical value representing the overall nutrient density of the food. A higher value for this indicator implies a more nutritious food product. Such nutrient-dense foods include vegetables, fruits, nuts and seeds. The second index given in the nutritional target map gives a numerical expression for the caloric density of the food. A higher index of caloric density means a more filling food, such as vegetables, fruits, tea and water. The nutritional target map gives a spatial representation of these indices, thus aiding the consumer in choosing the proper types of foods for proper weight management, gain, or loss as desired (Johnson, 2005).

The Caloric Ratio Pyramid also gives a spatial representation of various components of the food's nutritional profile (Figure 2.1c). This metric shows how the calorie sources of the food are related. The top portion of the pyramid correlates to foods where the calories are completely sourced from fats. The bottom right corner of the pyramid is where protein contributes all of the calories of the food. Carbohydrates provide all of the calories in foods found in the bottom left-hand corner of the caloric food pyramid. This graphic is yet another aid for assisting the older generation in choosing foods aligned with their nutritional needs.

The nutrition data website, nutritiondata.self.com (2016), uses another type of graphic to represent the density of each nutrient component analyzed (Figure 2.1d). The Nutrient Balance Indicator includes the levels of protein, dietary fiber, twelve vitamins, nine minerals, saturated fat, cholesterol, and sodium. These nutrient types are represented as color-coded spokes on a radial diagram. The density of each nutrient is represented by a filled portion of the spoke for that nutrient. A score based on these densities is also given in the graphic to help the consumer rank foods based on the composite nutrient profile. It is recommended to use this graphic to compile recipes resulting in a balanced nutritional profile (Nutritiondata.self.com, 2016).

The distribution of protein types is shown by a similar graphic copyrighted by nutritiondata.self.com (2016). The Protein Quality graphic also uses radial spokes to show the density of each type of protein in the food item (Figure 2.1e). These proteins include tryptophan, threonine, isoleucine, leucine, lysine, methionine, cystine, phenylalaline, tyrosine, valine, and histidine. Methionine and cystine share a spoke on the radial diagram, as do phenylalaline and tyrosine. The maximum value for each spoke is based on the "amino acid profile recommended by the Institute of Medicine's Food and Nutrition Board" (nutritionself.data.com, 2016). The amino acid score for the food item is also presented at the bottom of the graphic, but has not been adjusted for the digestibility of the item since the digestibility not only depends on the food itself, but also on the method of preparation.

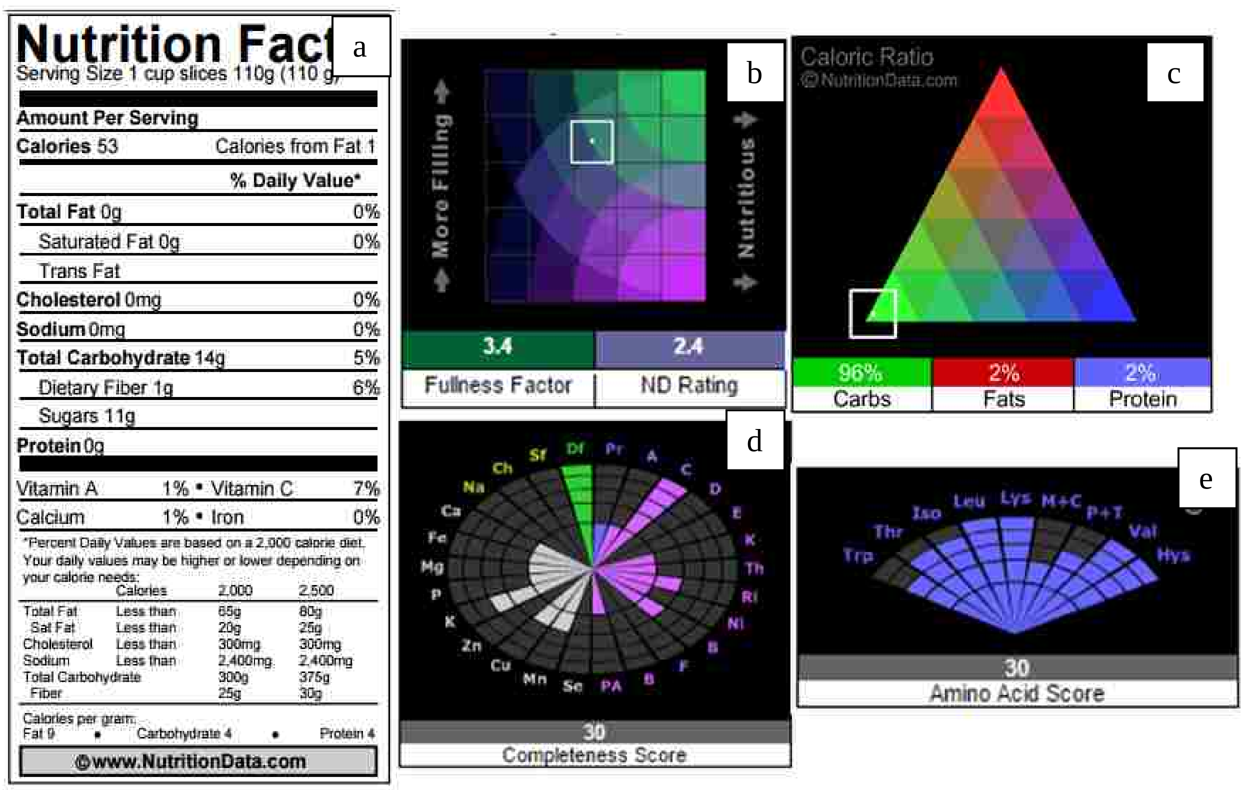

Figure 2.1 Examples of Nutritional Graphics. Nutrition Facts panel (a), Nutritional Target Map (b), Caloric Ratio Pyramid (c), Nutrient Balance Indicator (d), and Protein Quality (e) for a serving of raw apple slices. All graphics copyrighted by www.nutritiondata.com.

The variety of nutritional graphics discussed above provides an intricate view of the nutritional profile of foods on the market. These aids, and others, can be used to assess the nutritional adequacy and quality of the foods in question. However, these aids do not account for unexpected ingredients or unsafe food practices. As the body of knowledge on these topics increases, these variables are increasingly monitored in literature. These efforts include surveys on the presence of plastics, inorganic compounds, and heavy metals in foods, as well as an emphasis on safe food practices (Fankhauser-Noti et al, 2006; Radwan and Salama, 2006; Shogren et al, 1999; Schoof et al, 1999). Altogether, the current body of research thoroughly emphasizes ease of use of the nutritional profile of the available foods and their safety.

2.2: BENEFITS OF HIGH FIBER AND LOW GLYCEMIC LOAD FOODS

2.2.1 Dietary Fiber

The demographic most vulnerable to diseases (other than young children) are individuals ages 65 and older. Adults in this category commonly deal with osteoporosis, arthritis, heart disease, cancer, respiratory diseases, diabetes, and many other health issues (Vann, 2015). A diet high in fiber, low in glycemic load, and high in quality protein can help improve several of these health issues and increase the quality of life. The benefits of these components in a diet are described in this chapter. A review of the standard methods used to develop foods with these properties is given, along with a discussion of a sample of products described in literature.

Dietary fiber is found in varying levels in different types of legumes. In general, most legumes are a good source of total dietary fiber. Total fiber is the combination of soluble and insoluble fibers. The soluble fiber is found in foods including fruit, nuts, oats, and legumes. Insoluble fiber comes from the part of the plant that does not dissolve in water, including cell walls. Legumes as a whole contained a greater proportion of water insoluble to soluble fiber (Khan, 2007). These two types of dietary fiber assume different roles during digestion. Soluble fiber tends to slow digestion by turning into a gel as it absorbs water. Insoluble fiber tends to aid the digestion process. From these two main categories of fiber, researchers have shown that the soluble portion of fiber "can reduce the risk of coronary artery and stroke." The insoluble portion of the fiber is used "to treat digestive problems such as constipation, hemorrhoids, chronic diarrhea, and fecal incontinence" (Wald et al, 2013). The presence of soluble fiber in appreciable amounts also tends to stabilize blood sugar levels in the consumer.

In edible beans, the dietary fiber is made up of 70 percent insoluble dietary fiber (IDF) and 30 percent soluble dietary fiber (SDF). One can conclude that since beans and legumes are higher in insoluble dietary fiber than wheat flours and other simple carbohydrates, there is a better chance for individuals to not experience digestive problems. The use of beans in the human diet is important and becomes more diverse when edible beans are milled into flours. One study was completed on bean pasta with the use of milled green pea, yellow pea, chickpea and lentil milled flours. These pasta products were fortified up to 30% using the milled flours to produce spaghetti pasta (Zhao, 2005).

Of different types of beans grown today, navy beans are described as, small, pea-sized beans that are creamy white in color. They are mild-flavored beans that are dense and smooth. Like other common beans, navy beans are one of 13,000 species of the family of legumes, or plants that produce edible pods. Combined with whole grains such as rice, navy beans provide virtually fat-free high quality protein (Mateljan, 2008).

2.2.2 Glycemic Load and Other Nutrients

The presence of a balance of dietary fiber is important in a healthy diet, but is not enough alone. A healthy diet also includes foods with a low glycemic load. The glycemic load of foods can be calculated using the glycemic index. It is “the glycemic index divided by 100 and multiplied by its available carbohydrate content (i.e. carbohydrates minus fiber) in grams” (Mendosa, 2008). Glycemic index is defined as the bodies blood sugar response to the food consumed. If this information is not available, the glycemic load of a food can be approximated by finding the amount of digestible carbohydrates, which is the difference of the total carbohydrates and the dietary fiber expressed in grams (Liese, 2005).

The digestible carbohydrates calculated using this method may also include resistant starch, which would decrease the amount of digestible carbohydrates in the food. Resistant starch is “the fraction of dietary starch which escapes digestion in the small intestine” (Sajilata et al, 2006). Although normally categorized as dietary fiber, it is possible that remnants of resistant starch are included as digestible carbohydrates due to the difficulty of the approved classification tests (Nielson, 2010). Legumes typically include type I resistant starch, but the resistance is minimized when the legumes are milled. Since the amylose in the flour becomes retrograded in the pasta production process, fortified flours also contain type 3 resistant starch. Resistant starches have been shown to decrease risk of colonic cancer, improve metabolic control in type II diabetes, reduce the incidence of gallstones, improve cardiovascular health, and could also improve absorption of calcium and iron in the intestines (Morita et al, 1999; Raben et al, 1994; Reader et al, 1997; Malhotra, 1968; Martinez et al, 2004; Morias et al, 1996).

As emphasized in the previous chapter, both glycemic load and glycemic index are important when selecting the diet of individuals. A study conducted at Oregon State University suggests that the management of glycemic load and the consumption of foods with lower carbohydrate levels can lead to disease prevention. High glycemic load diets have been associated with an increase in type 2 diabetes mellitus and are also likely contributors of cardiovascular disease, gallbladder disease, and some types of cancer. In contrast, a diet low in glycemic load has contributed to a greater weight loss in obese individuals (see Higdon, 2005, and references therein). In addition to a high level of insoluble dietary fiber and a low glycemic load, it is also recommended that a healthy diet for adults include 0.8 grams of protein per kilogram of human body weight per day.

As adults age, the protein requirement increases to almost 1.3 grams (Kammer, accessed 3/12/2016). Proteins are made up of various types of amino acids. Amino acids are classified as either essential (required from food) or non-essential amino acids (those synthesized in the body). The quality of the protein in the food is based on the composition of amino acids in the food and the digestibility of the protein. The Protein Digestibility – Corrected Amino Acid Score (PDCAAS) method is the standard used to estimate the protein quality (Nielson, 2010). A study on protein quality substituted navy bean flour for sesame seeds to investigate the effect on the amino acid profile and the amount of protein (Boloorforooshan and Markakis, 1979). This information, combined with the true digestibility of the food, can be used to calculate PDCAAS.

A diet high in fiber, low in glycemic load, and high quality protein has numerous benefits, especially to the older demographic. High levels of dietary fiber, especially insoluble dietary fiber, aid digestion and tend to stabilize blood sugar levels. The consumption of foods low in glycemic load has been associated with weight loss and disease prevention. It is also recommended that the calorie intake for all adults be composed of 10% to 35% protein, or 0.8 grams of protein per kilogram of human body weight per day (Health.gov, 2010; Godman, 2014). Due to these benefits, foods high in dietary fiber, low in glycemic load, and high in protein are considered healthy food choices. Therefore, the goal of this research was to increase the nutritional value of prepared meals that the older generation finds appealing. One way to lower the overall glycemic load of a diet is to increase the consumption of legumes in place of other carbohydrates (see Higdon, 2005, and references therein). This method also increases the fiber and protein levels in the diet.

2.2.3 Nutritional Properties of Beans and Legumes

Dry beans, which are members of the legume family, have been shown to be a good source of protein with high levels of fiber. The increased consumption of beans in the diet has also been shown to decrease the risk of cardio vascular disease (CVD), diabetes, heart disease, and stroke (Siddiq, 2013). In knowing that the increased amounts of beans can help decrease the risk of CVD, the quantity of intake is also important. A study conducted with 10,000 adults showed that when eating beans 4 or more times a week they had a lower risk of developing diseases than people who did ate less often (Bazzano, 2001)

The legume family, as a whole, has been shown to contain a larger amount of insoluble fiber than soluble fiber, making legumes an easily digestible food (Khan, 2007). A recent study showed that 69 to 70% of the fiber in the edible part of beans was insoluble dietary fiber with the remaining 30 to 31% as soluble fiber (Kleintop, 2013). For example, navy beans are described as small, pea-sized beans that are creamy white in color, mild-flavored, dense and smooth. Combined with whole grains such as rice, navy beans provide virtually fat-free high quality protein (Mateljan, 2008). The inclusion of beans in the diet has several benefits, but when legumes are ground into flours, the potential application of the edible bean becomes more diverse. Namely, it becomes possible to use bean flours to fortify the standard flours in pasta products.

2.3: PASTA DEVELOPMENT

2.3.1 Improving the Nutritional Value of Pasta

In this day and age, pasta has been looked at as unhealthy and a food rich in carbohydrates. According to researchers, not all carbohydrates that are used in the formulation of pasta dough are unhealthy. One common trend in product development is to replace the rapidly digested carbohydrates in pasta, such as those from sugars, with healthier carbohydrate sources, such as protein and fiber, to obtain a higher nutritional value in pasta (Shogren, 2006). In some cases, this substitution also has other beneficial effects, such as lowering cholesterol and sodium. These improvements can help offset pasta's 'bad reputation' as a high carbohydrate food (Ipatenco, 2015). Whole grains, oat, and barley meal pasta varieties are only a few of the substitution choices that are already available on the market (Haris, 2015). Research concerning the formulation of pasta shows the substitution of traditional wheat flour with an alternative flour to have a beneficial change on the nutritional values of the final product.

2.3.2 Legume-Based Pasta Development

The effects of substitution of bean flour in place of other flours have been tested in several instances. The cases discussed here involve the fortification of pasta products. In one such project, a group of researchers from the University of Saskatchewan fortified wheat flour with white pea flour to create dried spaghetti noodles. After rehydration, an increase of 22% in protein levels in the pasta was observed when compared to 100% wheat flour pastas (Nielson et al, 1980). This study shows that when fortifying pasta with other flours, like beans and legumes, the final product will have higher levels of protein due to the larger protein content of beans and legumes. The protein quality of legumes can be further improved by combining legume flours with complimentary ingredients, such as sesame and wheat flour, although these effects depend on the processing the ingredients are subjected to (Boloorforooshan and Markakis, 2006; Gimenez et al, 2013; Azlan et al, 2011; Kavitha and Parimalavalli, 2014).

Another product experiment performed at North Dakota State University examined the fortification of spaghetti using different legume flours. Four different legume flours were substituted into 100% semolina flour at various substitution levels. The varieties of legume flour used were green pea, yellow pea, lentil and chickpea flours at substitution levels of 5%, 10%, 15%, 20%, and 30% of each type of legume flour. In this study, commercial post processing equipment was used for the extrusion of the pasta dough to form the dried spaghetti. The pasta was then cooked and tested for chemical composition, texture, and color. An increase in the level of legume substitution was found to cause an increase in firmness, pulse flavor, and color intensity of the pasta. However, the elasticity and overall quality of the product decreased at higher substitution levels. Results from a consumer sensory study showed that consumers preferred the spaghetti with 100% semolina flour, but also found the 15% lentil, 20% chickpea, and 20% yellow pea flour blends to be acceptable (Zhao et al, 2005). Other sensory studies also showed low substitution levels of legume flours to be acceptable (Gimenez et al, 2012; Sabanis et al, 2006).

The fortification of durum flour with chickpea flour was studied at the University of Thessaloniki in Greece. Various effects of this fortification of lasagna made with durum flour were studied at substitution levels of 5%, 10%, 20%, 30% and 50% chickpea flour. Each version of the cooked pasta was analyzed for nutritional content using a proximate chemical analysis. A sensory evaluation of these pastas was also performed to judge consumer opinion of taste, texture, and general appeal. Although the mixture of chickpea flour with durum flour results in a stronger pasta dough, the consumer opinion decreases with higher substitution levels. The expected increase in total protein with substitution level was observed, but the texture, handling, cooking characteristics, processing behavior, and color deteriorated with high levels of substitution, making those pasta blends undesirable (Sabanis et al, 2006). Similar effects on the quality of the pasta were also observed in other studies (Neilson, 1980; Arab et al, 2010; Gimenez et al, 2012). The amount of the effect observed depended on the type of legume flour used, generally deteriorating various properties of the pasta with higher substitution levels.

A similar study looked at the effects of the addition of bean flour on the digestibility of spaghetti. Common bean flour was substituted at various levels in semolina spaghetti to measure the protein level, cooking time, cooking loss and nutritional profile. Total starches, available starches, indigestible fractions, and many other factors of digestibility were measured via an in vitro starch hydrolysis kinetic study. Spaghetti made with higher substitution levels of common bean flour was observed to decrease the digestibility of the food, thus decreasing the glycemic load (Gallegos-Infante et al, 2010). The substitution of chickpea flour was also observed to have a similar effect on the glycemic load (Goni and Valentín-Gamazo, 2003).

In general, these studies show a decrease in pasta quality, starch availability, and consumer acceptance as legume flour substitution levels were increased. The protein content, protein quality, and fiber content increased with higher percentages of bean flours, lending additional nutritional value to the final product. It is proposed that increasing levels of bean flour should also increase fiber content and decrease glycemic load in the pasta product. These changes should result in a product that can contribute to a healthy diet, especially for consumers ages 65 and older. The goal of this research is to develop a fortified ravioli product that is appealing to this older demographic, yet has an improved nutritional profile. The process chosen to produce and analyze these bean-based ravioli is modeled on the papers discussed above and on Bentley (2013).

CHAPTER 3: MATERIALS AND METHODS

3.1: RESEARCH PHASES

The main goal of this research is to produce a healthy alternative pasta product using bean flour. The product is to be attractive to consumer 65 years and older. In general, the recommended diet for consumers in this age group consists of foods with high fiber, to decrease digestion problems, low glycemic loads, to decrease variability of glucose levels, and high protein, to achieve the recommended daily intake (Karter et al, 2001; Health.gov, 2010; Godman, 2014). Foods with these properties are thus considered to be healthy food choices.

The various steps of this research were conducted in the greater Baton Rouge area, but the results can apply to the older generation in any locale. This research was completed in three phases. Phase I consisted of a market survey to collect data about consumers' food choices in the Greater Baton Rouge area. In Phase II, a variety of flours and pasta doughs were tested for compatibility and visual appeal. The third phase entailed production of the final product and a consumer sensory test of that product. A blind consumer survey of the older generation was also conducted in the third phase to compare how the acceptance ratings of the commercially available products compared to the results of the sensory test of the fortified pasta product developed during this research. Analysis of this data will be discussed in Chapter 4.

3.2: PHASE 1 – SURVEYS

3.2.1 Two Market Surveys

In order to conduct of survey of the target population, several steps were required. First, a market survey was conducted to understand the availability of healthy alternative products on the market in the Greater Baton Rouge area. A more focused market survey was then conducted to gather data on the availability of frozen pasta products. The classification of these items into various fiber and glycemic load categories is discussed in the next chapter. The categories themselves are introduced here.

3.2.2 Market Survey

A survey of approximately 400 products in nine stores was conducted to analyze the choices consumers have at a variety of grocery stores in the Greater Baton Rouge area. The store survey method described here is modeled on the market survey done in Bentley (2013). The nine grocery stores chosen were selected based on local popularity, location, and price point. The stores were required to be in the Greater Baton Rouge area, must have more than one location in that area, and be part of a local or national chain of grocery stores. Three stores with a high price point, three stores with a mid-range price point and three stores with a low price point were chosen. These requirements assured the diversity of the products in the survey.

After permission and confidentiality were granted by the stores, the survey was conducted in each of the nine stores. The items chosen were either frozen meals, snack items, or shelf-stable meals. On average, fifty products from each store were surveyed for a total of 398 products. For each product surveyed, the data collected consists of a picture of the front of the product and a picture of the nutrition facts label of that product. The pictures were taken using a Samsung Rugby Pro smart phone with a 1.3 megapixel camera. Each picture was automatically assigned an identification number by the smart phone. The items surveyed included frozen meal products, boxed ambient/dry meals, and snack items.

After the survey was conducted, a variety of information from each image was entered into a spreadsheet for analysis. Specifically, the product's two identification numbers, the product name, and the store where the product was found. A selection of information from each product's nutrition facts label was also included in the spreadsheet: total calories, total cholesterol, total sodium, total fat, total carbohydrates, total sugars, total fiber content, and total protein per serving. As done by Liese et al, 2005, the total digestible carbohydrates per serving were calculated by subtracting the total fiber levels from the total carbohydrates. This data is included in Appendix B. For confidentiality reasons, the names of the stores have been replaced with numbers.

The products were classified into several groups based on the fiber level and the amount of digestible carbohydrate per serving. As per U. S. Food and Drug Administration (FDA) definitions, low fiber was defined to have a value of less than or equal to 6 percent of the prescribed daily value (%DV), medium fiber between 6 and 20 %, and high fiber greater than or equal to 20 %DV (21CFR101.54). Digestible carbohydrate, which is a representation of glycemic load (GL), was then classified into three levels: low glycemic load (LGL) with values of less than or equal to 10 grams, medium glycemic load (MGL) between 10 and 20, and high glycemic load (HGL) with values of greater than or equal to 20 g/serving (Mendosa, 2008). The products were then subjected to a frequency test to determine the number of products in each category and in each of the combination categories shown in Table 3.1 below. Further results from this study are discussed in Chapter 4.

3.2.3 Market Survey of Pasta Items

Based on the industry experience of the author in Italian cuisine, the variety of products in the market survey was narrowed by choosing to focus on a pasta product. Based on this decision, a second survey was performed on all market survey items that could be classified as frozen and contained pasta. In a data set of 398 items, 60 items satisfied these criteria. These products were then analyzed in an identical fashion into the nine categories described in Table 3.1. None of these products were found to have high fiber and low glycemic loads (HF/LGL). The lack of products in the desired category further justifies the development of a frozen pasta product with high fiber content and low glycemic load.

Table 3.1 Fiber and Glycemic Load Categories

	Low Fiber (LF) ($x \leq 6\%$)	**Medium Fiber** (MF) ($6\% < x < 20\%$)	**High Fiber** (HF) ($x \geq 20\%$)
Low Glycemic Load (LGL) ($y \leq 10$ g)	LF/LGL	MF/LGL	HF/LGL
Medium Glycemic Load (MGL) (10 g $< y < 20$ g)	LF/MGL	MF/MGL	HF/MGL
High Glycemic Load (HGL) ($y \geq 20$ g)	LF/HGL	MF/HGL	HF/HGL

Fiber and Glycemic Load categories used to analyze the products in the market survey. Fiber value (x) is measured in percent daily value of the total recommended intake. Glycemic load (y) is measured in grams.

3.3: PHASE II – TESTING AND FORMULATION

3.3.1 Testing and Formulation Variables

The goal of the research was to produce a frozen pasta product with high fiber content and a low glycemic load. The proposed method was to substitute a portion of the wheat flour with bean flour to increase fiber content and decreased glycemic load. However, this substitution changed several basic properties of the pasta dough, including viscosity, appearance, and dough behavior. In order to test how these variables change as the substitution levels increase, various mixtures of pasta dough were tested using Rapid Moisture Analysis, Rapid Visco Analysis, and visual methods. The method used was based on the analysis method used by Bentley (2013) and proposed by Batey (2000).

3.3.2 Rapid Moisture Analysis

A Rapid Moisture Analysis (RMA) was done on each variation of pasta dough to calculate the moisture content of the dough. Three different types of bean flours were tested at six substitution levels, namely navy bean, black bean, and pinto bean flours. The six substitution levels chosen were 20%, 25%, 30%, 50%, 75%, and 100% bean flour by weight. The bean flours used in this research were provided by Best Cooking Pulses, Inc. (Manitoba, Canada). The control flour used in each substitution mixture was a 50/50 blend of "00" and semolina flour. Type "00" flour is a high-gluten flour made from red spring wheat. In addition to these combinations, the control mixture was also analyzed for a total of 19 flour combinations (Table 3.2).

The RMA process described below was used to determine the moisture content of each flour sample. This process was performed by placing the 3.5 grams of the chosen sample of flour mixture in a 15 mL centrifuge test tube. The flour sample was then poured onto the foil tray which was then placed in the Ohaus MB45 Rapid Moisture Analyzer (Ohaus Corporation, Parsippany, NJ). The Analyzer temperature and duration were then set to 110 °C for a maximum duration of 13 minutes. The moisture content of each sample was then documented and the sample discarded (Table 3.2). These values were used to determine the amount of deionized water and flour mixture needed to make a sample of each flour mixture with a moisture content of 14% (see RVA Durum Method 11.06 in Perten Instruments, 2007, and below). Each of these samples was then analyzed with the Rapid Visco Analysis (RVA) to understand the visco-elastic properties of each type of flour mixture as described in the next section.

Table 3.2 Weight Percentage Substitution Levels of Pinto, Navy, and Black Bean Flours, With Percent Moisture Content for Each Flour Mixture

% Bean Flour	% Control Blend	Bean Flour	% Moisture Content
0	100	N/A	10.90
20	80	Pinto	12.33
25	75	Pinto	13.10
30	70	Pinto	12.43
50	50	Pinto	12.45
75	25	Pinto	13.51
100	0	Pinto	13.55
20	80	Navy	10.95
25	75	Navy	10.51
30	70	Navy	11.34
50	50	Navy	10.24
75	25	Navy	9.90
100	0	Navy	9.23
20	80	Black	11.08
25	75	Black	10.58
30	70	Black	11.63
50	50	Black	10.45
75	25	Black	10.28
100	0	Black	9.92

3.3.3 Rapid Visco Analysis

A Rapid Visco Analysis (RVA) was performed on each flour blend in duplicate (Table 3.2 and RVA Durum Method 11.06 in Perten Instruments, 2007). The RVA tests for the 100% bean flours were not performed in duplicates since the tests on these flours were only performed to acquire reference values, not for use in the pasta doughs. Water was added as needed to each flour blend to yield a final moisture of 14% using the results in Table 3.2. The amount of water needed to obtain the required moisture content was calculated by the RVA software accompanying the machine (described below) using the equation shown in Figure 3.1, where M_1 is the standard flour mass of 3.5 g, M_2 is the corrected mass of the flour sample, W_1 is the percentage moisture content of the flour sample, and W_2 is the amount of added water required to obtain a 14% moisture content. The appropriate amounts of flour mixture (M_2) and deionized water (W_2) for each sample were combined using the RVA sample paddle in the RVA aluminum cup until thoroughly mixed. Once the sample was completely mixed, the RVA aluminum cup and sample paddle were attached to the tower of the RVA machine.

$$W_2 = 25.0 + (M_1 - M_2), \ \ where \ \ M_2 = \frac{(100-14)M_1}{100-W_1}$$

Figure 3.1 Correction Formula for 14% Moisture Content. M_1 is the standard flour mass of 3.5 g, M_2 is the corrected mass of the flour sample, W_1 is the percentage moisture content of the flour sample, and W_2 is the amount of added water required to obtain a 14% moisture content.

The RVA was then completed using a Newport scientific RVA-4 (Newport Scientific Pty. Ltd., Warriewood NSW, Australia) instrument and a Neslab RTE 7 water bath (Thermo Fisher Scientific, Newington, NH). The RVA software accompanying the machine was then set to run each sample for a 13 minute cycle adjusting temperature and speed at the different times as defined in the RVA Durum Method 11.06 (Perten Instruments, 2007). At the start of each run, the temperature was set to 50 °C with a rotation rate of 960 rpm. At ten seconds (0:10), the machine was set to decrease the speed to 160 rpm while maintaining the temperature. At run time 4:42, the machine temperature was increased to 95 °C while maintaining the rotation rate. At eleven minutes (11:00), the temperature was decreased to 50 °C until the completion of the run. The RVA software reported various properties of each flour mixture, including the viscosity of each sample.

Figure 3.2 shows the amylograph of the control flour mixture (50/50 blend enriched semolina and "00" flours) as an example of the typical behavior of the viscosity of a flour mixture throughout the 13-minute testing process. The trapezoidal line in the plot refers to the temperature inside the Rapid Visco Analyzer during the testing process. The flat line towards the bottom of the plot gives the rotation rate of the paddle in revolutions per minute. The curve represents the viscosity of the flour mixture sample in the standard centiPoise units. The shape of this curve is typical of the curves of all the flour mixtures tested. The viscosity of the flour mixture is typically marginally high while the rotation rate is high at the beginning of the test, then falls once the rotation rate decreases to the standard value. As the temperature inside the Analyzer increases, the viscosity of the flour mixture begins to increase. The temperature at which this occurs, called the pasting temperature, is associated with the minimum energy required to cook the flour mixture. The viscosity of the flour mixture continues to gradually increase until a peak viscosity is reached. This peak viscosity indicates that the starch molecules have swelled to their maximum capacity and have begun to paste.

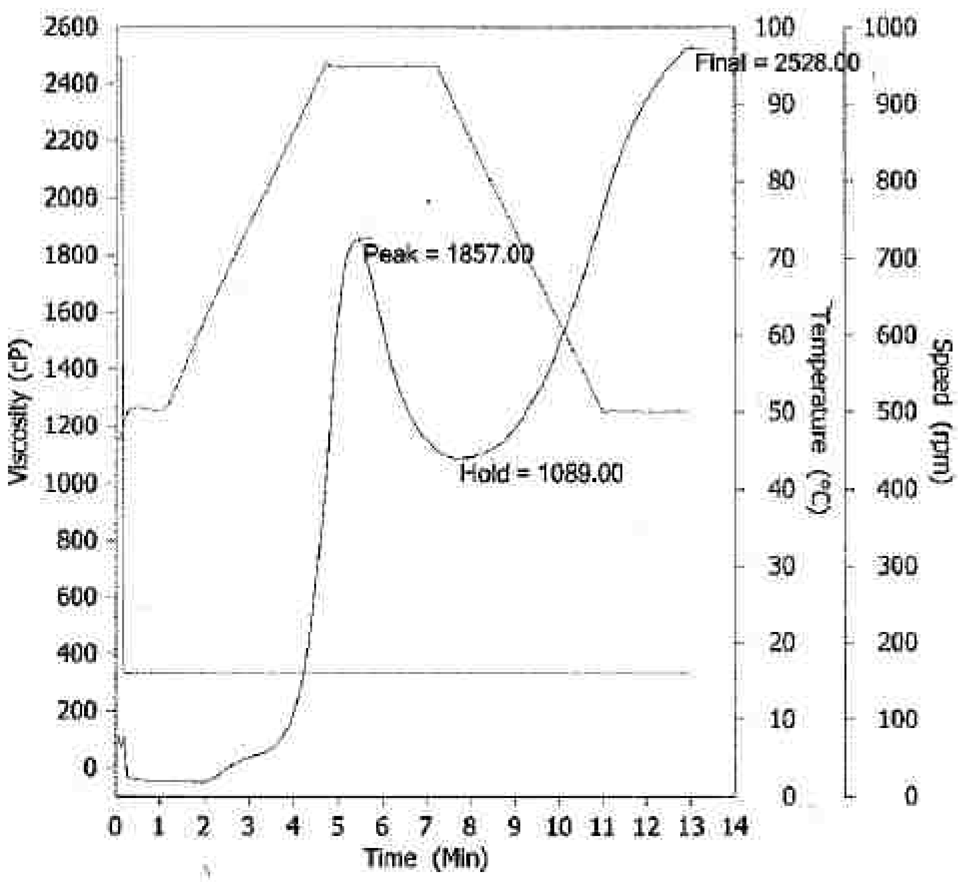

Figure 3.2 Amylograph of the Control Flour Mixture

The viscosity then decreases by varying amounts for each flour mixture to a new minimum viscosity. The difference between the peak viscosity and this new minimum value, the breakdown value, is an indicator of the stability of the starch paste during the cooking process. The viscosity again increases for the remainder of the test, reaching a final maximum value. As explained in Jacobs et al. (1995), this final viscosity can be used to measure the total setback or retrogradation tendency of the proteins in the starch. The greater the difference between the final and minimum viscosity, the more likely it is that the starch will form a gel as it cools. The results of the RVA tests are reported and discussed in Chapter 4.

3.3.4 Ravioli Formulation

In addition to the final viscosity of the flour, the flour blends used in the final ravioli product were selected based on the visual appearance and the behavior of the doughs. Six types of flours were used to test dough properties, including a 50/50 blend of “00” and semolina flour mixture as a control, three navy bean flour mixtures, and one each of pinto bean and black bean flour blends as shown in Table 3.3. These mixtures were chosen to determine how the dough color and behavior changed with bean flour type and with increasing navy bean flour substitution compared to the control dough. The first number next to each bean flour type in the table indicates the percentage by weight of the navy bean flour in the flour blend. The second number indicates the percent by weight of the 50/50 “00” and semolina flour mixture (the control flour). The weights of each type of flour are also indicated in Table 3.3. In some dough formulations, it was necessary to add water to the pasta dough to balance the lack of moisture in those flour mixtures as shown in the last column.

Table 3.3 Weights of Flour Types in Dough Formulations

Pasta Dough Type	**Bean Flour (g)**	**50/50 Control Blend (g)**	**Added Water* (g)**
Control (50/50 "00" and Semolina Blend)	0.0	120.9	0.0
Navy Bean (25/75)	30.23	90.60	2.0
Navy Bean (50/50)	60.45	60.45	2.0
Navy Bean (75/25)	90.68	30.23	5.2
Pinto Bean (30/70)	36.30	84.60	0.0
Black Bean (30/70)	36.30	84.60	0.0

*In some dough types, it was necessary to add water for proper dough behavior. The amounts of water are shown in grams in the last column.

The dough prepared from the flour mixtures were then used to prepare cheese-stuffed ravioli. The recipe used for the pasta dough formulation was based on a recipe acquired from Food.com and is described in detail below. The ingredient amounts in this formula are indicated in Table 3.4.

The standardized dough formulation process is as follows. The first step in the formulation of the pasta dough was to sift the prescribed amount of flour mixture and salt together into a medium sized bowl. Two eggs were whipped together in a separate bowl using a fork for approximately 30 seconds or until the egg yolk and egg white were combined. The required amount of whipped eggs was then weighed and extra material removed from the bowl. The extra virgin olive oil was then added to the egg mixture. The flour mixture was then transferred to a 5 quart Globe kitchen mixer with a dough hook attachment. The mixer was set to a medium speed and the egg and olive oil mixture was slowly added to the flour mixture. The mixer was allowed to run at medium speed until the dough formed into a ball (approximately two minutes).

Table 3.4 Weights of Each Ingredient in the Control Pasta Dough Recipe.

Ingredients	**Weights (g)**	**Weights (%)**
Flour Mixture	120.9	60.24
Table Salt	0.70	0.35
Eggs	72.7	36.22
Olive Oil	6.40	3.19

When the dough mixture came together, the dough was removed from the mixer and placed on a floured surface. The dough was kneaded by hand for two minutes or until the dough slowly retracted when pressed with a finger. The dough was then wrapped up in plastic wrap and placed in the refrigerator until the dough completely chilled (about twenty-five to thirty minutes). The filling for the ravioli was prepared. In a 10 inch stainless steel mixing bowl, 425 grams of whole milk ricotta cheese from Albertson's was thoroughly mixed with 170 grams of finely shredded parmesan cheese from Albertson's. The cheese mixture was covered with Glad plastic wrap and placed in the cooler. The chilled dough ball was placed onto a floured surface and cut into two equal portions. Pictures were taken for each dough formulation to document dough color, internal structure, and apparent texture. The cheese filling was also removed from the cooler and allowed to come to room temperature at this time. Based on the appearance of the black bean pasta dough, this dough variation was not prepared into ravioli. Only the control dough, the pinto bean dough, and the three variations of navy bean pasta dough were prepared beyond this point (Figure 3.3).

For each type of pasta dough, the two portions of the pasta dough were each kneaded and flattened out, then run through a Kitchen Aid pasta roller attachment on the mixer. The mixer was turned to speed setting 4 (medium speed) and the roller attachment was set to setting 0 (the thickest setting). One section of pasta dough was then flattened and sent through the roller attachment. The dough was run through the attachment twice, folded into three layers, and then rolled through again at the same setting for a total of three runs at the same setting. The roller was then turned to setting 2 and the process repeated for each incremental setting up to setting five on the roller attachment.

Figure 3.3 Pasta Dough Variations. Colors and internal textures of the six pasta dough variations prepared. From the left: Control dough (50/50 "00" and semolina blend), 25/75 Navy Bean dough, 50/50 Navy Bean dough, 75/25 Navy Bean dough, 30/70 Pinto Bean dough, and 30/70 Black Bean dough. As in the text, the first number refers to the percentage by weight of the bean flour while the second number refers to the percentage by weight of the control flour used.

After rolling both portions of pasta dough through the roller on setting five, each dough portion was then cut into two equal sections. A one ounce portion of cheese mixture was placed onto the two section of the dough with 1.5 inch spacing. The remaining exposed pasta on these sections was brushed with water. The other sections of dough that contained no cheese were then placed on the sections of dough containing cheese. Each pair of dough sheets were then crimped together by pressing firmly on the top layer of pasta dough between the portions of cheese. The ten ravioli produced were then cut from the pasta sheets and placed on an 18" x 26" restaurant sheet pan that had been lined with one 18" x 26" sheet of parchment paper.

The ravioli were then parboiled with the following process. Six quarts of water were brought to a rolling boil in an eight-quart pot. Five quarts of ice water were also prepared in a large bowl and set aside. Ten ravioli were dropped into the boiling water and boiled for one minute. The ravioli were then removed from the boiling water with a strainer and placed in the ice water for approximately 1.5 minutes. The parboiled ravioli were then removed from the ice water and placed back on the sheet pan. The sheet pan of parboiled ravioli was then placed in a freezer at -5 °F for fifteen minutes. The sheet pan was removed from the freezer and five ravioli were placed into each of two freezer safe microwaveable plastic bowls (donated from the LSU AgCenter Food Incubator stock). The bowls were placed back into the freezer overnight and then removed for testing. The ravioli were then microwaved in the loosely covered bowls on high for 2.5 minutes each and submitted for sensory evaluation. Based on the preliminary appearance and taste as judged by the author, Dr. Joan King and Dr. Witoon Prinyawiwatkul of the LSU School of Nutrition and Food Science, the 50/50 navy bean, 75/25 navy bean, and the control ravioli doughs were chosen for a consumer sensory test.

3.4: PHASE III – LARGE-SCALE DEVELOPMENT, SENSORY TEST, AND A BLIND CONSUMER SURVEY

3.4.1 Large-Scale Development

Phase III of the research involved large-scale production of the chosen ravioli doughs to prepare for a large sensory test. A consumer sensory test of approximately 100 participants was done to gather data concerning consumer preferences. The three ravioli types chosen for the sensory test were the control ravioli, the 50/50 navy bean ravioli, and the 75/25 navy bean ravioli (bean/wheat). In order to prepare for this sensory test, 100 ravioli of each type had to be prepared. The original recipe weights were multiplied by 15 to compensate for possible cooking mistakes. The cheese stuffing for the ravioli was prepared by thoroughly mixing 90 ounces of finely shredded parmesan cheese with 225 ounces of ricotta with a Hobart 20-quart mixer. The scaled-up ingredient amounts for each type of ravioli are listed in Table 3.5. The process followed to make the ravioli was identical to the process described in Section 3.3.4, except it was necessary to add additional water to the 75/25 navy bean pasta dough to achieve the proper moisture level in the pasta dough.

Table 3.5 Weights of the Ingredients in the Scaled-Up Versions of the Pasta Doughs

Ingredients	**Control Ravioli**		**50/50 Navy Bean Ravioli**		**75/25 Navy Bean Ravioli**	
	g	**%**	**g**	**%**	**g**	**%**
50/50 Flour Blend	1813.5	60.24	906.75	29.82	453.37	14.68
Navy Bean Flour	0.0	0.0	906.75	29.82	1360.13	44.04
Whole Eggs	1090.5	36.22	1090.5	35.87	1090.5	35.31
Olive Oil	96.0	3.19	96.0	3.16	96.0	3.11
Table Salt	10.5	0.349	10.5	0.345	10.5	0.340
Water	0.0	0.0	30.0	0.987	78.0	2.53

3.4.2 Sensory Test

Once the large-scale ravioli production was completed, the sensory test was then executed at the Sensory Lab of the School of Nutrition and Food Science at LSU. To preserve the anonymity of the ravioli types, the ravioli types were assigned identification numbers. The control ravioli was assigned "341" as the identification number, the 50/50 navy bean ravioli was assigned "842", and the 75/25 navy bean ravioli was assigned "643" as the identification number. Electronic consent forms and sensory evaluation forms were used to obtain responses from the general population (Appendix C, and Figure 3.4 below). These forms were created and

Sample # ____________ **Gender:** [ ] Male [ ] Female

Please evaluate the following attributes of this product.

Please evaluate the sample by tasting it. After tasting the sample, set aside and save a portion to taste with the serving of tomato sauce.

1. How would you rate the **overall appearance** of this product?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
1	2	3	4	5	6	7	8	9

2. How would you rate the **odor/aroma** of this product?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
1	2	3	4	5	6	7	8	9

3. How would you rate the **taste** of this product?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
1	2	3	4	5	6	7	8	9

4. How would you rate the **texture** of this product?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
1	2	3	4	5	6	7	8	9

5. Do you detect a **bean flavor** of this product?

YES [ ] NO [ ]

6. How would you rate the **overall liking** of this product?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
1	2	3	4	5	6	7	8	9

7. Is this product **ACCEPTABLE**? YES [ ] NO [ ]

8. Would you **BUY** this product if it were commercially available? YES [ ] NO [ ]

Figure 3.4 Sensory Evaluation Form. The form was electronically distributed in triplicates to each participant in the sensory test.

Now please evaluate the following attributes of this product with the sauce that is provided.

1. How would you rate the **overall appearance** of this product?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
1	2	3	4	5	6	7	8	9

2. How would you rate the **odor/aroma** of this product?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
1	2	3	4	5	6	7	8	9

3. How would you rate the **taste** of this product?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
1	2	3	4	5	6	7	8	9

4. How would you rate the **texture** of this product?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
1	2	3	4	5	6	7	8	9

5. Do you detect a **bean flavor** of this product?

YES [ ]   NO [ ]

6. How would you rate the **overall liking** of this product?

Dislike Extremely	Dislike Very much	Dislike Moderately	Dislike Slightly	Neither Like nor Dislike	Like Slightly	Like Moderately	Like Very much	Like Extremely
[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
1	2	3	4	5	6	7	8	9

7. Is this product **ACCEPTABLE**?   YES [ ]   NO [ ]

8. Would you **BUY** this product if it were commercially available?   YES [ ]   NO [ ]

(Figure 3.4 Continued)

accessed using Compusense software provided by the School of Nutrition and Food Sciences at LSU.

To prepare the ravioli for the sensory test, the ravioli were removed from the freezer and heated as described in Section 3.3.4 for 2 minutes. Once the ravioli were heated, a single ravioli of each type was then served in a 400 PC translucent 4 ounce plastic portion cup with each sample cup labeled with the proper identification number. The three samples were place on a white five compartment foam school lunch tray. One heated two ounce portion of Ragu's Old World Style Traditional tomato sauce was served in an identical portion cup alongside of the three samples. Other items that were provided for each participant were a 2 ounce plastic cup of water, 2 unsalted tops-premium saltine crackers, one napkin and one plastic fork.

Each participant in the sensory test had to first complete an electronic consent form (see Appendix C). The participant was then given a sampling tray and completed three sensory evaluation forms. The sensory evaluation gathered information regarding the consumer acceptance on the appearance, aroma, taste, texture, and bean flavor. The participant rated these attributes of each ravioli sample using a nine-point hedonics scale (Figure 3.4). This form also included instructions for the participant on how to properly execute the sensory test. Each participant was instructed to complete one sensory evaluation form per ravioli sample for a total of three samples. The sensory test was completed by 103 participants, ranging from college freshman to faculty of both genders. This sensory test was approved by the LSU IRB committee as per state regulation requirements (see Appendix C for supporting documentation).

The responses on the survey form included 5 hedonics scale questions (1 = dislike extremely to 9 = like extremely) concerning appearance, aroma, taste, texture, and overall liking. The remaining three questions were yes/no questions concerning the detectability of bean flavor, acceptability of the product, and purchase intent. The bean flavor question was phrased so that a yes answer indicated that a bean flavor was detectable, resulting in a yes answer that was negative. The remaining two yes/no questions were phrased so that a yes answer indicated a positive review of the product. These questions were repeated for each type of ravioli with and without sauce, resulting in three complete survey forms for each participant. The data collected was analyzed and is discussed in Chapter 4.

The data acquired with the sensory survey were analyzed to compare the distributions of the data sets. An Analysis of Variance (ANOVA) test was performed comparing the three ravioli types for each question type without sauce. An identical test was performed comparing the ravioli types with sauce. Since the ANOVA tests only showed whether one (or more) of the three ravioli types were different for that question type, the Tukey method was used to determine which of the ravioli types were significantly different for each question type. This method was only applied if the ANOVA test reported a difference in the data set. The yes/no questions were each compared by calculating the percent of 'yes' answers compared to the total number of answers for each question. The results of these analyses are reported in the next chapter.

3.4.3 Blind Consumer Survey

A blind consumer survey was conducted on individuals ages 65 and older to record their preferences regarding frozen pasta meals. The majority of the 60 frozen pasta products found in the market survey were categorized as medium fiber and high glycemic load (MF/HGL). As a result, this category was chosen to select products from for a blind consumer survey. A blind consumer survey is a survey in which consumer preference data is collected, but no identifying information about the consumers taking the survey is gathered or disclosed. The MF/HGL category was also chosen because the substitution of bean flour in pasta products increases the fiber level and decreases glycemic load in the final product, resulting in a healthier product.

Out of the 46 MF/HGL pasta products found in the market survey, two products from each of nine stores were chosen for the survey. This restriction was chosen to assure a level distribution of price point among the products. The products were chosen for the survey in a way to maximize the variety of product types in the total sample. For example, if a lasagna product was chosen from one store, a different type of pasta product (such as spaghetti) was chosen from another store. The brand name of the products was also chosen to be as varied as possible within these restrictions.

This survey was done to collect information about consumer preferences concerning the currently available pasta products. For each pasta product chosen, consumers were asked a variety of questions concerning purchase history and product appeal (see Figure 3.5). If the consumer purchased and consumed the product in question, data concerning the taste, texture, aroma, and color were collected. Approximately 75 responses were collected from consumers aged 65 and older. Out of these responses, 38 participants indicated past consumption of the food items chosen. The analysis of these data is discussed in the next chapter. The results were also compared to those of the sensory study to determine if the substitution of bean flour resolved any of the issues recorded in the blind consumer survey. This consumer survey was approved by the Louisiana State University (LSU) Institutional Review Board (IRB) committee as per state regulation requirements (see Appendix C for supporting documentation).

This survey is being done as part of a Master Program research project by Christopher Ringuette, a graduate student at Louisiana State University. This information is for research purposes only. This study will be a blind study, so that no information about the individuals who completed the form can or will be disclosed. If you are age 65 or older, your participation in this study is greatly appreciated. Please circle yes (Y) or no (N) to each question. Again, your participation is greatly appreciated. Please circle or check the categories below.

Gender: Male____ Female_____ **Age**: 65 to 70 _____ 71 to 75_____ 76 to 80_____ 81 to 85_____ 86 or older_____
Ethnicity: Caucasian African American Asian Hispanic Other Decline

Frozen Pasta Products	**Have you purchased this product? If no, state reason (Brand, availability, price, etc) and go to next product:**	**Have you eaten this product?**	**Acceptable Taste?**	**Acceptable Texture?**	**Acceptable Aroma?**	**Acceptable Color?**	**If any other issue? (Please specify.)**
Any frozen pasta products	Y N	Y N	Y N	Y N	Y N	Y N	
Spaghetti w/ Meat Sauce #1	Y N	Y N	Y N	Y N	Y N	Y N	
Vegetable Chicken with Spaghetti	Y N	Y N	Y N	Y N	Y N	Y N	
Blackened Chicken Alfredo	Y N	Y N	Y N	Y N	Y N	Y N	
Grilled Chicken Primavera	Y N	Y N	Y N	Y N	Y N	Y N	
Crawfish Fettuccine	Y N	Y N	Y N	Y N	Y N	Y N	
Lasagna with Meat & Sauce	Y N	Y N	Y N	Y N	Y N	Y N	
Rich and Creamy Penne and Cheese	Y N	Y N	Y N	Y N	Y N	Y N	

Figure 3.5 Blind Consumer Survey Form

Frozen Pasta Products	**Have you purchased this product? If no, state reason and go to next product: (Brand, availability, price, etc)**	**Have you eaten this product?**	**Acceptable Taste?**	**Acceptable Texture?**	**Acceptable Smell?**	**Acceptable Color?**	**If any other issue? (Please specify.)**
Five Cheese Ravioli	Y N	Y N	Y N	Y N	Y N	Y N	
Tricolor Cheese Tortelloni	Y N	Y N	Y N	Y N	Y N	Y N	
Spinach & Ricotta Ravioli	Y N	Y N	Y N	Y N	Y N	Y N	
Four Cheese Cannelloni	Y N	Y N	Y N	Y N	Y N	Y N	
Swedish Meatballs with Pasta	Y N	Y N	Y N	Y N	Y N	Y N	
Garden Vegetable Lasagna	Y N	Y N	Y N	Y N	Y N	Y N	
Spaghetti with Meat Sauce #2	Y N	Y N	Y N	Y N	Y N	Y N	
Seafood Fettuccine	Y N	Y N	Y N	Y N	Y N	Y N	
Shrimp Rotini w/ Applewood Bacon	Y N	Y N	Y N	Y N	Y N	Y N	
Ravioli 3-cheese tortellini	Y N	Y N	Y N	Y N	Y N	Y N	
Chicken Florentine with Pasta	Y N	Y N	Y N	Y N	Y N	Y N	

(Figure 3.5 Continued)

CHAPTER 4: RESULTS AND DISCUSSION

4.1: OVERVIEW AND SURVEY RESULTS

4.1.1 Market Survey Results

Of the 398 items selected in the market survey, 233 were frozen meals, 120 were shelf-stable meals, and 45 were boxed snack items. These items were categorized by their nutrition data into the nine categories shown in Figure 3.1. The total numbers of items in each category are presented in Figure 4.1 below. The two items in the HF/LGL category are shown at the top of the pie chart, with the remaining categories presented in a clockwise order. The categories are arranged so that the three categories in the top right section are considered healthier and the three categories in the top left to bottom left sections are considered less healthy. Out of 398 items documented in the market survey, 65.08% of the items are considered unhealthy while 5.28% of the items are considered healthy, with the remaining 29.65% of the items falling into categories in between. The lack of items in healthy categories justifies research to modify existing foods to shift them into these categories. The vast majority of the items found will benefit from the proposed modifications to increase fiber content and decrease glycemic load.

The general distribution of the number of items in each fiber and glycemic load category shows a plethora of items in the medium fiber high glycemic load category, but only two items in the high fiber low glycemic load category. The neighboring categories of high fiber medium glycemic load and medium fiber low glycemic load were also found to have a low total item count – twelve and seven items respectively across all store types. The low item count in these categories shows the lack of healthy choices available in the markets and serves to justify this research.

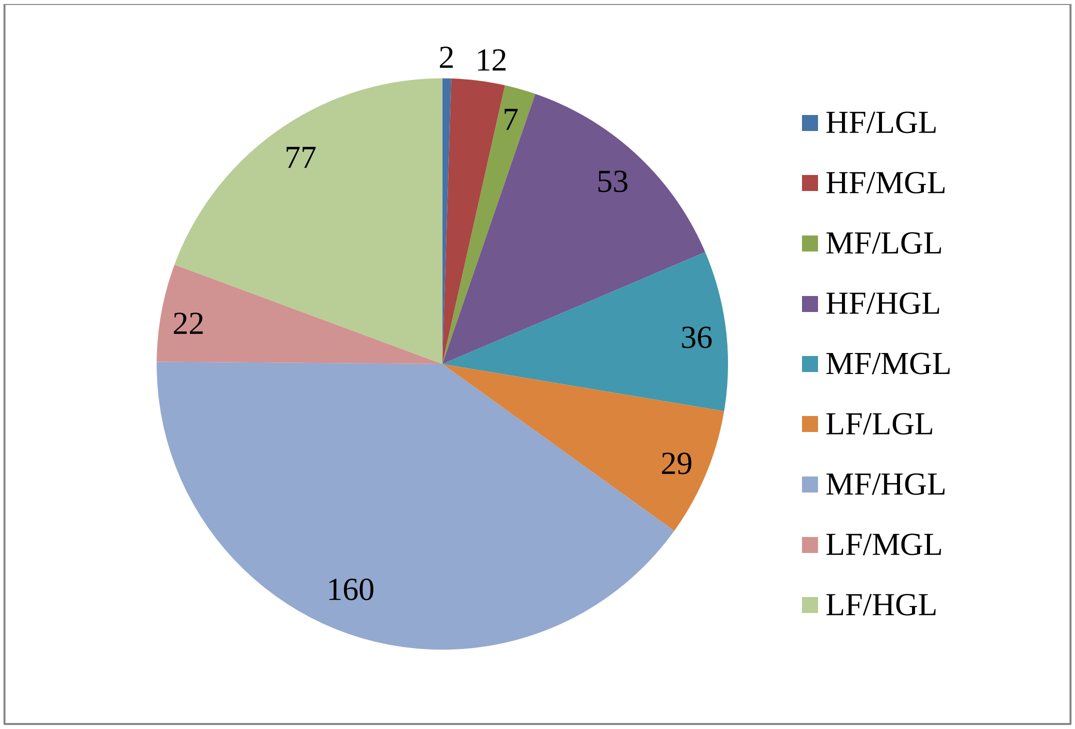

Figure 4.1 Market Survey of the Total Number of Items in Each of the Nine Fiber and Glycemic Load Categories. HF is high fiber content, MF is medium fiber content, LF is low fiber content, HGL is high glycemic load, MGL is medium glycemic load, and LGL is low glycemic load. See Table 3.1 for more details.

Other similar studies have also found a lack of gluten-free and high quality food choices in the market. Bentley (2013) performed a market survey of stores across two Louisiana parishes and reported 555 gluten-free items. These items are required for autistic individuals and those with Celiac disease. These alternative food choices were noted to be costlier than their standard counterparts and less appealing in taste. Kezis et al (1998) also performed a market survey of individuals attending a farmer's market in Maine. These individuals were willing to pay more for produce at the farmers market than elsewhere because of the quality of the products and to support local farmers. A Worldwatch Paper also presents the arguments for the emphasis of local food in the context of farmer's markets, including the effect of large-chain supermarkets (Warweil, 2002). Additional reputable, detailed market analyses are generally performed by corporations and are thus inaccessible to the researcher. However, the emphasis on healthier food items is recent research is undeniable, ranging from studies concerning the presence of various plastics, heavy metals, and inorganic arsenic in food to food safety practices (Schoof et al, 1999; Fankhauser-Noti et al, 2006; Shogren et al, 1999; and Radwan and Salama, 2006). The overall lack of items with high dietary fiber, low glycemic load and high protein content in the market compared with the abundance of foods with low dietary fiber, high glycemic load and low protein content justifies an effort to create an alternative healthy meal choice. The effort is further justified by the increasing trend in the demand for healthier food choices, especially in low end stores (MarketResearch.com, 2016).

4.1.2 Frozen Pasta Market Survey Results

A market analysis was also done based on a subset of the full market survey that consisted of only frozen prepared meals with pasta, resulting in 60 frozen pasta items. This focus was chosen based on the generally unhealthy nutritional profile of pasta products and the experience of the researcher with Italian cuisine. These items were categorized by their nutrition data into the nine categories shown in Figure 3.1 and are presented in Figure 4.2 below. The majority of these items were found to be categorized as MF/HGL, an unhealthy food category. Two of the remaining items fell into healthy categories (both in MF/LGL), two others into unhealthy categories (both in LF/HGL), and the remaining ten items into reasonably healthy categories (eight in HF/HGL and two in MF/MGL). With the large majority of items in unhealthy categories, it is a justified endeavor to find a way to make the items in the MF/HGL, LF/MGL, and LF/HGL categories healthier by increasing the fiber content and decreasing the glycemic load.

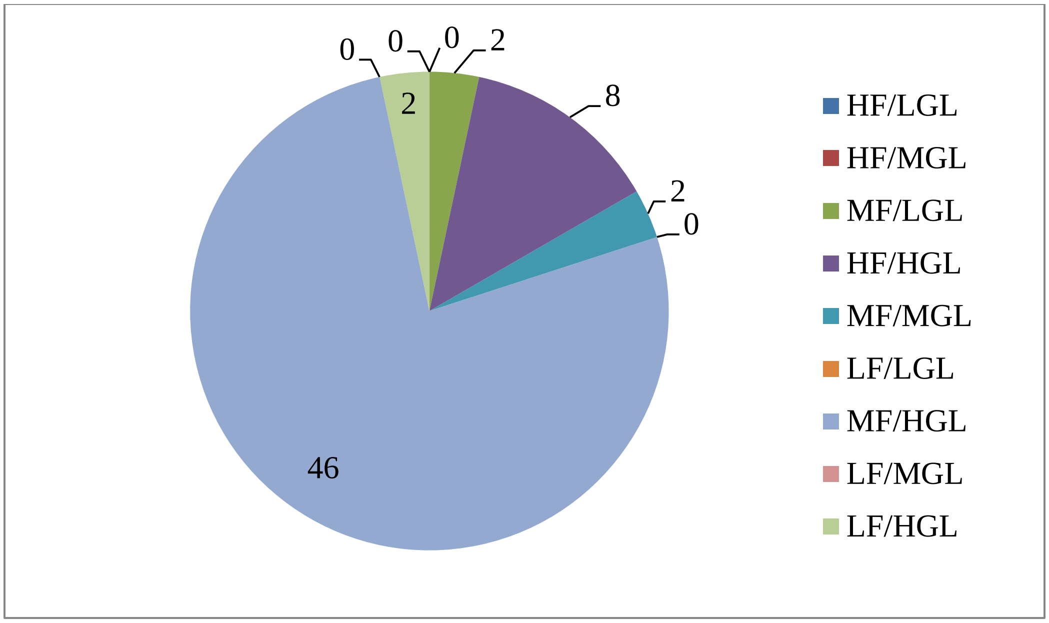

Figure 4.2 Frozen Pasta Market Survey of the Total Number of Items in Each of the Nine Fiber and Glycemic Load Categories. HF is high fiber content, MF is medium fiber content, LF is low fiber content, HGL is high glycemic load, MGL is medium glycemic load, and LGL is low glycemic load. See Table 3.1 for more details.

In general, the selection in all of the stores favored unhealthy frozen pasta meals, mostly in the MF/HGL category. Since this trend is the same across all price points, any change made to the items in the MF/HGL category that moves those items to a healthier category, such as HF/HGL, would vastly increase the number of healthy or reasonably healthy frozen pasta meal choices across the market. It is the goal of this research to achieve this increase in fiber content by substituting bean flour for a portion of the semolina flour generally found in frozen pasta products.

4.2: PRODUCT ANALYSIS AND TESTING

4.2.1 Rapid Visco Analysis Results

The RVA procedure was done in duplicate for all the flour mixtures except for the 100% bean flour since the results from those three flours were only used as a maximum reference point. The amylograph for each RVA are shown in Appendix D. The average peak viscosity, minimum viscosity, breakdown value, final viscosity, total setback, and pasting temperature for each flour mixture are reported with their uncertainties in Table 4.1. The single values for the 100% bean flours are also reported in Table 4.1. Again, the first number indicates the percentage by weight of the bean flour. In general, the peak viscosity decreased as more bean flour was substituted for the control flour, regardless of the type of bean flour substituted.

The control flour mixture was used as a standard of comparison for the remaining flour mixtures' pasting properties. Figure 4.3 shows the amylographs for the control flour and the 50/50 navy bean flour viscosities during their RVA tests. This side-by-side comparison shows a lower peak viscosity and a lower minimum viscosity for the 50/50 navy bean flour as compared to the control flour. Slight changes can also be seen in the final viscosity and the pasting temperature for the composite flour.

Instead of comparing each flour blend to the control in this manner, it is easier to plot how each visco-elastic property changes with increasing substitutions. Figure 4.4a shows the peak viscosities of each of the flour mixtures, where the black, navy, and red lines indicate the peak viscosities of the black bean, navy bean, and pinto bean flour mixtures. The data point on the far left of the graph indicates the peak viscosity for the control flour. This graphing method allows for the peak viscosities of each flour blend to be easily compared to the control. Similar graphs for the other visco-elastic properties are shown in the remaining parts of Figure 4.4.

The control flour mixture yielded the highest values for peak viscosity, minimum viscosity, and breakdown viscosity. The final viscosity of the control flour was the second highest of all the flour mixtures tested and its pasting temperature was the lowest. As bean flour

Table 4.1 Pasting Properties of Control and Bean Flour Mixtures

Flour Mixture	Peak Viscosity (cP)	Minimum Viscosity (cP)	Breakdown (cP)	Final Viscosity (cP)	Total Setback (cP)	Pasting Temp (°C)
100% Control	2045.0 ± 265.9	1255.5 ± 235.5	789.5 ± 30.4	2802.5 ± 388.2	1547.0 ± 152.7	81.58 ± 0.04
20% Pinto/80% Control	1254.0 ± 104.7	890.5 ± 62.9	363.5 ± 41.7	2019.0 ± 121.6	1128.5 ± 58.7	83.68 ± 0.53
25% Pinto/75% Control	1209.0 ± 4.2	911.0 ± 1.4	298.0 ± 5.7	2038.0 ± 9.9	1127.0 ± 8.5	82.90 ± 0.71
30% Pinto/70% Control	981.5 ± 31.8	793.0 ± 14.1	188.5 ± 17.7	1816.0 ± 45.3	1023.0 ± 31.1	83.28 ± 0.11
50% Pinto/50% Control	543.5 ± 13.4	527.0 ± 9.9	16.5 ± 3.5	1340.0 ± 41.0	813.0 ± 31.1	84.43 ± 0.60
75% Pinto/25% Control	331.5 ± 3.5	305.0 ± 7.1	26.5 ± 3.5	888.0 ± 2.8	583.0 ± 9.9	85.70 ± 1.13
100% Pinto*,**	25.0	20.0	5.0	186.0	166.0	error
20% Navy/80% Control	1513.5 ± 31.8	1012.5 ± 33.2	501.0 ± 1.4	2575.0 ± 48.1	1562.5 ± 14.9	83.28 ± 0.04
25% Navy/75% Control	1132.0 ± 4.2	909.0 ± 15.6	223.0 ± 11.3	2886.0 ± 18.4	1977.0 ± 2.8	82.88 ± 0.67
30% Navy/70% Control	1456.0 ± 22.6	1024.0 ± 24.0	432.0 ± 1.4	2735.0 ± 32.5	1711.0 ± 8.5	82.88 ± 0.53
50% Navy/50% Control	1039.5 ± 31.8	828.5 ± 30.4	211.0 ± 1.4	2704.0 ± 50.9	1875.5 ± 20.5	82.38 ± 0.04
75% Navy/25% Control	639.5 ± 140.7	610.0 ± 128.7	29.5 ± 12.0	2164.0 ± 292.7	1554.0 ± 164.1	84.13 ± 1.24
100% Navy*	411.0	361.0	50.0	1202.0	841.0	85.65
20% Black/80% Control	1451.0 ± 62.2	954.5 ± 34.7	496.5 ± 27.6	2271.5 ± 58.7	1317.0 ± 24.0	83.35 ± 0.07
25% Black/75% Control	1367.5 ± 9.2	953.5 ± 6.4	414.0 ± 2.8	2244.5 ± 5.0	1291.0 ± 1.4	82.45 ± 0.07
30% Black/70% Control	1441.0 ± 29.7	1020.5 ± 20.5	420.5 ± 9.2	2387.0 ± 46.7	1366.5 ± 26.2	82.88 ± 0.53
50% Black/50% Control	895.0 ± 111.7	755.0 ± 72.1	140.0 ± 39.6	1974.0 ± 147.1	1219.0 ± 75.0	84.10 ± 1.13
75% Black/25% Control	673.5 ± 19.1	648.0 ± 18.4	25.5 ± 0.7	1869.5 ± 37.5	1221.5 ± 19.1	83.30 ± 0.00
100% Black*	301.0	247.0	54.0	855.0	608.0	89.75

The control flour was a 50/50 blend of enriched semolina flour and “00” flour. The amylograph for each flour mixture test is presented in Appendix D.
*The original values are reported for these flours since a duplicate RVA was not performed.
**The RVA apparatus was not able to calculate the pasting temperature of this flour.

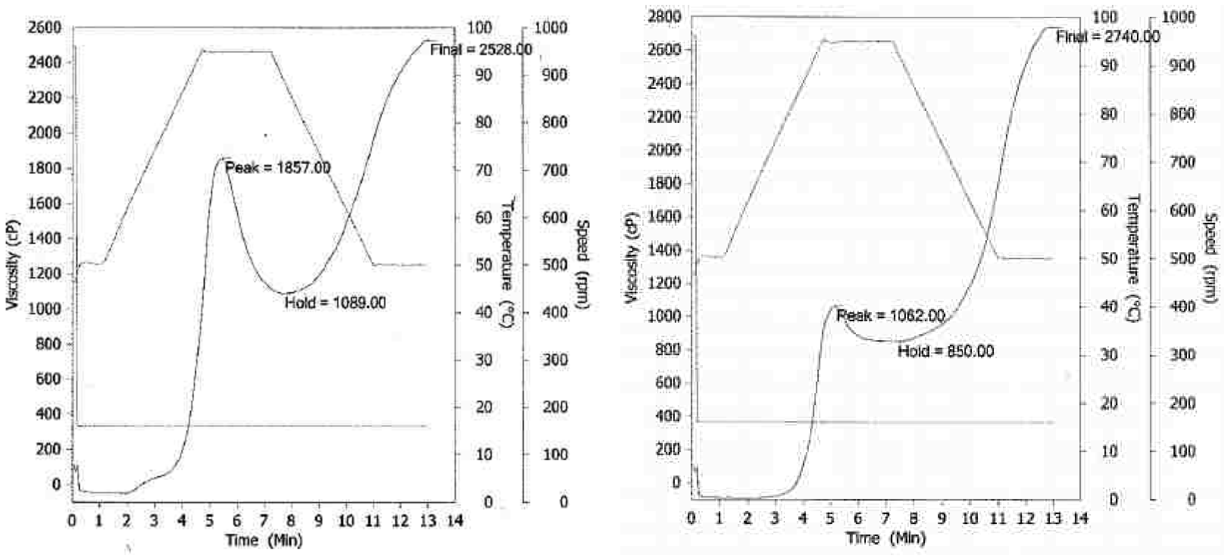

Figure 4.3 Amylograph Comparison for Control and 50/50 Navy Bean Flours. The amylograph for the control flour is on the left. The amylograph for the 50/50 navy bean flour is on the right.

substitution increased, the peak viscosity, minimum viscosity, breakdown, final viscosity, and total setback decreased with an accompanying increase in the pasting temperature.

According to pasting trends shown in Figure 4.4, the flour stability increased with increasing levels of pinto bean flour, as evidenced by the decreasing trend in the breakdown and total setback, and the increasing trend in the pasting temperature of the flour mixtures. This was not the case with the navy and black bean flour substitutions. The peak viscosities of the black bean and navy bean flour mixtures did generally decrease with increasing substitution levels, but there was a slight increase for a substitution level of 30% for the peak, minimum, and breakdown viscosities. This was also the case for the minimum and breakdown viscosities, indicating a possible optimum substitution level of 30% in these flour blends.

The final viscosity of the navy bean flour decreased below the control value for 20% substitution, but then increased above the final viscosity of the control at 25% and remained close to the control's value for the 30% and 50% substitution levels (Figure 4.4b). The final viscosities of the navy bean flour blends at higher levels were lower than the values for the

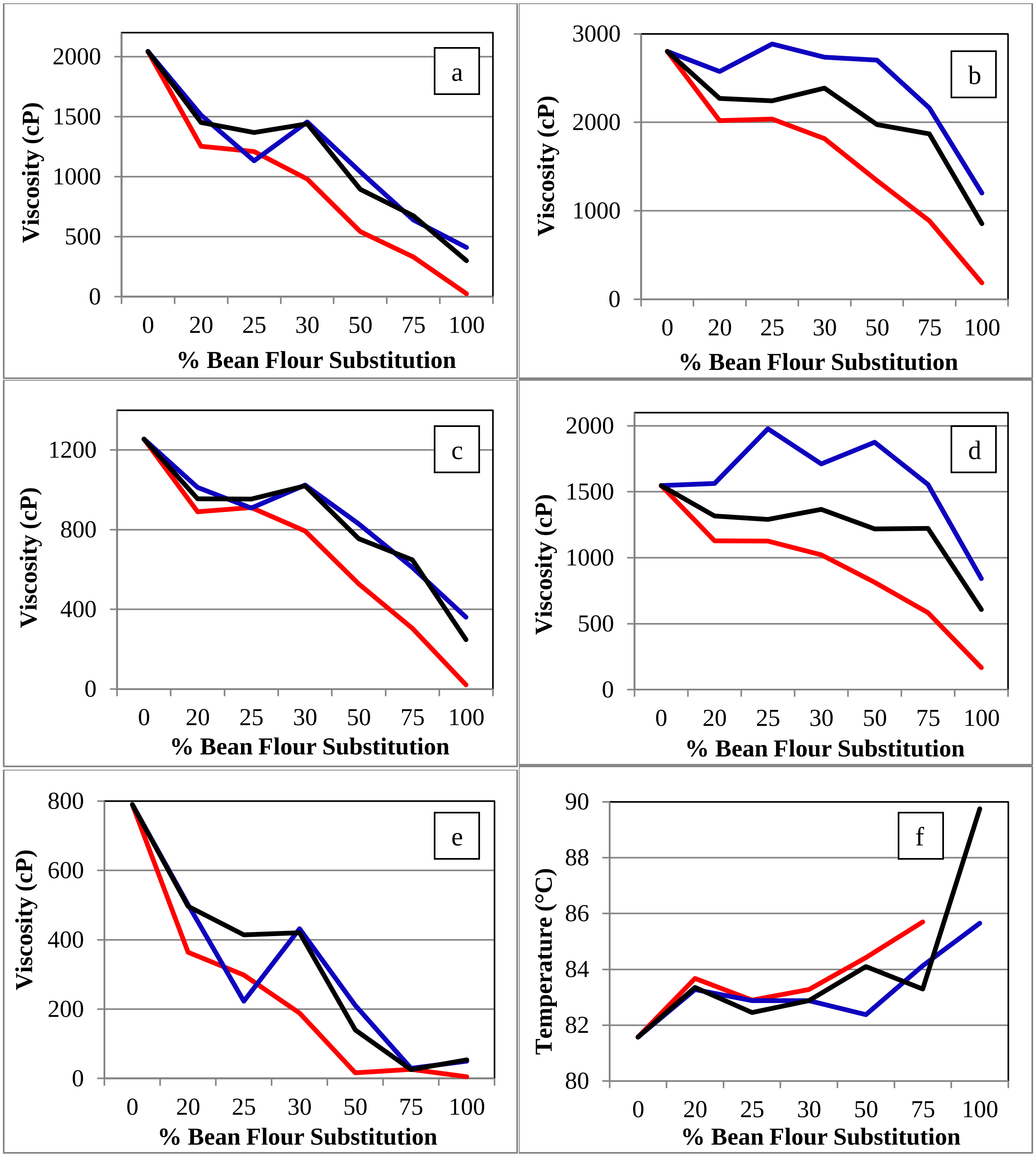

Figure 4.4 Pasting Trends of Control and Bean Flour Mixtures. The red, blue, and black lines indicate the trends for the pinto, navy, and black bean flour mixtures, respectively. Parts a-f show the trends in the peak viscosity, final viscosity, minimum viscosity, total setback, breakdown viscosity, and pasting temperature.

control, indicating a less firm texture than the control. The final viscosity of the black bean flour blends also initially decreased with substitution level, slightly increased at 30%, then decreased at higher substitution levels. All of the black bean flour blends demonstrated a lower final viscosity than the control blend. The final viscosities of the pinto bean mixtures were all lower than those of the navy and black bean mixtures at the same substitution levels. The navy bean blends of 25%, 30% and 50% substitution levels yield flours with textures similar to the control.

The minimum viscosity of each flour blend was well below the control (Figure 4.4c). The flours closest to the control were the navy bean and black bean blends at 30%. The trends observed in the total setback of each flour were similar to the trends described of the final viscosities of the flours (Figure 4.4d). The pinto bean trend line was again well below the trend lines of the navy bean and black bean blends, with the black bean results also lower than the total setbacks of the navy bean blends. The total setback of the navy bean flours were larger than the control for substitution levels of 25%, 30%, 50%, and 75%, which may indicate a less stable flour product during storage.

The breakdown viscosity of the flour blends were all well below the control, exhibiting greater flour stability during the mixing process (Figure 4.4e). The pasting temperatures of the flour mixtures were all greater than the control, although most of the pasting temperatures were within two degrees Celsius of the control's value (Figure 4.4f). Similar pasting temperatures imply similar cooking temperatures during production.

Based on final viscosity, these comparisons indicated pinto bean flour as the poorest choice of the three flour types to be added to the control flour mixture. The result suggests that the best bean flour choice was navy bean flour at substitution levels ranging from 25% to 50%. In addition, the results showed that black bean flour substitution resulted in lower flour mixture final viscosities than the navy bean flour, but still yielded a better quality flour than the pinto bean flour mixtures. Based on these trends and the final viscosities of the flours, the 25/75 navy bean, 50/50 navy bean, and the 75/25 navy bean flour mixtures were chosen to produce pasta dough as described in Chapter 3 (Figure 3.3). The 30/70 pinto bean and the 30/70 black bean flour mixtures were also chosen to sample the colors of the dough. Based on the visual appearance and general behavior of the pasta doughs, and for the reasons discussed in Section 4.2.2, the 50/50 navy bean and the 75/25 navy bean pasta doughs, along with the control, were chosen for the consumer sensory study.

Previously reported studies performed on legume-fortified pasta report lower pasta quality, such as color, cooking time, and firmness, as bean flour addition increased (Zhao et al, 2005; Sabanis et al, 2006; Nielson et al, 1980). These studies were performed using green pea, yellow pea, lentil, and chickpea flours. In comparison, this research observed similar results with pinto bean flour, but significantly different results for navy bean flour and, to a lesser extent, black bean flour. The substitution of navy bean flour instead slightly increased the final viscosity of the pasta dough above the original values reported for the control pasta dough. This increase implies a finer texture, and thus a better quality, of the pasta with the addition of navy bean flour at a substitution level of 25%.

4.2.2 Calculated Proximate Analysis of Formulations

The fiber content of the ravioli was expected to increase and the glycemic load to decrease when substituting navy bean flour for the 50/50 blend of semolina and “00” flour. Type “00” flour is a high-gluten flour made from red spring wheat. This was tested by comparing the total carbohydrates and the fiber content of each flour type used. A calculated proximate analysis of the three formulations produced was performed on raw flour mixtures and the raw and cooked ravioli (without sauce) using Nutritionist Pro™ food labeling software by Axxya Systems. This software calculates the nutritional profile of the desired product using the weights of each ingredient and the cooking process selected. Ingredients are chosen from a database of over 26,000 foods, each with their own nutritional profiles, to ensure accurate representation of the product in compliance with FDA and USDA standards (Grosevenor and Smolin, 2010).

The nutrition facts panels per 100 grams were obtained for the enriched semolina flour and the “00” flour from the flour packaging. The nutrition data for the navy bean flour was obtained from www.nutritiondata.self.com for an initial comparison. Since navy bean flour was not an option, the nutrition facts for raw mature seeded navy beans were used. The total carbohydrates and dietary fiber per 100 grams for each flour type were recorded (Table 4.2). The predicted values per 100 grams were also calculated for the control, the 50/50 navy bean, and the 75/25 navy bean flour mixtures using weighted averages of the values for the component flours and are included in the table below. By comparing the nutrition facts panels of uncooked flours, it was concluded that substituting navy bean flour in the 50/50 blend of semolina and “00” flours will result in a slight decrease in total carbohydrates, a large increase in the dietary fiber, and an increase in the total protein as shown in Figure 4.5. The change in dietary fiber is large enough to increase the fiber category of the product from medium fiber to high fiber. The combined change also decreases the glycemic load, thus converting the ravioli pasta into a healthier choice.

A calculated proximate analysis was performed on the three raw flour blends to be used to prepare three ravioli types for the sensory study. This analysis was done using Nutritionist Pro, provided by Axxya System, which also produced the nutrition fact panels. The three nutrition labels are shown in Figure 4.5 below. The details of the full analysis are included in

Appendix E. The nutrition information for the navy bean flour used to create the nutrition panels was provided by Best Cooking Pulses, Inc. (Manitoba, Canada), the provider of the navy bean flour, and is included in Figure 4.5 on the top right (see Appendix A). Each nutrition panel provides the calories, total fat, cholesterol, sodium, total carbohydrates, dietary fiber, protein content, and other nutritional information per 100 gram serving. The predicted dietary fiber and total carbohydrates in these nutrition labels match the values predicted in Table 4.2 within rounding errors. As the substitution level of navy bean flour increased, the fiber increased and the total carbohydrates decreased. The predicted protein content of the flour also increased with increasing substitution levels. It is also worth noting that the flour mixtures were predicted to have approximately the same calorie content despite the differences in total carbohydrate and protein values.

Table 4.2 Total Carbohydrate and Fiber Content of the Flour Types per 100 Grams

	Total Carbohydrate (g)	**Dietary Fiber (g)**	**Dietary Fiber (%DV)**	**Glycemic Load (g)**
“00” Flour	77	3	13	74
Semolina Flour	74	5	19	69
Navy Bean Flour*	61	24	98	37
Control Flour**	76	4	16	72
50% Navy/50% Control**	69	14	57	55
75% Navy/25% Control**	65	19	78	46

*Nutritional data courtesy of www.NutritionData.com.
** Predicted values per 100 grams of flour mixture. The control flour was a 50/50 blend of enriched semolina flour and “00” flour, a high-gluten flour made from red spring wheat.

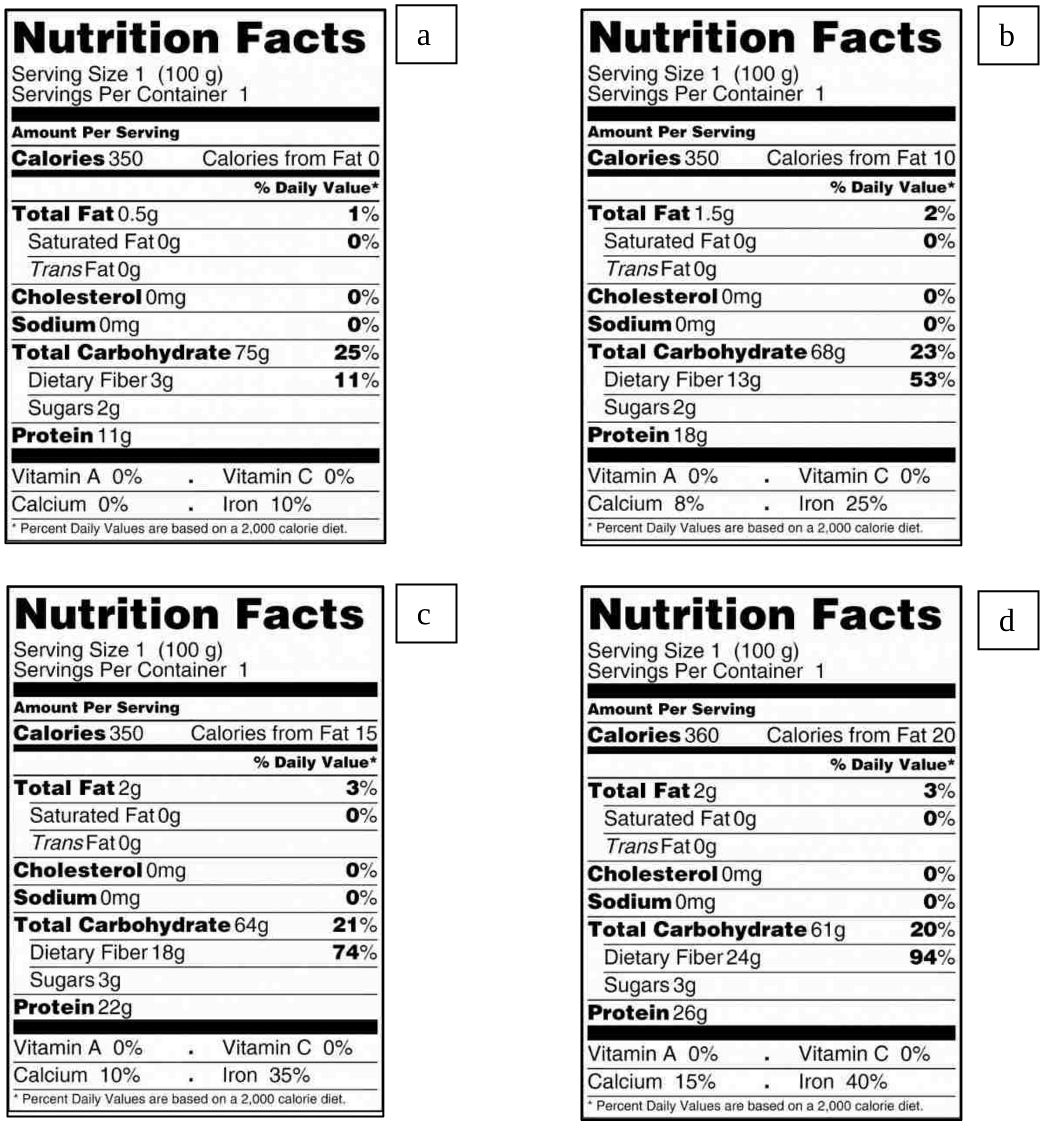

Figure 4.5 Nutrition Facts Panels for Raw Flour Mixtures. The control, 50% navy bean/50% control, 75% navy bean/25% control, and 100% navy bean flour mixture panels are shown in parts a, b, c, and d.

A calculated proximate analysis was also performed for the raw and cooked ravioli product (without sauce) used in the sensory study. The amount of sauce used for consumer tasting was not controlled in the sensory study and so is not included in the nutrition labels. Nutrition fact panels were produced for the raw control ravioli, the raw 50/50 navy bean ravioli, and the raw 75/25 navy bean ravioli with a standard serving size of 100 grams (Figure 4.6). The software calculated the nutritional values contributed by each ingredient using the weights of the ingredients for each formulation and the nutritional profiles (Table 3.5). Each nutrition panel provides the calories, total fat, cholesterol, sodium, total carbohydrates, dietary fiber, and protein content per 100 gram serving. The full analysis is included in Appendix E.

The Nutritionist Pro software does not account for the proper moisture content change and starch loss for each ravioli type during cooking as observed in Cabello and Uebersax (1990) and in other literature (Arab et al, 2010; David et al, 2015). However, the practice of using nutrition labels for raw products is a reasonable one (see Kaur et al, 2011; Kaur et al, 2013; David et al, 2015; and Mahmoud et al, 2012).

Nutrition Facts	
Serving Size 1 (100 g)	
Servings Per Container 1	
Amount Per Serving	
Calories 270	Calories from Fat 90
	% Daily Value*
Total Fat 10g	**16**%
Saturated Fat 4.5g	**23**%
Trans Fat 0g	
Cholesterol 110mg	**36**%
Sodium 310mg	**13**%
Total Carbohydrate 31g	**10**%
Dietary Fiber 1g	**5**%
Sugars 1g	
Protein 14g	
Vitamin A 6% .	Vitamin C 0%
Calcium 20% .	Iron 8%
* Percent Daily Values are based on a 2,000 calorie diet.	

Nutrition Facts	
Serving Size (100 g)	
Servings Per Container	
Amount Per Serving	
Calories 270	Calories from Fat 100
	% Daily Value*
Total Fat 11g	**16**%
Saturated Fat 4.5g	**23**%
Trans Fat 0g	
Cholesterol 110mg	**36**%
Sodium 300mg	**13**%
Total Carbohydrate 28g	**9**%
Dietary Fiber 5g	**21**%
Sugars 1g	
Protein 17g	
Vitamin A 6% .	Vitamin C 0%
Calcium 20% .	Iron 15%
* Percent Daily Values are based on a 2,000 calorie diet.	

Nutrition Facts	
Serving Size (100 g)	
Servings Per Container	
Amount Per Serving	
Calories 270	Calories from Fat 100
	% Daily Value*
Total Fat 11g	**16**%
Saturated Fat 4.5g	**23**%
Trans Fat 0g	
Cholesterol 110mg	**36**%
Sodium 300mg	**13**%
Total Carbohydrate 27g	**9**%
Dietary Fiber 7g	**29**%
Sugars 1g	
Protein 18g	
Vitamin A 6% .	Vitamin C 0%
Calcium 20% .	Iron 15%
* Percent Daily Values are based on a 2,000 calorie diet.	

Figure 4.6 Nutrition Facts Panels for Raw Raviolis. From left: control, 50% navy bean/50% control, and 75% navy bean/25% control raviolis.

The substitution of navy bean flour for the control flour had several effects on the nutritional profile of the ravioli. The total carbohydrate in the ravioli decreased with increasing amounts of navy bean flour. The dietary fiber and the protein content increased for higher substitution levels. The calories, calories from fat, total fat, saturated fat, trans fat, sodium, and sugars for each ravioli type were either equal or approximately so. The amounts of vitamin A, vitamin C, and calcium remained unchanged, while the iron level increased.

As with the products in the market survey, the fiber level and glycemic load were calculated from the nutrition label for each ravioli type (see Table 4.3 and Section 4.1.2). The calculation of the glycemic load assumed that all the resistant starch in the fortified flours was correctly classified as dietary fiber, which may not be entirely accurate (Nielson, 2010; Sajilata et al, 2006). The total carbohydrates, calories, and protein content are also included in Table 4.3. Based on these calculations, the control ravioli was categorized into the LF/HGL food group, and the 50/50 and 75/25 navy bean ravioli types into the HF/HGL group.

Table 4.3 Total Carbohydrate and Fiber Content of the Flour Mixtures and Ravioli Types

	Total Carbs (g)	**Dietary Fiber (g)**	**Dietary Fiber (%DV)**	**Glycemic Load (g)**	**Calories**	**Protein (g)**	**Predicted Category**
Control Ravioli	31	1	5	30	270	14	LF/HGL
50% Navy/50% Control Ravioli	28	5	21	23	270	17	HF/HGL
75% Navy/25% Control Ravioli	27	7	29	20	270	18	HF/HGL

*Values predicted by theoretical proximate analysis per 100 grams. HF is high fiber content, MF is medium fiber content, LF is low fiber content, HGL is high glycemic load, MGL is medium glycemic load, and LGL is low glycemic load. See Table 3.1 for more details.

A calculated analysis of a 50% fortification of the control ravioli with navy bean flour resulted in a moderate decrease of glycemic load, a large increase in fiber content, and a slight increase in protein compared to the control. A 75% substitution saw similar results with larger differences. These changes increased the fiber classification of the fortified ravioli by two categories for both fortified ravioli types, but failed to change the glycemic load category for either one. These predicted changes do not take into account the cooking process used to prepare the ravioli.

Several studies have been performed on the fortification of pasta with various legume flours. In general, these fortifications resulted in an increase of dietary fiber and protein levels, depending on the type of legume used, the cooking method used, and the type of processing used on the flour (Nielson et al, 1980; Sabanis et al, 2006; Arab et al, 2010; David et al, 2015; Kavitha and Parimalavalli, 2014; Azlan et al, 2011; Gallegos-Infante et al, 2010). In these studies, proximate analyses were performed either on the raw flours alone or the dried spaghetti produced with the flours.

A selection of these studies also investigated changes in the pasta during cooking with various legume substitution levels (see Arab et al, 2010; Gallegos-Infante et al, 2010). One particular study investigated these effects for a 15% navy bean/85% semolina flour mixture (Cabello and Uebersax, 1990). This mixture was prepared with a method similar to the one used in the present research. A proximate analysis was performed on the individual flours, raw pasta, partially precooked pasta, and fully precooked pasta. The navy bean flour was shown to have a lower moisture and carbohydrate content and a higher protein, fat and ash content than the semolina flour used in the study. The lower moisture content reported for 100% navy bean flour versus 100% semolina flour matches the results presented in Chapter 3 for the Rapid Moisture Analysis (RMA) of various substitution levels of navy bean flour with the control, although the moisture levels vary over intermediate substitution levels.

The effect of legume substitution in pasta products in literature varies with the choice of legume. Petitot et al (2010a, 2010b) substituted 35% of their durum wheat flour with split pea flour, but did not observe any significant impact on the glycemic load of the product. Gularte et al (2012) did a similar study using chickpea, pea, lentil and common bean flours, observing a decrease in glycemic load for all flours except the chickpea combinations. A related study investigated the effects of the substitution of chickpea and pea flours into wheat breads and also reported a decrease in glycemic load (Angioloni and Collar, 2012). In general, the trend in literature is a decrease in glycemic load when bean flours are substituted into pasta products, which is also observed in the current research.

4.2.3 The Protein Digestibility – Corrected Amino Acid Score

The Protein Digestibility – Corrected Amino Acid Score (PDCAAS) for each ravioli type was calculated using values gathered from literature to estimate the nutritional quality of each ravioli (Nielson, 2010; Torres et al, 2006; WHO, 2007; Pulse Canada, 2011). The PDCAAS for any food type is a product of the amino acid score with the percent true digestibility. The amino acid score is defined as the milligrams of amino acid in one gram of test protein divided the by number of milligrams of amino acid in one gram of reference protein, where the reference values used were standards published by the World Health Organization (WHO) (2007). The reference protein is the protein with the lowest amino acid score. True digestibility "is calculated based on nitrogen ingested and feed intake, corrected for metabolic losses in the feces" of male weanling rats (Nielsen, 2010). It can also be calculated based on values given in the literature, although this does not take into account changes in the true digestibility due to the cooking method (Khan and Gafoor, 1978).

The amino acid score of each ravioli type was calculated using the food database of the United States Department of Agriculture (USDA). The amino acid profiles of each ravioli ingredient were combined using the weights of the ingredients in each recipe. The amino acid profile of unenriched, bleached, 10% protein industrial white wheat flour was used since type '00' flour was not in the USDA database. This ingredient was chosen due to the similarity of its nutrition facts label to that of the ‘00’ flour used in the ravioli. The amino acid profile of navy bean flour was also not provided by the Best Cooking Pulses, so raw mature navy bean seeds were used instead (includes USDA commodity food A918, A924). Using these ingredients in a comparable calculated proximate analysis resulted in smaller protein contents per 100 gram serving for each type of ravioli as compared to the original analysis presented in Section 4.2.2. These replacements resulted in protein contents of 13.8, 15.9, and 16.9 grams for the control, 50/50 navy bean blend, and 75/25 navy bean blend raviolis. The lower protein contents in this analysis will result in slightly differing PDCAAS values.

The score for each amino acid in the three ravioli types is shown in Table 4.4. The sulfur amino acids, methionine and cystine, and the aromatic amino acids, phenylalanine and tyrosine, are combined as done in Neilson (2010). Tryptophan was the limiting amino acid in all three ravioli types and determines the amino acid score of the product. The amino acid scores of isoleucine, histidine, and methionine and cystine were also lower than 1, indicating a deficiency of these amino acids in the ravioli. The amount of each amino acid per serving increased with the addition of navy bean flour with the exception of the sulfur amino acids. However, the tryptophan amino acid score slightly decreased due to the increased overall protein content, decreasing the overall amino acid score of the product.

The true digestibility of each ingredient in the raviolis were gathered from literature and used to calculate the true digestibility and the PDCAAS of each product (Torres et al, 2007; WHO, 2007) (Table 4.4). The true digestibility decreased with increasing amounts of navy bean flour due to the lower availability of the milled navy bean flour compared to the control. The PDCAAS of the ravioli products thus decreased due to the increase in protein content per serving, lowering the amino acid score, and the decrease in true digestibility (Table 4.4).

Table 4.4 Ravioli Amino Acid Scores, True Digestibility, and PDCAAS

Amino Acid Type	Control Ravioli	50/50 Navy Bean Ravioli	75/25 Navy Bean Ravioli
Tryptophan	0.72	0.70	0.68
Threonine	1.222	1.22	1.21
Isoleucine	0.78	0.78	0.77
Leucine	1.72	1.72	1.71
Lysine	2.79	2.91	2.94
Methionine/Cystine	0.90	0.77	0.72
Phenylalanine/Tyrosine	3.45	3.39	3.36
Valine	8.12	8.32	8.36
Histidine	0.74	0.72	0.71
True Digestibility (%)	91.31	89.24	88.20
PDCAAS	0.65	0.62	0.60

A study by Pulse Canada (2011) reported the PDCAAS of cooked navy bean pulse as 0.67. The generally accepted PDCAAS value for 100% durum wheat flour is 0.43. The PDCAAS value of other wheat flours, including the enriched semolina and "00" flours used in this research, can be approximated by this value due to the similar protein structures of the flours. (The typical reference for PDCAAS is casein, with a PDCAAS of unity.) Since the PDCAAS for navy bean flour is higher than for wheat flours, the substitution of navy bean flour for the wheat flour blend should not only increase the fiber content, but also increase the protein nutritional quality of the flour mixture. Additionally, bean flours and wheat flours have been shown to have complementary amino acid profiles, implying that a mixture of these flours should produce a higher protein quality food than either of them individually (Pulse Canada, 2011).

The main differences between the Pulse Canada report and the current research lies in the ingredients. Pulse Canada reported the amino acid scores, true digestibility, and the PDCAAS of a cooked navy bean pulse in comparison to autoclaved wheat flour. The amino acid score and the true digestibility of the navy bean pulse were assessed in the study. The values for the wheat flour were calculated based on the 1989 report on protein quality (Pulse Canada, 2011). In the current research, the amino acid profile of the navy bean flour was approximated using the USDA database ingredient raw mature navy bean seeds (includes USDA commodity food A918, A924). The amino acid score of the navy bean pulse could not be used in the calculation of the amino acid score of the ravioli since the identity of the limiting amino acid was not reported. The approximation of the amino acid profile of the navy bean pulse is considered the source of error in the calculation reported in the present research.

4.3: SENSORY AND BLIND STUDIES

4.3.1 Consumer Sensory Study Results

The results of the sensory evaluation of the three ravioli types (with and without sauce) were analyzed as follows. The average values, standard deviations, and analysis results of each hedonics question are reported in Tables 4.5 and 4.6. The average percentage of 'yes' answers for the three yes/no questions of each type are given in Tables 4.7 and 4.8.

The ANOVA test reported no differences between the distributions in the aroma of the ravioli types with and without sauce, so the tukey method was not applied for those entries. The results of the tukey method are indicated by the subscripts in Tables 4.5 and 4.6. The overall trend in the tables above is a decreasing approval rate with increasing levels of navy bean flour substitution, but an overall higher approval rate when the ravioli types were sampled with sauce. The subscripts indicate that the consumers detected a difference between the 75/25 ravioli blend, with or without sauce, but could not record a significant difference between the control ravioli and the 50/50 navy bean ravioli.

Table 4.5 Analysis of Hedonics Data for Ravioli Without Sauce

Samples	Appearance	Aroma	Taste	Texture	Liking
Control	$5.9 \pm 1.7_a$	$5.5 \pm 1.6_a$	$6.1 \pm 1.5_a$	$5.7 \pm 1.8_a$	$6.0 \pm 1.6_a$
50% Blend	$5.5 \pm 1.7_{ab}$	$5.7 \pm 1.5_a$	$5.8 \pm 1.8_{ab}$	$5.5 \pm 1.8_a$	$5.9 \pm 1.9_a$
75% Blend	$5.1 \pm 1.9_b$	$5.7 \pm 1.5_a$	$5.4 \pm 1.7_b$	$4.9 \pm 1.8_b$	$5.3 \pm 1.8_b$

*The average and standard error associated with each hedonic question. Matching subscripts indicate that the means of those two ravioli were not found to be significantly different at $\alpha = 0.05$.

Table 4.6 Analysis of Hedonics Data for Ravioli With Sauce

Samples	Appearance	Aroma	Taste	Texture	Liking
Control	$6.8 \pm 1.3_a$	$6.7 \pm 1.4_a$	$6.7 \pm 1.7_a$	$6.3 \pm 1.8_a$	$6.4 \pm 1.8_a$
50% Blend	$6.4 \pm 1.5_{ab}$	$6.4 \pm 1.5_a$	$6.3 \pm 1.7_{ab}$	$5.9 \pm 1.8_{ab}$	$6.2 \pm 1.8_a$
75% Blend	$6.1 \pm 1.6_b$	$6.3 \pm 1.5_a$	$6.1 \pm 1.8_b$	$5.5 \pm 1.9_b$	$5.3 \pm 1.8_b$

*The average and standard error associated with each hedonic question. Matching subscripts indicate that the means of those two ravioli were not found to be significantly different at $\alpha = 0.05$.

The average percentage of yes answers for the three yes/no questions are reported in the two tables below. Table 4.7 gives the percentages for each question for the ravioli types without sauce. Table 4.8 gives the percentages for the ravioli sampled with sauce. The bean flavor question was phrased so that a ‘yes’ answer was a negative review. The remaining two questions were phrased in a way that a ‘yes’ answer indicated a positive review.

A portion of the consumers reported a detectable bean flavor in the control ravioli, indicating a false positive detection rate of 16.5% without sauce and 7.8% with sauce. A substantially larger portion of the consumers detected a bean flavor with the bean ravioli types, although this number was smaller for the ravioli types sampled with sauce. The majority of the consumer base found all of the ravioli types acceptable, with or without sauce. The acceptability percentages of the control and the 50/50 navy bean ravioli were within 2% of each other regardless of the presence of sauce, but the acceptability of the 75/25 navy bean ravioli was substantially lower than the other two in both cases. In general, the acceptability of the ravioli types increased when sampled with sauce. This trend also held for the consumer's purchase intent of the ravioli types. The percentage of consumers who indicated a positive purchase intent for the ravioli types decreased with increasing navy bean flour substitution level regardless of the presence of sauce, but were overall larger when the ravioli were sampled with sauce.

Table 4.7 Percentages of "Yes" Responses for Ravioli Without Sauce in Consumer Sensory Study

Samples	Detectable Beany Flavor	Acceptability	Purchase Intent
Control	16.5%	80.6%	52.4%
50% Blend	35.0%	78.6%	46.6%
75% Blend	37.9%	64.1%	31.3%

The percentages reported in Tables 4.7 and 4.8 also show a preference for the 50/50 navy bean ravioli over the 75/25 navy bean ravioli. Based on these results, a 50/50 navy bean ravioli with sauce is recommended. Lower substitution levels of navy bean flour should also be considered given the pasting properties and nutritional components of those substitution levels discussed in previous sections.

Table 4.8 Percentages of "Yes" Responses for Ravioli With Sauce in Consumer Sensory Study

Samples	Detectable Beany Flavor	Acceptability	Purchase Intent
Control	7.8%	84.5%	63.1%
50% Blend	22.3%	82.5%	54.4%
75% Blend	19.4%	71.8%	43.7%

An early study of a similar substitution method in pasta indicates favorable consumer reports in terms of color, texture, and flavor of the pasta, but deteriorated the noodle dough handling characteristics of the pasta dough (Nielson et al, 1980). The favored pasta in this study was red spring wheat spaghetti with 33% of the wheat flour replaced with pea flour. This substitution level was chosen to obtain an optimum composition of protein (an early version of the PDCAAS). A later study also found a 30% substitution of broad bean flour in place of wheat bread flour to give a favorable change in the nutritional content of the flour (Gimenez et al, 2012). The study also reports no detectable change in the texture, flavor, or physical-chemical properties of the spaghetti produced with a 30% substitution of broad bean flour.

The results in these two studies are similar to those presented here, but with certain differences. While the studies discussed above investigated the basic physical-chemical properties of pasta flour at low bean flour substitution levels, the results here investigate the effects of bean flour substitution at discrete intervals up to 100%. A variety of studies have shown legume-fortified pasta to be acceptable to consumers at low substitution levels, generally for 30% substitution level and below (Nielson et al, 1980; Gimenez et al, 2012; Zhao et al, 2005; Sabanis et al, 2006). In general, these papers also report a decreasing consumer acceptance with increasing substitution levels, which is also the general trend here.

4.3.2 Blind Consumer Survey Results

The analysis presented below is based on the 38 participants age 65 years and older who consumed frozen pasta meals as of the date of the survey. The participants in the survey were asked six 'yes or no' questions concerning specific characteristics of each product: purchase history, consumption, taste, texture, aroma, and color (see Fig. 3.4 for more details). Each question was phrased in a way that a 'yes' choice resulted in a favorable answer about the product in question. An additional entry field for each product allowed the participant to comment on the products as desired.

The total number of votes for each product in the four attribute categories (taste, texture, aroma, and color) are shown by the grey line in Figure 4.7 below. The product numbers shown on the horizontal axis are the same as the order used in the blind consumer survey form. (The first product referenced in the survey form is indicated here as product 1, the second as product 2, and so on.) Only the votes of the participants that indicated consumption of that product were used in that product's total. A total vote count of zero means there were no participants that indicated consumption of the product, as was the case for product numbers 7, 17, and 18.

The percentage of total "no" votes for each product was calculated using the total number of "no" votes, again only using the attribute categories, compared with the total number of votes as described above. These percentages are shown by the height of the black columns in Figure 4.7. The percentage of "no" votes for product numbers 2, 5, 9, 10, 11, 13, 15, and 16 were all zero, meaning the participants that consumed those products did not find anything wrong with the taste, texture, aroma, or color of those products. Since the purpose of this analysis is to find what is wrong with the products selected, the responses concerning these products were not analyzed further.

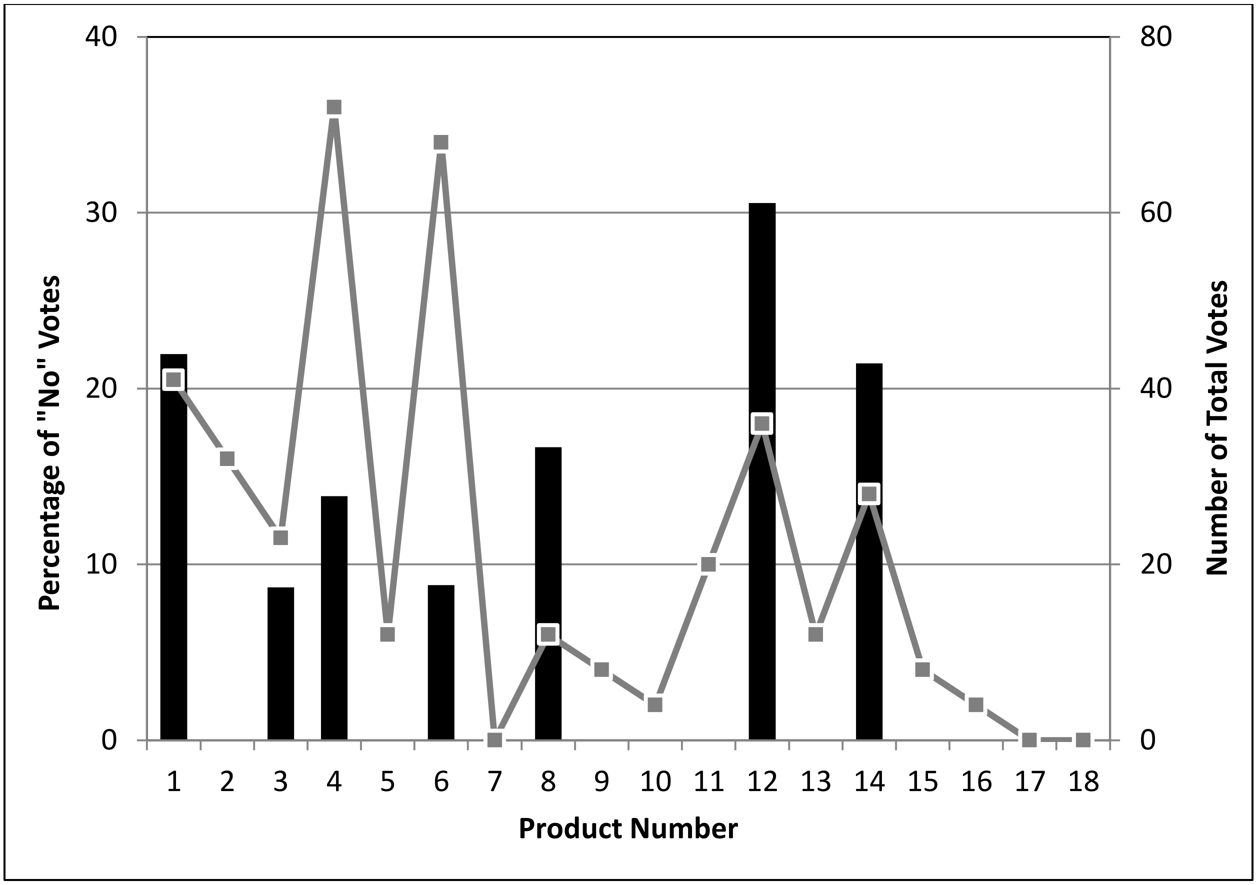

Figure 4.7 Total Voting Statistics For Blind Consumer Survey. The black bars indicate the total percentage of “no” votes recorded for each product for the taste, texture, aroma, and color categories. The grey line indicates the number of total votes recorded per product in the same categories.

However, this satisfactory trend did not hold for the remaining products. Product numbers 1, 3, 4, 6, 8, 12, and 14 all had a nonzero value for the total number of votes and for the percentage of “no” votes, indicating the participants that consumed those products found something wrong with them. Figure 4.8 shows a more detailed comparison for these products. This figure shows the percentage of “no” votes calculated individually for the four attribute categories (taste, texture, aroma, and color) for each product. For ease of comparison, the same range was chosen for the vertical axis in each of the graphs. This calculation was performed by dividing the number of “no” votes by the total number of votes for each attribute category of each product and then converting the number to a percent. Again, only the votes cast by the participants indicating consumption of the product were used in these calculations. It should be noted that the total number of votes in each category were not equal for the categories of the same product.

In this figure, a high percentage of “no” votes in a particular category means a large percentage of the participants indicating consumption of the product had a problem with the indicated attribute category for that product. The data for product 1 indicates the texture and color of the product were not attractive for a substantial percentage of the consumer of that product, with the remaining two categories showing a low percentage of dissatisfaction. The only problematic category for product 3 was the texture attribute, with one-third of the consumers rating this category as unsatisfactory. For product 4, the attribute categories with the highest percentage of “no” votes were the taste and texture categories. The percentage of consumers that found the remaining two categories (aroma and color) unappealing was less than 6% per category. Although the percentages reported for product 6 were all near 10% or lower, more of consumers disliked the taste and texture more than the aroma and color.

The percentage of “no” votes for product 8 were recorded only for the texture and color attribute categories for the product, resulting in relatively high percentages in those categories. This indicates the taste and aroma of the product were satisfactory, but the texture and color need improvement. Three of the four attribute categories for product 12 were rated as unsatisfactory with more than 30% in those categories. The color of this product was generally acceptable since the disapproval rate was near 10%. Product 14 received highly unfavorable ratings in the texture and taste categories, but no problems were recorded with the color. The aroma of the product was reasonably acceptable with about 15% of the consumers rating the aroma as unattractive.

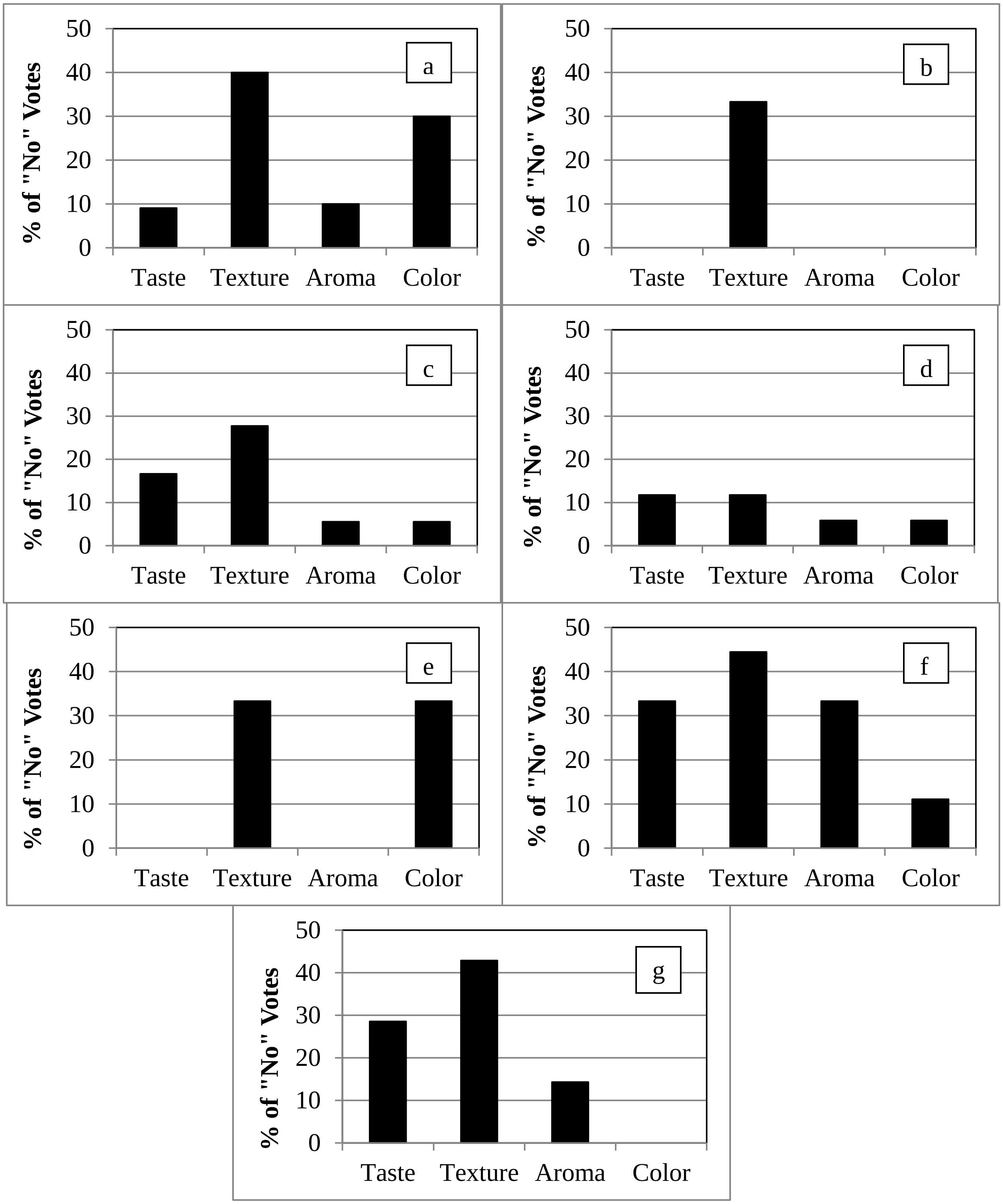

Figure 4.8 Attribute Voting Statistics For Blind Consumer Survey. The black bars indicate the percentage of “no” votes recorded for each product for the taste, texture, aroma, and color categories. Parts a-g show the data for products 1, 3, 4, 6, 8, 12, and 14, respectively.

Based on these graphs, products 1, 12 and 14 were found to have the highest overall disapproval ratings. The majority of these rating were mostly recorded in the texture category, although the other categories provided a significant contribution as well. Products 4 and 6 were found to be acceptable, with disapproval ratings in each attribute category generally below 20%. The remaining products (1, 3, 8, 12, and 14) all received more than a 30% disapproval rating in at least one of the attribute categories, indicating improvement is needed for these attributes of these products.

Participants in the survey who did not consume any of the products generally indicated a preference for fresh pasta meals or other fresh foods. One such participant indicated dissatisfaction with the generally high sodium content of frozen pasta. Other participants cited lack of availability or appeal as reasons for not purchasing some of the products. A smaller number of participants found the number of calories and fat too high in some of the products, and so did not purchase them. Still others mentioned a lack or abundance of spice or a lack of flavor as one of the reasons for their dissatisfaction with the frozen pasta meals that were consumed. In general, the participants that did not purchase one or more of the frozen pasta meals did so because of the low appeal compared to fresh foods or because that product was not available at the store where they shop. Others found the nutritional value of the product unsatisfactory due to high sodium, fat, and calorie levels and did not purchase the item.

The appeal of these products may be increased by encouraging the manufacturer's to use fresh ingredients in their products, preferably from local farmers. Indicating this on the front of the product packaging may increase the appeal of the product due to the observed favorability of some consumers towards local farmers (Halweil, 2002). The substitution of navy bean flour for a portion of the pasta flour in these products is not predicted to change the sodium, fat, or calorie levels by a significant amount, and so does not address the issues consumers mentioned in the blind consumer survey (see Section 4.2.2). However, this substitution is predicted to increase the fiber and protein content of the product and decrease the glycemic load, thus making these products healthier choices. These changes will help older individuals consume the recommended levels of fiber and protein without adding additional calories to their diets.

The use of navy bean flour in ravioli was observed to generally decrease the approval ratings in the appearance, aroma, taste, and texture categories in the sensory study reported in the previous section (see Section 4.3.1). These decreases were not significant at a 50% substitution level when compared to a control, but became significant in most categories at a 75% substitution level. Consequently, the substitution of navy bean flour at a 50% level or lower into the frozen pasta products discussed above is not predicted to change the approval (or disapproval) ratings of that product, but is predicted to increase their nutritional value. Some studies have reported an increase in the approval of the flavor of their durum wheat pasta when bean flour was added (Sabanis et al, 2006). Although that effect was not investigated here, it would address some of the comments given by the participants in the blind consumer survey.

4.4: SUMMARY AND FURTHER RESEARCH

4.4.1 Summary

In the research presented here, a market survey was performed to analyze the types of prepared meals available across the various price categories in the greater Baton Rouge area. The majority of these products were categorized into unhealthy fiber and glycemic load categories. A more focused market survey revealed 80% of the frozen pasta meals available were classified as unhealthy options with medium or low fiber contents. If the fiber content of these products could be increased and the glycemic load decreased, then these unhealthy food choices would become reasonably healthy choices.

The proposed way to increase the fiber content of pasta products was to substitute part of the flour used to produce the pasta with navy bean flour. This bean flour choice was made by comparing the RVA testing results of various mixtures of pinto, black, and navy bean flours with a control blend of enriched semolina flour and "00" flour. A 50 percent substitution ratio of navy bean flour is predicted to decrease the glycemic load by seven grams and to increase in fiber content by 16% DV. These increases resulted in no change to the glycemic load category of the product and a double category shift (LF to HF) in the fiber content category. This partial substitution also resulted in a predicted increase in the protein level. The PDCAAS of the ravioli decreased with the addition of navy bean flour due to the decreasing amount of tryptophan in the flour blend and the decrease in the calculated true digestibility of the product.

The sensory characteristics of the control and navy bean raviolis were also compared in a consumer sensory study. An ANOVA test was performed on these results, showing a detectable preference for the 50/50 navy bean ravioli over the 75/25 version. Thus, the 50/50 navy bean ravioli and similar substitution levels are recommended for further development. When selecting other possible substitution levels of navy bean flour, the quality differences reported in the RVA results should be considered in balance with the predicted nutritional profile and protein quality of those flour mixtures. These products should be tested in a manner similar to that presented here.

A blind consumer study was conducted using frozen pasta meals selected from the frozen pasta market survey on seniors 65 years and older to assess their preferences. Several of the products were found to have high disapproval ratings in one or more of the four attribute categories (taste, texture, aroma, and color). The substitution of navy bean flour into these products at a 50% substitution level or lower is not predicted to decrease (or increase) the acceptability of these products, but is predicted to increase their nutritional value. This change will help older individuals consume the recommended nutritional spectrum without adversely affecting their diet.

4.4.2 Further Research

Although the nutritional value of the control ravioli was increased by the substitution of navy bean flour, a few of the nutritional values bear further consideration. A large portion of the sodium content of the product came from the parmesan cheese and the table salt added to the dough. The sodium level can be reduced by approximately 50% by simply replacing the parmesan cheese with whole milk ricotta cheese. Removing the salt from the recipe would decrease the sodium content by an additional 30%, although the effect on taste remains to be tested. The combined decrease in sodium resulting from these two changes would make the product more attractive to seniors with restricted sodium diets.

The calculated proximate analysis of the three ravioli produced predicted an increase in fiber with increasing bean flour substitution as expected. The protein level was also predicted to increase with larger amounts of bean flour while the glycemic load (digestible carbohydrates) was predicted to decrease. It is recommended that a proximate chemical analysis of the three ravioli produced by performed to measure changes in total carbohydrates, insoluble fiber, soluble fiber, dietary fiber, protein levels, amino acid profiles, glycemic load, and protein quality. The results of these tests can be used to track the changes in the nutritional profile of the ravioli as bean flour substitution levels increase.

Even though the nutrition facts panel on the finished product may portray healthy contents, the consumer will not purchase the item more than once if the flavor profile of the product is not satisfactory. Since the ANOVA tests revealed a preference for each ravioli type with sauce compared to the same ravioli without sauce, it would be wise to add a thoughtfully prepared sauce to the ravioli before commercialization. The flavor profile of the sauce should be appealing, but the added nutritional value should not substantially increase the glycemic load of the finished product. The cheeses for the ravioli filling should also be chosen by the same standards. Mild cheeses are recommended based on a generally low sodium content and a low glycemic index due to its low carbohydrate level.

Other options for future research include creating composed frozen meals based on the bean pasta produced, possibly including meat, vegetables, fruit, and other various items to complement the amino acid profile of the ravioli. These meals may also provide more appealing options than the basic pasta presented in this thesis. It would also be interesting to consider an additional substitution of the remaining control flour with various vegetable flours to further increase the nutritional value of the meal. Sensory surveys of these options should be conducted in a manner to address the issues recorded in the blind consumer survey.

In conclusion, this thesis reports an increase in nutritional value of a frozen pasta product by substituting a portion of the standard pasta flours for navy bean flour. The substitution resulted in a predicted large increase in fiber content, a moderate decrease in glycemic load, an increase in protein content, and a decrease in protein quality, thereby increasing the overall predicted nutritional value of the pasta product. A consumer sensory test indicated little difference in preference between the 50/50 navy bean pasta product and a semolina/”00” flour blend. However, a preference was indicated when the 75/25 navy bean ravioli product was much less preferred compared to the same standard product. It is recommended that the 50/50 navy bean ravioli be further researched to optimize the navy bean flour substitution level, to reduce its sodium content, and to improve its flavor profile by the various methods discussed.

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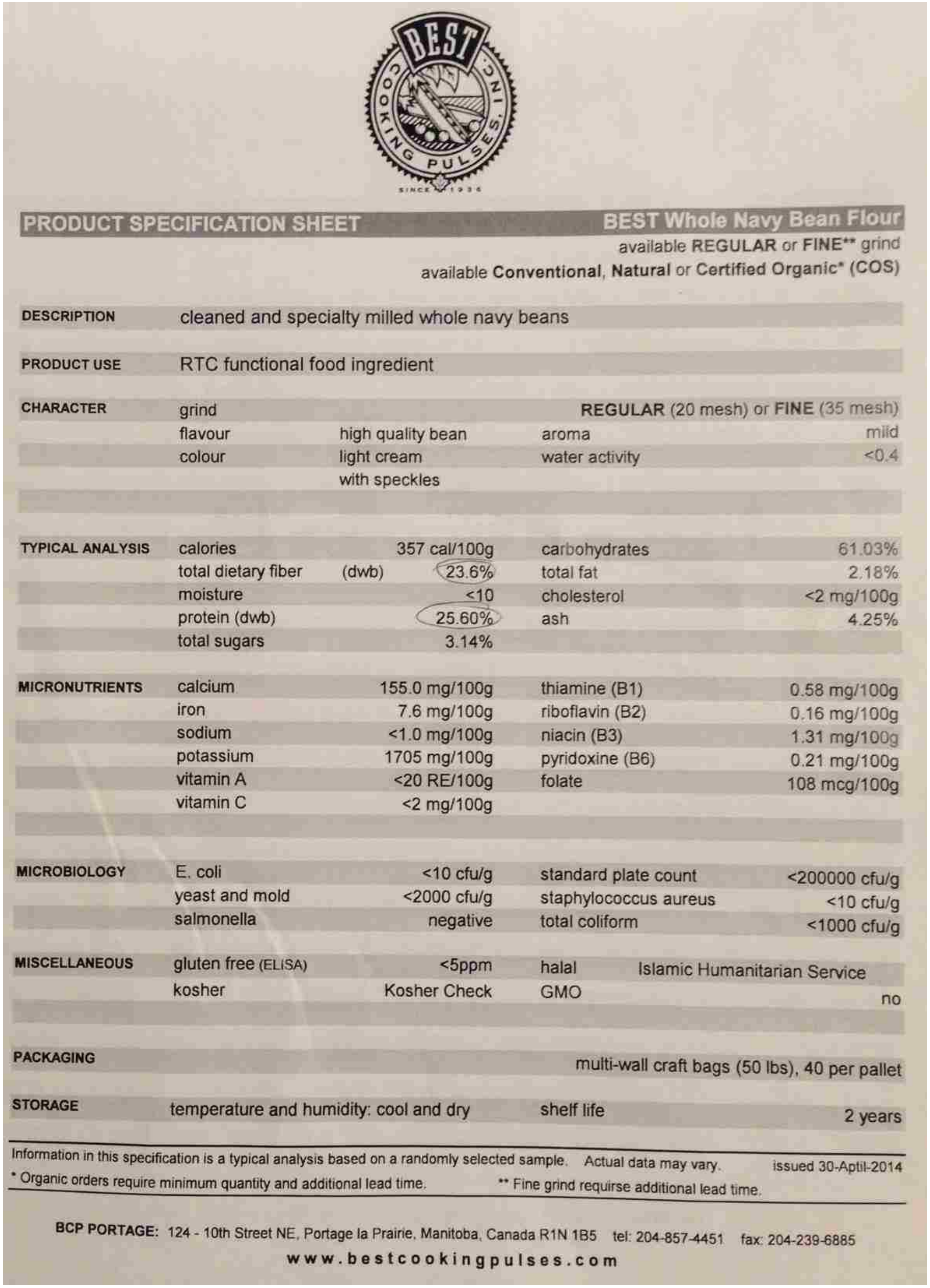
APPENDIX A: NUTRITION PROFILES OF BEANS

Navy bean flour, pinto bean flour, and black bean flour were analyzed as prospective components of a ravioli product. The nutritional data for these bean flours are presented in the following pages (Figures A.1, A.2, and A.3). The nutritional profile for the navy bean flour (Chapter 4, Figure 4.7) was calculated using the data included in this appendix. The bean flours and their nutritional data included here were provided by Best Cooking Pulses, Inc.



SINCE 1936

BEST COOKING PULSES, INC.

PRODUCT SPECIFICATION SHEET — **BEST Whole Navy Bean Flour**

available **REGULAR** or **FINE**** grind

available **Conventional**, **Natural** or **Certified Organic*** **(COS)**

DESCRIPTION	cleaned and specialty milled whole navy beans			
PRODUCT USE	RTC functional food ingredient			
CHARACTER	grind			**REGULAR** (20 mesh) or **FINE** (35 mesh)
	flavour	high quality bean	aroma	mild
	colour	light cream with speckles	water activity	<0.4
TYPICAL ANALYSIS	calories	357 cal/100g	carbohydrates	61.03%
	total dietary fiber (dwb)	23.6%	total fat	2.18%
	moisture	<10	cholesterol	<2 mg/100g
	protein (dwb)	25.60%	ash	4.25%
	total sugars	3.14%		
MICRONUTRIENTS	calcium	155.0 mg/100g	thiamine (B1)	0.58 mg/100g
	iron	7.6 mg/100g	riboflavin (B2)	0.16 mg/100g
	sodium	<1.0 mg/100g	niacin (B3)	1.31 mg/100g
	potassium	1705 mg/100g	pyridoxine (B6)	0.21 mg/100g
	vitamin A	<20 RE/100g	folate	108 mcg/100g
	vitamin C	<2 mg/100g		
MICROBIOLOGY	E. coli	<10 cfu/g	standard plate count	<200000 cfu/g
	yeast and mold	<2000 cfu/g	staphylococcus aureus	<10 cfu/g
	salmonella	negative	total coliform	<1000 cfu/g
MISCELLANEOUS	gluten free (ELISA)	<5ppm	halal	Islamic Humanitarian Service
	kosher	Kosher Check	GMO	no
PACKAGING				multi-wall craft bags (50 lbs), 40 per pallet
STORAGE	temperature and humidity: cool and dry		shelf life	2 years

Information in this specification is a typical analysis based on a randomly selected sample. Actual data may vary. issued 30-Aptil-2014

* Organic orders require minimum quantity and additional lead time. ** Fine grind requirse additional lead time.

BCP PORTAGE: 124 - 10th Street NE, Portage la Prairie, Manitoba, Canada R1N 1B5 tel: 204-857-4451 fax: 204-239-6885

www.bestcookingpulses.com

Figure A.1 Nutritional Profile for Navy Bean Flour. Percentages for dry weight basis (dwb) are given for total dietary fiber and protein.

PRODUCT SPECIFICATION SHEET **BEST Whole Pinto Bean Flour**

available **REGULAR** grind

available **Conventional**, **Natural** or **Certified Organic* (COS)**

DESCRIPTION	cleaned and specialty milled whole pinto beans			
PRODUCT USE	RTC functional food ingredient			
CHARACTER	grind			**REGULAR** (20 mesh)
	flavour	high quality bean	aroma	mild
	colour	light cream	water activity	<0.4
TYPICAL ANALYSIS	calories	324 cal/100g	total fat	2.20%
	total dietary fiber (dwb)	21.04%	*saturated fat*	*0.50%*
	insoluble fiber	*16.83%*	*monosaturated fat*	*0.20%*
	soluble fiber	*4.21%*	*polyunsaturated fat*	*1.40%*
	moisture	9.7%	*trans fat*	*<0.10%*
	protein (dwb)	23.8%	cholesterol	<2mg/100g
	carbohydrates	61.7%	ash	4.90%
	total sugars	2.8%		
MICRONUTRIENTS	calcium	74.0 mg/100g	thiamine (B1)	0.33 mg/100g
	iron	6 mg/100g	riboflavin (B2)	0.14 mg/100g
	sodium	<1.0 mg/100g	niacin (B3)	1.5 mg/100g
	magnesium	168 mg/100g	pyridoxine (B6)	0.43 mg/100g
	zinc	3 mg/100g	folate	186 mcg/100g
	vitamin A	<20 RE/100g		
	vitamin C	<2 mg/100g		
MICROBIOLOGY	E. coli	<10 cfu/g	standard plate count	<200000 cfu/g
	yeast and mold	<2000 cfu/g	staphylococcus aureus	<10 cfu/g
	salmonella	negative	total coliform	<1000 cfu/g
MISCELLANEOUS	gluten free (ELISA)	<5ppm	Halal	Islamic Humanitarian Service
	kosher	Kosher Check	GMO	no
PACKAGING				multi-wall craft bags (50 lbs), 40 per pallet
STORAGE	temperature and humidity: cool and dry		shelf life	2 years

Information in this specification is a typical analysis based on a randomly selected sample. Actual data may vary. issued 30-Apirl-2014

* Organic orders require minimum quantity and additional lead time.

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Figure A.2 Nutritional Profile for Pinto Bean Flour. Percentages for dry weight basis (dwb) are given for total dietary fiber and protein.

PRODUCT SPECIFICATION SHEET — **BEST Whole Black Bean Flour**

available REGULAR grind

available **Conventional, Natural** or **Certified Organic* (COS)**

DESCRIPTION	cleaned and specialty milled whole black beans			
PRODUCT USE	RTC functional food ingredient			
PHYSICAL CHARACTER	grind			REGULAR (20 mesh)
	flavour	high quality bean	aroma	mild
	colour	light cream with speckles	water activity	[illegible]
TYPICAL ANALYSIS	calories	358 cal/100g	carbohydrates	62.10%
	total dietary fiber (dwb)	26.2%	total sugars	3.98%
	insoluble	*20.15%*	total fat	2.30%
	soluble	*6.09%*	*saturated*	*0.45%*
	protein (dwb)	24.57%	*monounsaturated*	*0.38%*
	moisture	<14%	*polyunsaturated*	*1.49%*
MICRONUTRIENTS	calcium	140.0 mg/100g	thiamine (B1)	0.71 mg/100g
	iron	7.01 mg/100g	riboflavin (B2)	0.25 mg/100g
	sodium	<3.0 mg/100g	niacin (B3)	2.6 mg/100g
	potassium	1580 mg/100g	pyridoxine (B6)	0.38 mg/100g
	vitamin A	<20 RE/100g	folate	190 mcg/100g
	vitamin C	<.5 mg/100g		
MICROBIOLOGY	E. coli	<10 cfu/g		
	salmonella	negative		
MISCELLANEOUS	gluten free (ELISA)	<5ppm	halal	Islamic Humanitarian Service
	kosher	Kosher Check	GMO	no
PACKAGING			multi-wall craft bags (50 lbs), 40 per pallet	
STORAGE	temperature and humidity: cool and dry		shelf life	2 years

Information in this specification is a typical analysis based on a randomly selected sample. Actual data may vary. revised 16-April-2014

* Organic orders require minimum quantity and additional lead time.

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Figure A.3 Nutritional Profile for Black Bean Flour. Percentages for dry weight basis (dwb) are given for total dietary fiber and protein.

APPENDIX B: MARKET SURVEY DATA

The nutritional information for each product in the market survey is included in the following pages (Table B.1). A selection of information from each product's nutrition facts label are included in the spreadsheet: calories, total cholesterol, total fat, sodium, total carbohydrates, total sugars, total fiber, and total protein per serving. The total fiber is also presented as a percent daily value for classification into the high fiber, low fiber, and medium fiber groups as per FDA regulations. The amount of digestible carbohydrates per serving was calculated by subtracting the total fiber levels from the total carbohydrates as done in Liese et al, 2005. The item type is indicated by the letters in the item number column, where 'd' means the item was a dry item, 'f' means frozen item, and 's' means snack item. For confidentiality reasons, the names of the stores and food items have been replaced with numbers.

Table B.1: Market Survey Data

Item #	Item Type	Calories	Total Cholesterol (mg)	Total Fat (g)	Sodium (mg)	Total Carbohydrate (g)	Total Sugar (g)	Total Fiber (g)	Total Protein (g)	Total Fiber (%DV)	Digestible Carbohydrate (g)
1	d	160	0	0.5	440	34	0	1	4	4	33
2	d	130	0	1	940	26	2	5	5	20	21
3	d	320	5	3	880	66	18	2	8	6	64
4	f	150	10	4.5	360	20	2	2	5	8	18
5	d	310	30	10	980	45	5	2	16	8	43
6	f	320	30	10	660	41	8	3	16	12	38
7	f	210	65	10	550	23	8	2	9	6	21
8	f	260	30	11	220	32	2	2	7	7	30
9	f	310	15	12	760	39	5	1	10	4	38
10	f	240	10	5	710	38	4	4	11	16	34
11	d	190	0	2	660	38	2	2	7	8	36
12	d	90	0	0	450	21	1	1	2	5	20
13	d	210	0	2.5	420	44	14	2	4	8	42
14	f	350	20	20	540	33	3	2	10	8	31
15	f	420	40	13	810	58	5	7	16	28	51
16	f	180	35	3.5	560	21	3	3	16	12	18
17	f	430	70	14	590	62	6	9	16	35	53
18	f	280	40	13	740	30	4	4	16	16	26
19	f	290	20	13	220	27	2	1	13	6	26
20	d	160	0	0.5	460	34	1	2	4	8	32
21	f	250	65	14	480	9	1	0	21	0	9
22	f	250	55	14	430	13	1	1	18	4	12
23	f	310	40	10	890	37	3	2	17	8	35
24	f	430	20	21	690	45	3	4	16	16	41
25	f	370	20	11	780	54	8	6	13	24	48
26	f	240	30	14	440	18	2	3	9	12	15

(Table B.1 Continued)

Item #	Item Type	Calories	Total Cholesterol (mg)	Total Fat (g)	Sodium (mg)	Total Carbohydrate (g)	Total Sugar (g)	Total Fiber (g)	Total Protein (g)	Total Fiber (%DV)	Digestible Carbohydrate (g)
27	f	170	0	2.5	490	32	4	10	12	40	22
28	f	260	10	7	390	35	5	5	7	20	30
29	f	220	10	9	600	28	6	4	7	16	24
30	f	90	5	2.5	450	9	3	5	9	18	4
31	f	370	90	18	890	38	9	2	16	7	36
32	f	280	95	16	680	26	2	1	9	3	25
33	f	300	35	14	510	35	3	0	17	0	35
34	f	400	115	25	790	30	6	0	14	0	30
35	f	410	340	34	1230	19	0	2	28	9	17
36	f	240	25	8	720	19	1	2	22	8	17
37	f	180	0	7	180	27	9	1	3	2	26
38	f	90	5	4	200	6	0	2	10	8	4
39	f	320	15	3	690	62	19	1	11	4	61
40	f	240	40	11	1120	26	4	2	10	8	24
41	f	310	20	11	670	42	2	2	10	8	40
42	f	380	45	15	1260	41	8	5	20	20	36
43	f	470	95	17	520	62	10	3	18	12	59
44	f	500	65	21	990	56	12	2	21	8	54
45	f	210	5	3.5	220	38	4	3	8	12	35
46	f	410	40	14	610	47	2	3	23	12	44
47	f	190	10	4	530	33	6	4	6	16	29
48	f	480	150	20	980	56	5	3	18	12	53
49	f	420	85	21	930	39	4	4	19	16	35
50	f	220	20	4	580	31	5	4	16	16	27
51	f	250	30	6	580	40	10	4	8	16	36
52	f	290	25	5	640	49	4	3	11	12	46

(Table B.1 Continued)

Item #	Item Type	Calories	Total Cholesterol (mg)	Total Fat (g)	Sodium (mg)	Total Carbohydrate (g)	Total Sugar (g)	Total Fiber (g)	Total Protein (g)	Total Fiber (%DV)	Digestible Carbohydrate (g)
53	f	220	65	9	610	13	1	2	21	9	11
54	f	250	10	4.5	460	42	10	8	11	32	34
55	f	300	40	16	340	27	1	1	12	5	26
56	d	80	0	1	500	18	1	2	2	9	16
57	d	30	0	0	730	6	3	1	1	2	5
58	d	40	0	0	530	8	1	1	2	4	7
59	d	280	0	1	900	59	3	1	5	6	58
60	d	260	5	1.5	660	45	1	2	6	8	43
61	d	150	5	1.5	460	32	7	1	4	3	31
62	s	60	0	0	170	12	1	0	2	0	12
63	s	160	0	3	290	29	1	4	7	23	25
64	s	190	0	5	140	32	11	5	8	19	27
65	s	150	5	5	85	26	8	5	2	20	21
66	s	190	0	7	180	24	13	2	10	6	22
67	s	140	0	7	100	17	7	5	6	20	12
68	s	190	0	7	150	29	12	2	4	8	27
69	d	100	0	1.5	460	20	1	1	3	5	19
70	d	100	0	1.5	470	20	1	1	3	5	19
71	f	180	<5	8	320	19	0	1	5	3	18
72	f	190	0	6	380	31	7	3	5	11	28
73	f	190	0	8	180	26	9	1	3	2	25
74	f	210	65	10	550	23	8	2	9	6	21
75	f	170	20	9	440	18	1	2	4	8	16
76	d	160	0	0.5	440	34	0	1	4	4	33
77	f	330	15	16	690	37	3	2	10	8	35
78	f	220	25	7	470	28	1	3	10	12	25

(Table B.1 Continued)

Item #	Item Type	Calories	Total Cholesterol (mg)	Total Fat (g)	Sodium (mg)	Total Carbohydrate (g)	Total Sugar (g)	Total Fiber (g)	Total Protein (g)	Total Fiber (%DV)	Digestible Carbohydrate (g)
79	d	420	35	10	1110	61	13	4	22	16	57
80	f	630	80	18	1060	85	4	5	30	18	80
81	f	700	45	44	1060	61	9	6	21	24	55
82	f	440	75	21	1170	35	3	4	26	16	31
83	f	230	25	8	710	24	6	2	15	8	22
84	f	220	80	6	850	31	12	2	10	8	29
85	f	280	<5	11	820	38	3	1	9	4	37
86	f	470	52	24	765	43	4	2	21	8	41
87	f	350	0	0.5	580	23	1	2	2	2	21
88	d	360	5	7	820	31	5	1	8	4	30
89	d	90	15	3.5	850	10	0	0	4	0	10
90	d	190	0	12	1190	39	2	2	7	8	37
91	d	330	50	18	990	28	0	2	15	8	26
92	d	310	5	8	860	51	6	2	10	7	49
93	d	230	10	7	700	34	5	4	7	16	30
94	d	200	10	7	790	24	2	2	6	8	22
95	d	160	5	7	4	20	4	5	4	20	15
96	s	160	0	2	210	34	7	18	4	40	16
97	s	160	0	2	260	32	12	4	4	12	28
98	s	200	0	5	170	38	16	1	2	3	37
99	d	160	10	3.5	580	25	3	5	9	20	20
100	d	150	10	3.5	640	23	3	3	7	12	20
101	s	120	0	3	125	24	11	3	2	10	21
102	s	170	0	8	200	18	9	7	10	30	11
103	d	250	25	14	770	21	9	2	9	8	19
104	d	210	25	5	790	25	9	4	15	8	21

(Table B.1 Continued)

Item #	Item Type	Calories	Total Cholesterol (mg)	Total Fat (g)	Sodium (mg)	Total Carbohydrate (g)	Total Sugar (g)	Total Fiber (g)	Total Protein (g)	Total Fiber (%DV)	Digestible Carbohydrate (g)
105	d	210	10	8	750	28	4	3	7	12	25
106	d	350	480	25	900	11	1	1	20	4	10
107	d	160	0	4.5	890	27	3	2	2	8	25
108	d	30	0	1	720	5	3	3	1	1	2
109	d	209	0	1	0	44	0	2	5	8	42
110	d	310	<5	2	630	45	4	4	9	12	41
111	f	230	85	13	340	18	4	1	9	3	17
112	f	290	25	7	480	42	5	1	12	4	41
113	d	220	30	9	980	24	5	6	11	24	18
114	f	700	45	44	1060	61	9	6	21	24	55
115	f	230	25	8	710	24	6	2	15	8	22
116	f	320	50	5	390	43	2	2	20	8	41
117	f	360	30	16	480	38	6	5	16	20	33
118	f	400	30	23	780	40	4	4	9	16	36
119	f	200	0	4.5	260	37	23	3	1	12	34
120	f	200	0	6	330	33	1	1	2	4	32
121	f	160	10	4.5	480	21	3	4	11	16	17
122	f	400	15	18	680	40	4	6	20	24	34
123	f	250	25	12	230	32	17	1	3	4	31
124	f	210	0	7	460	34	4	1	1	4	33
125	s	190	0	7	60	28	9	3	3	12	25
126	s	150	0	2	130	29	1	3	4	12	26
127	s	180	0	4	125	32	9	9	11	34	23
128	s	130	0	5	250	19	1	0	3	0	19
129	d	150	0	0.5	760	27	5	7	8	28	20
130	d	100	5	1	480	17	2	2	5	8	15

(Table B.1 Continued)

Item #	Item Type	Calories	Total Cholesterol (mg)	Total Fat (g)	Sodium (mg)	Total Carbohydrate (g)	Total Sugar (g)	Total Fiber (g)	Total Protein (g)	Total Fiber (%DV)	Digestible Carbohydrate (g)
131	d	80	0	1	600	15	4	5	4	20	10
132	d	130	0	0.5	480	23	2	9	8	36	14
133	d	200	50	15	320	9	1	1	7	4	8
134	d	170	0	1	340	31	2	12	9	48	19
135	f	280	20	16	280	22	0	5	10	20	17
136	s	100	10	5	180	9	0	0	5	0	9
137	f	90	0	2	390	9	1	4	10	16	5
138	f	100	0	1.5	390	9	0	5	11	20	4
139	f	240	0	14	200	21	2	4	8	16	17
140	f	320	0	10	750	48	4	4	11	16	44
141	f	430	90	13	480	66	4	3	12	12	63
142	f	270	40	12	650	25	6	5	18	20	20
143	f	460	120	26	780	44	4	3	12	12	41
144	f	350	0	17	490	43	3	7	8	27	36
145	f	260	20	4.5	170	44	1	2	10	8	42
146	f	320	20	8	550	43	2	3	16	12	40
147	d	500	0	12	1000	86	17	3	16	12	83
148	d	140	0	1	380	26	2	9	8	36	17
149	d	200	0	1	0	42	2	5	7	20	37
150	d	70	0	0	310	15	1	1	2	4	14
151	f	410	35	16	520	47	14	3	19	12	44
152	f	230	35	2.5	460	29	5	8	24	32	21
153	f	400	90	21	840	34	3	3	19	11	31
154	f	170	35	9	350	10	0	0	12	0	10
155	d	300	0	0.5	430	41	3	1	2	4	40
156	d	110	0	0	90	25	4	1	1	4	24

(Table B.1 Continued)

Item #	Item Type	Calories	Total Cholesterol (mg)	Total Fat (g)	Sodium (mg)	Total Carbohydrate (g)	Total Sugar (g)	Total Fiber (g)	Total Protein (g)	Total Fiber (%DV)	Digestible Carbohydrate (g)
157	s	130	0	3	135	24	8	1	2	4	23
158	f	250	45	11	930	45	2	3	13	12	42
159	f	420	25	16	550	54	14	7	15	28	47
160	f	230	15	10	510	27	0	3	8	12	24
161	f	410	20	20	590	47	1	4	10	16	43
162	f	270	0	5	620	43	3	2	11	6	41
163	f	230	25	8	710	24	6	2	15	8	22
164	f	320	30	10	660	41	8	3	16	12	38
165	f	450	65	20	1120	41	5	7	25	28	34
166	f	210	20	7	430	25	4	2	11	8	23
167	f	340	20	8	680	52	7	4	16	18	48
168	s	220	30	4	420	38	7	4	7	16	34
169	f	300	25	9	670	43	8	4	12	16	39
170	f	290	30	5	580	44	3	5	16	19	39
171	f	180	5	3	500	27	1	1	12	4	26
172	f	340	20	18	550	35	3	1	10	4	34
173	f	330	20	13	820	44	10	1	9	4	43
174	s	210	20	7	290	29	2	2	8	9	27
175	d	190	5	8	400	27	9	1	3	6	26
176	f	180	0	7	180	27	9	1	3	2	26
177	f	370	145	26	770	22	3	2	12	8	20
178	f	260	90	5	480	32	3	2	16	8	30
179	f	120	70	5	370	10	2	0	8	0	10
180	f	130	55	3	950	15	2	1	10	4	14
181	f	260	80	2	390	42	2	2	17	8	40
182	f	140	10	3	490	20	5	5	9	19	15

(Table B.1 Continued)

Item #	Item Type	Calories	Total Cholesterol (mg)	Total Fat (g)	Sodium (mg)	Total Carbohydrate (g)	Total Sugar (g)	Total Fiber (g)	Total Protein (g)	Total Fiber (%DV)	Digestible Carbohydrate (g)
183	f	360	90	18	780	23	2	1	37	4	22
184	d	150	0	1.5	450	31	6	1	5	4	30
185	s	120	0	3	110	24	12	3	2	10	21
186	d	210	0	2.5	420	44	14	2	4	8	42
187	d	200	10	7	750	28	5	3	6	12	25
188	f	25	0	0	580	6	0	1	1	4	5
189	d	200	0	3	400	36	1	1	4	4	35
190	d	150	0	3.5	870	28	5	1	3	4	27
191	d	140	0	5	680	29	7	6	6	24	23
192	d	150	0	0	690	27	5	5	8	19	22
193	d	90	5	2	630	16	9	2	2	8	14
194	d	70	0	0	750	15	3	2	3	8	13
195	d	250	0	1	660	39	4	1	6	5	38
196	d	380	10	9	910	27	7	1	7	4	26
197	d	270	10	8	590	40	5	2	10	8	38
198	s	200	0	6	360	33	0	2	4	4	31
199	s	200	0	6	360	33	0	2	4	4	31
200	s	280	0	6	120	41	15	4	6	16	37
201	f	190	20	3	360	25	0	2	7	6	23
202	f	190	15	3	330	22	1	1	6	2	21
203	f	260	55	10	620	33	0	2	16	6	31
204	f	190	15	2.5	540	26	0	2	7	6	24
205	f	210	0	8	390	28	3	2	6	7	26
206	f	420	25	20	850	46	13	2	14	9	44
207	f	230	20	10	360	27	2	2	9	6	25
208	f	290	254	9	510	41	5	2	10	7	39

(Table B.1 Continued)

Item #	Item Type	Calories	Total Cholesterol (mg)	Total Fat (g)	Sodium (mg)	Total Carbohydrate (g)	Total Sugar (g)	Total Fiber (g)	Total Protein (g)	Total Fiber (%DV)	Digestible Carbohydrate (g)
209	s	180	15	10	420	14	1	1	8	2	13
210	f	420	25	17	620	49	6	3	17	12	46
211	f	400	35	19	660	41	7	3	16	12	38
212	f	350	35	17	640	34	4	2	10	8	32
213	f	480	120	26	1380	35	4	2	16	8	33
214	f	100	35	5	240	9	0	0	5	0	9
215	f	80	25	3	1040	8	2	0	7	0	8
216	f	290	35	17	470	29	1	0	6	0	29
217	f	190	35	1	650	34	6	2	10	12	32
218	f	140	50	5	190	17	1	2	6	8	15
219	f	490	40	27	1180	48	6	1	14	4	47
220	f	420	110	35	85	0	0	0	25	0	0
221	f	250	80	18	640	4	0	2	20	8	2
222	f	370	30	14	680	45	8	4	17	16	41
223	f	330	0	8	740	53	4	9	9	36	44
224	f	220	10	10	260	25	1	1	7	4	24
225	f	200	10	10	290	26	1	1	8	4	25
226	f	300	15	15	330	33	1	3	9	12	30
227	f	120	15	7	80	9	0	1	6	4	8
228	f	155	15	6	360	19	8	2	5	6	17
229	f	400	95	20	640	38	1	3	15	12	35
230	f	400	35	23	780	36	2	2	10	8	34
231	f	260	10	5	600	42	9	3	12	12	39
232	f	320	10	4	570	10	8	4	15	16	6
233	f	230	30	6	690	33	12	3	11	12	30
234	f	290	25	6	610	44	3	2	14	8	42

(Table B.1 Continued)

Item #	Item Type	Calories	Total Cholesterol (mg)	Total Fat (g)	Sodium (mg)	Total Carbohydrate (g)	Total Sugar (g)	Total Fiber (g)	Total Protein (g)	Total Fiber (%DV)	Digestible Carbohydrate (g)
235	f	210	15	6	470	28	2	7	11	27	21
236	f	300	20	9	530	43	10	6	13	24	37
237	f	300	25	7	650	44	3	5	16	22	39
238	f	190	15	8	360	21	3	3	9	14	18
239	d	290	30	9	800	36	14	3	15	12	33
240	d	270	25	8	950	33	8	8	17	32	25
241	d	220	55	3.5	600	29	4	3	19	28	26
242	d	260	15	9	750	35	9	4	9	16	31
243	s	160	0	4	90	28	16	1	3	4	27
244	s	140	0	4	90	29	10	9	2	35	20
245	s	190	0	6	160	29	12	2	4	8	27
246	d	140	10	1.5	470	27	6	1	3	3	26
247	s	190	0	5	135	38	1	10	7	40	28
248	d	230	0	0.5	900	46	1	6	9	24	40
249	d	240	5	6	660	43	3	1	6	4	42
250	d	130	0	0.5	520	21	1	1	1	5	20
251	s	140	0	4	250	23	0	3	3	12	20
252	s	200	0	1	5	41	3	2	7	8	39
253	d	350	480	26	920	8	2	1	17	4	7
254	d	160	30	9	660	9	2	2	10	8	7
255	f	340	30	11	680	43	8	4	16	16	39
256	f	380	60	10	600	45	8	7	28	27	38
257	f	140	10	3	400	21	4	3	8	10	18
258	f	280	0	7	740	44	4	10	9	40	34
259	f	150	15	5	710	19	4	2	8	10	17
260	f	230	20	10	360	27	3	2	9	6	25

(Table B.1 Continued)

Item #	Item Type	Calories	Total Cholesterol (mg)	Total Fat (g)	Sodium (mg)	Total Carbohydrate (g)	Total Sugar (g)	Total Fiber (g)	Total Protein (g)	Total Fiber (%DV)	Digestible Carbohydrate (g)
261	f	250	10	5	460	39	9	5	13	19	34
262	f	210	15	6	470	28	2	7	11	27	21
263	d	15	3	0	410	3	0	0	0	0	3
264	f	480	50	18	1200	58	6	3	22	12	55
265	f	340	0	16	300	47	17	2	3	8	45
266	d	130	0	0.5	290	23	2	9	8	39	14
267	d	110	10	3.5	510	18	5	4	2	16	14
268	d	150	30	9	750	17	10	2	2	8	15
269	d	150	0	1	480	29	1	6	8	24	23
270	f	380	25	17	690	43	6	2	13	8	41
271	f	270	50	8	700	35	2	2	13	8	33
272	f	320	10	15	610	37	3	1	10	4	36
273	f	240	255	18	770	5	3	0	15	0	5
274	f	340	315	19	810	20	1	2	21	10	18
275	f	320	25	17	370	33	2	1	10	4	32
276	f	240	35	8	520	33	12	1	10	4	32
277	s	210	0	9	240	28	9	2	6	7	26
278	f	270	90	12	670	18	5	2	23	8	16
279	f	180	0	5	370	31	7	3	4	11	28
280	f	230	10	4	380	45	10	1	4	4	44
281	f	200	100	8	730	20	3	3	12	12	17
282	f	290	0	9	490	45	5	3	8	13	42
283	f	330	30	12	560	42	1	3	14	12	39
284	f	340	30	13	530	41	1	2	14	8	39
285	d	320	79	3.5	640	44	3	3	9	12	41
286	d	290	30	9	800	36	14	3	15	12	33

(Table B.1 Continued)

Item #	Item Type	Calories	Total Cholesterol (mg)	Total Fat (g)	Sodium (mg)	Total Carbohydrate (g)	Total Sugar (g)	Total Fiber (g)	Total Protein (g)	Total Fiber (%DV)	Digestible Carbohydrate (g)
287	d	250	45	11	1300	22	3	2	15	8	20
288	d	100	0	0.5	480	21	1	1	4	4	20
289	d	140	5	3.5	750	22	3	1	5	4	21
290	d	220	5	4.5	400	37	2	3	7	12	34
291	d	220	10	8	590	30	3	1	8	4	29
292	d	160	25	6	890	16	2	1	9	4	15
293	d	190	10	7	700	26	4	2	6	8	24
294	d	220	25	6	770	26	4	6	13	24	20
295	d	230	10	7	750	34	6	3	7	12	31
296	d	35	0	0	60	7	1	7	1	4	0
297	d	0	0	0	1060	31	1	1	3	4	30
298	d	190	5	5	520	21	2	1	2	4	20
299	d	180	0	0	15	17	1	1	2	6	16
300	d	170	5	4.5	340	27	7	1	2	3	26
301	d	280	5	2.5	660	47	1	1	6	4	46
302	d	310	10	3.5	660	42	3	2	9	8	40
303	d	100	5	4	890	13	1	1	3	4	12
304	d	140	20	5	790	17	3	3	7	12	14
305	d	70	15	2	870	15	0	1	3	4	14
306	d	90	15	1	390	12	2	1	8	4	11
307	d	70	0	0	310	15	1	1	2	4	14
308	d	160	0	0	590	34	1	0	4	0	34
309	d	240	5	0	660	43	3	1	6	4	42
310	d	260	15	9	750	35	9	4	9	16	31
311	d	160	5	1	690	28	1	7	10	28	21
312	d	190	5	3.5	530	30	1	8	10	32	22

(Table B.1 Continued)

Item #	Item Type	Calories	Total Cholesterol (mg)	Total Fat (g)	Sodium (mg)	Total Carbohydrate (g)	Total Sugar (g)	Total Fiber (g)	Total Protein (g)	Total Fiber (%DV)	Digestible Carbohydrate (g)
313	d	180	10	3.5	670	30	1	7	9	28	23
314	d	140	40	3	670	14	10	1	14	4	13
315	d	290	30	9	800	36	14	3	15	12	33
316	d	250	0	1	660	39	4	1	6	5	38
317	d	210	15	7	600	31	3	1	8	5	30
318	d	360	5	7	820	31	5	1	8	4	30
319	d	280	0	0.5	560	25	1	1	3	3	24
320	s	70	0	8	310	30	20	4	20	16	26
321	s	170	0	4.5	180	26	15	5	10	20	21
322	f	410	130	26	830	26	4	2	12	7	24
323	f	230	20	13	410	23	10	1	6	2	22
324	f	260	70	17	640	5	1	0	20	0	5
325	f	140	50	5	190	17	1	2	6	8	15
326	f	210	41	19	680	1	0	0	10	0	1
327	f	310	50	26	950	6	0	1	13	3	5
328	f	290	30	18	480	29	1	0	6	0	29
329	f	300	120	9	1170	33	7	2	23	8	31
330	f	100	35	5	240	9	0	0	5	0	9
331	f	70	10	2	260	8	2	1	4	4	7
332	f	90	30	4.5	460	7	2	1	5	4	6
333	f	630	80	18	1060	85	4	5	30	18	80
334	f	230	35	9	500	25	2	1	11	4	24
335	f	270	65	17	500	19	2	3	12	10	16
336	f	340	30	14	560	42	27	1	11	4	41
337	f	410	15	12	530	66	34	5	11	20	61
338	s	220	0	0	95	56	51	0	1	0	56

(Table B.1 Continued)

Item #	Item Type	Calories	Total Cholesterol (mg)	Total Fat (g)	Sodium (mg)	Total Carbohydrate (g)	Total Sugar (g)	Total Fiber (g)	Total Protein (g)	Total Fiber (%DV)	Digestible Carbohydrate (g)
339	f	440	100	24	1000	36	2	2	20	9	34
340	f	480	185	28	990	32	2	2	24	8	30
341	d	380	190	16	830	35	1	1	22	4	34
342	d	220	5	1.5	570	31	3	1	5	4	30
343	s	290	0	8	270	53	22	5	6	21	48
344	s	270	0	7	240	49	18	5	6	21	44
345	s	280	0	8	200	49	19	5	7	20	44
346	s	300	0	10	45	37	10	5	6	20	32
347	s	90	0	2.5	80	17	5	5	1	20	12
348	f	320	10	13	740	42	4	2	10	7	40
349	f	180	35	8	490	14	1	0	14	0	14
350	f	310	45	8	720	40	11	1	20	4	39
351	f	270	30	14	660	26	5	1	9	4	25
352	f	350	20	15	910	39	5	3	14	12	36
353	f	400	15	18	650	48	13	1	12	4	47
354	f	210	5	9	350	26	2	1	7	5	25
355	f	260	15	14	630	39	2	2	7	8	37
356	f	30	5	2	135	2	1	1	2	2	1
357	f	260	15	19	460	15	1	1	7	4	14
358	f	220	10	10	260	25	1	1	7	4	24
359	f	220	10	10	290	26	1	1	8	4	25
360	f	290	15	14	300	33	1	3	9	12	30
361	f	290	15	14	340	33	1	3	9	12	30
362	f	310	10	3.5	190	54	3	5	12	8	49
363	f	390	2	6	280	67	6	3	12	12	64
364	f	210	25	4	180	36	2	1	8	5	35

(Table B.1 Continued)

Item #	Item Type	Calories	Total Cholesterol (mg)	Total Fat (g)	Sodium (mg)	Total Carbohydrate (g)	Total Sugar (g)	Total Fiber (g)	Total Protein (g)	Total Fiber (%DV)	Digestible Carbohydrate (g)
365	f	190	15	9	490	19	2	1	6	4	18
366	f	230	85	13	340	18	4	1	9	3	17
367	f	210	20	11	300	21	1	2	7	8	19
368	f	240	25	8	650	31	9	2	12	8	29
369	f	190	35	10	750	9	2	1	17	4	8
370	f	230	40	11	430	20	5	2	16	8	18
371	f	480	135	28	780	42	1	3	16	13	39
372	f	270	75	21	590	4	1	1	15	4	3
373	f	410	30	22	740	44	8	3	10	12	41
374	f	400	95	20	640	38	1	3	15	12	35
375	f	480	50	21	700	56	22	5	17	20	51
376	f	360	30	16	480	38	6	5	16	20	33
377	f	370	15	11	1020	63	2	9	12	35	54
378	f	500	70	24	990	41	3	6	30	24	35
379	f	540	80	27	1020	47	4	3	26	12	44
380	f	420	70	15	810	42	5	4	27	16	38
381	f	200	95	7	420	20	2	4	13	15	16
382	f	190	5	2	190	38	16	5	5	20	33
383	f	290	20	9	680	39	6	3	14	12	36
384	f	190	10	3	500	28	2	2	12	8	26
385	f	370	400	29	1030	6	2	1	22	4	5
386	f	320	130	24	620	14	2	0	10	0	14
387	f	230	70	7	750	16	2	1	25	4	15
388	d	160	55	7	600	8	2	2	16	8	6
389	d	220	15	2.5	610	42	9	1	6	5	41
390	d	170	0	2	440	17	3	2	2	8	15

(Table B.1 Continued)

Item #	Item Type	Calories	Total Cholesterol (mg)	Total Fat (g)	Sodium (mg)	Total Carbohydrate (g)	Total Sugar (g)	Total Fiber (g)	Total Protein (g)	Total Fiber (%DV)	Digestible Carbohydrate (g)
391	s	110	0	1.5	170	22	6	3	3	12	19
392	s	160	0	1	0	35	0	1	4	4	34
393	s	200	0	7	200	24	12	2	10	8	22
394	s	120	0	3	425	24	11	3	2	10	21
395	s	80	0	2	60	15	7	2	1	8	13
396	d	190	20	2	740	28	7	7	14	28	21
397	d	170	30	10	880	17	8	2	2	8	15
398	d	210	20	7	710	25	5	6	11	24	19

APPENDIX C: INSTITUTIONAL REVIEW BOARD APPROVAL

The research presented in this document included a blind consumer survey and a consumer sensory test. Both of these components required prior approval by the Louisiana State University (LSU) Institutional Review Board (IRB) committee as per state regulation requirements. The approved application and supporting documentation are included in the following pages (Figures C.1, C.2, and C.3).

LSU AgCenter Research & Extension

LSU AgCenter Institutional Review Board (IRB)
Dr. Michael J. Keenan, Chair
School of Human Ecology
209 Knapp Hall
225-578-1708
mkeenan@agctr.lsu.edu

Application for Exemption from Institutional Oversight

All research projects using living humans as subjects, or samples or data obtained from humans must be approved or exempted in advance by the LSU AgCenter IRB. This form helps the principal investigator determine if a project may be exempted, and is used to request an exemption.

- Applicant, please fill out the application in its entirety and include the completed application as well as parts A-E, listed below, when submitting to the LSU AgCenter IRB. Once the application is completed, please submit the original and one copy to the chair, Dr. Michael J. Keenan, in 209 Knapp Hall.

- A Complete Application Includes All of the Following:
  (A) The original and a copy of this completed form and a copy of parts B through E.
  (B) A brief project description (adequate to evaluate risks to subjects and to explain your responses to Parts 1 & 2)
  (C) Copies of all instruments and all recruitment material to be used.
    - If this proposal is part of a grant proposal, include a copy of the proposal.
  (D) The consent form you will use in the study (see part 3 for more information)
  (E) Beginning January 1, 2009: Certificate of Completion of Human Subjects Protection Training for all personnel involved in the project, including students who are involved with testing and handling data, unless already on file with the LSU AgCenter IRB.
  Training link: (http://grants.nih.gov/grants/policy/hs/training.htm)

1) Principal Investigator: Witoon Prinyawiwatkul **Rank:** Professor **Student?** No
School of Nutrition and Food Sciences **Ph:** 8-5188
E-mail: wprinyawiwatkul@agcenter.lsu.edu **and** wprinya@lsu.edu

2) Co-Investigator(s): please include department, rank, phone and e-mail for each NONE
- If student as principal or co-investigator(s), please identify and name supervising professor in this space

3) Project Title: The Development of a Low Glycemic High Fiber Bean Pasta
4) Grant Proposal?(yes or no) NO **If Yes, Proposal Number and funding Agency**______
Also, if Yes, either: **this application completely matches the scope of work in the grant Y/N**__
OR
more IRB applications will be filed later Y/N___
5) Subject pool (e.g. Nutrition Students) **LSU Faculty, Staff, Students and off-campus consumers**
- Circle any **"vulnerable populations" to be used:** (children<18, the mentally impaired, pregnant women, the aged, other). ~~Projects with~~ incarcerated persons cannot be exempted. **NONE**

6) PI signature______ ****Date** 3-12-2015 (no per signatures)
****I certify that my responses are accurate and complete.** If the project scope or design is later changed I will resubmit for review. I will obtain written approval from the Authorized Representative of all non-LSU AgCenter institutions in which the study is conducted. I also understand that it is my responsibility to maintain copies of all consent forms at the LSU AgCenter for three years after completion of the study. If I leave the LSU AgCenter before that time the consent forms should be preserved in the Departmental Office.

Committee Action: Exempted ✓ Not Exempted____ **IRB#** HE15-17
Reviewer Michael Keenan **Signature** Michael Keenan **Date** 9-4-2015

Figure C.1 Approved Application for Exemption from Institutional Oversight

(Figure C.1 Continued)

APPROVED BY
LSU AG CENTER
IRB AS #E15-17
ON 9-4-2015

Research Consent Form

I, ________________________, agree to participate in the research entitled "The Development of a High Fiber Low Glycemic Bean Pasta" which is being conducted by Christopher Ringuette, Graduate Student at Louisiana State university, under supervision of Dr. Witoon Prinyawiwatkul, Professor of the School of Nutrition and Food Sciences at Louisiana State University, Agricultural Center, phone number (225) 578-5188.

I understand that participation is entirely voluntary and whether or not I participate will not affect how I am treated on my job. I can withdraw my consent at any time without penalty or loss of benefits to which I am otherwise entitled and have the results of the participation returned to me, removed from the experimental records, or destroyed. Up to 100 consumers will participate in this research. For this particular research, about 15-20 minutes participation will be required for each consumer.

The following points have been explained to me:

1. In any case, it is my responsibility to report prior to participation to the investigator any food allergies I may have.

2. The reason for the research is to gather information on sensory acceptability, emotion and purchase intent of new and healthier food products. The benefit that I may expect from it is a satisfaction that I have contributed to quality improvement of these products.

3. The procedures are as follows: 3-5 coded samples will be placed in front of me, and I will evaluate them by normal standard methods and indicate my evaluation on score sheets. All procedures are standard methods as published by the American Society for Testing and Materials and the Sensory Evaluation Division of the Institute of Food Technologists.

4. Participation entails minimal risk: The only risk which can be envisioned is that of an allergic reaction toward common food ingredients [red beans, bell pepper, onion, garlic, celery, thyme, cayenne pepper, bay leaf, pork products, rice and rice products, milk and dairy products, yogurt or fermented milk products, peanuts, mayonnaise products, wheat flour, tapioca flour, eggs, table sugar, vanilla, sweet potato, salt (sodium chloride) and salt substitute (potassium chloride and common amino acids such as glycine and lysine), and plain unsalted crackers]. However, because it is known to me beforehand that the food to be tested contains common food ingredients, the situation can normally be avoided.

5. The results of this study will not be released in any individual identifiable form without my prior consent unless required by law.

6. The investigator will answer any further questions about the research, either now or during the course of the project.

The study has been discussed with me, and all of my questions have been answered. I understand that additional questions regarding the study should be directed to the investigator listed above. In addition, I understand the research at Louisiana State University, Agricultural Center, which involves human participation, is carried out under the oversight of the Institutional Review Board. Questions or problems regarding these activities should be addressed to Dr. Michael Keenan, Chair of LSU AgCenter IRB, (225) 578-1708. I agree with the terms above and acknowledge.

I have been given a copy of the consent form.

______________________ Signature of Investigator

______________________ Signature of Participant

Witness: ______________________

Date: ______________________

Experimental Protocol for "The Development of a High Fiber Low Glycemic Bean Pasta" to be conducted by Christopher Ringuette, Graduate Student under supervision of Witoon Prinyawiwatkul, Professor, School of Nutrition and Food Sciences, LSU AgCenter

1. Consumers who will be participating in this study consist of faculty, students, and staff from LSU campus as well as off-campus consumers (Retirement home individuals). Up to 100 consumers will be participating. No vulnerable populations and incarcerated persons will be recruited for this study.

2. Upon arrival at the testing location,
- if a paper ballot is used, each consumer will be given a set of questionnaire including a consent form.
- if a computerized ballot is used, a set of questionnaire including a consent form will be provided on a computer screen.

3. After reading and signing (a paper ballot) or acknowledging (a computer ballot) the consent form, consumers will be provided with 3-5 samples (either red beans and rice, pasta filata, telita, demano or cheddar cheeses, angel cake, sponge cake, sweet potato soup, hard-boiled eggs, mayonnaise, peanuts, kefir, iced tea, BBQ sauces, bagels, vegetable salads, pasta, etc.). These are either commercial products or lab-prepared samples containing only GRAS ingredients. Consumers will also be provided with water and unsalted crackers to cleanse the palate between samples.

4. Consumers will then evaluate the samples according to the questionnaire that corresponds with each sample. They have to indicate their perception (sensory differences and/or acceptability) of the products (See the attached questionnaire).

5. After evaluating all samples, consumers will be provided with gratis refreshment (soft drink or beverages) as an incentive for participating in the study.

6. Data collected will be analyzed and interpretation of the results will be done. The results will not be released in any individually identifiable form without prior consent from the consumers. In fact, the consumer names will not be collected on the questionnaire.

Figure C.2 Experimental Protocol

APPENDIX D: AMYLOGRAPHS

The amylographs for each flour sample analyzed with the Rapid Visco Analyzer are included here. The RVA was completed using a Newport scientific RVA-4 (Newport Scientific Pty. Ltd., Warriewood NSW, Australia) machine and a Neslab RTE 7 water bath (Thermo Fisher Scientific, Newington, NH). The RVA software accompanying the machine was set to run each sample for a 13 minute cycle adjusting temperature and speed at the different times as defined in the RVA Durum Method 11.06 (Perten Instruments, 2007). The amylographs are presented in the same order of the flour mixtures in Table 3.2. As discussed in Chapter 4, the trapezoidal line in each plot refers to the temperature (°C) inside the Rapid Visco Analyzer during the testing process. The flat line towards the bottom of each plot gives the rotation rate of the paddle in revolutions per minute (rpm). The curve represents the viscosity of each flour mixture sample in the standard centoPoise units (cP). The value of each quantity is plotted over time (minutes). The Rapid Visco Analysis (RVA) procedure was done in duplicates for all the flour mixtures except for the 100% bean flour since the results from those three flours were only used as a maximum reference point. The percentage weights of the bean and control flours in each flour mixture are indicated in the figure titles. As in the text, the first number indicates the percentage by weight of the bean flour specified, and the second number indicates the percentage by weight of the control flour. The implications of the features of these graphs are discussed in Section 4.2.1. The graphs begin on the following page.

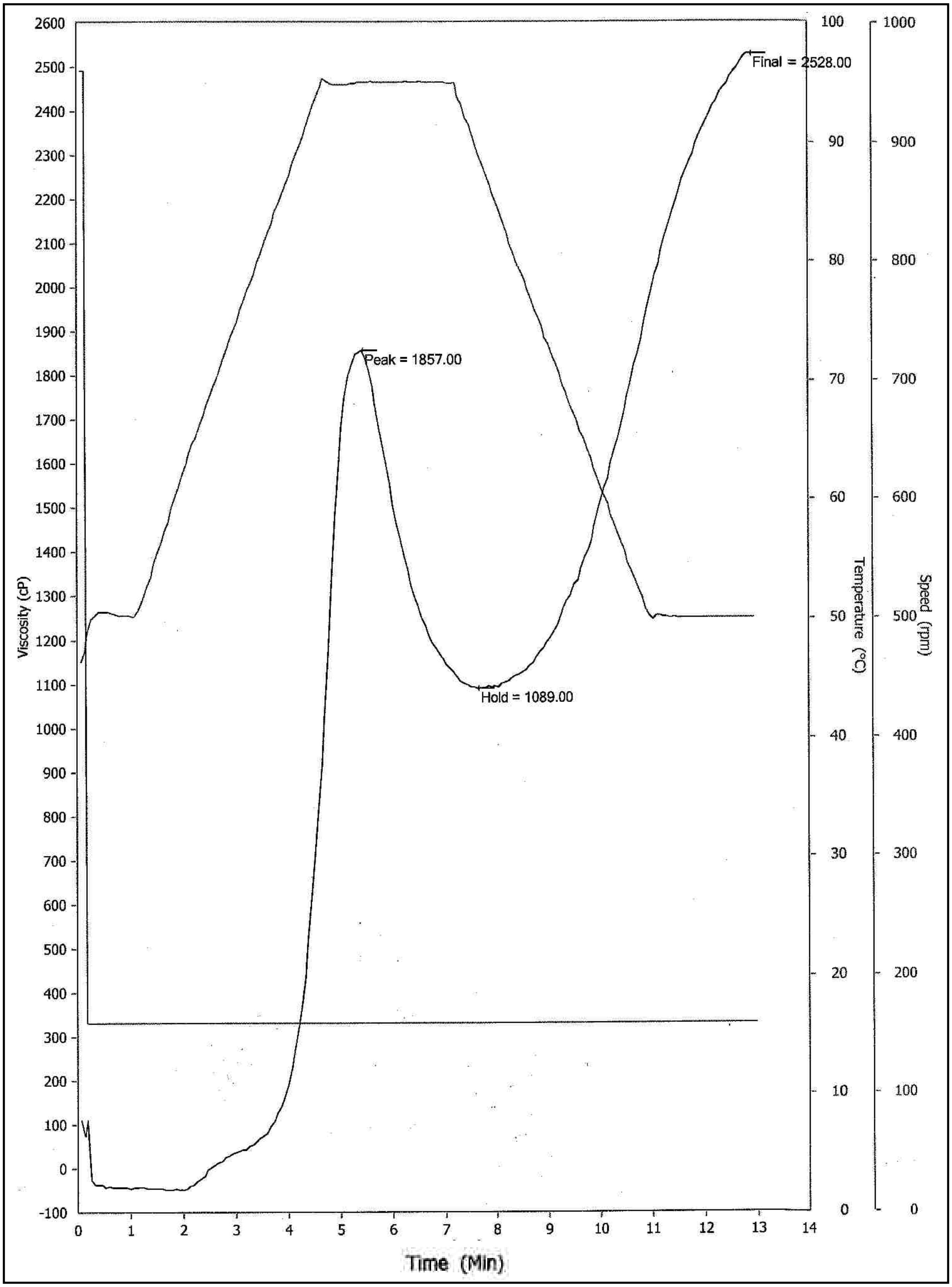

Figure D.1 Amylograph for the Control Flour Mixture A

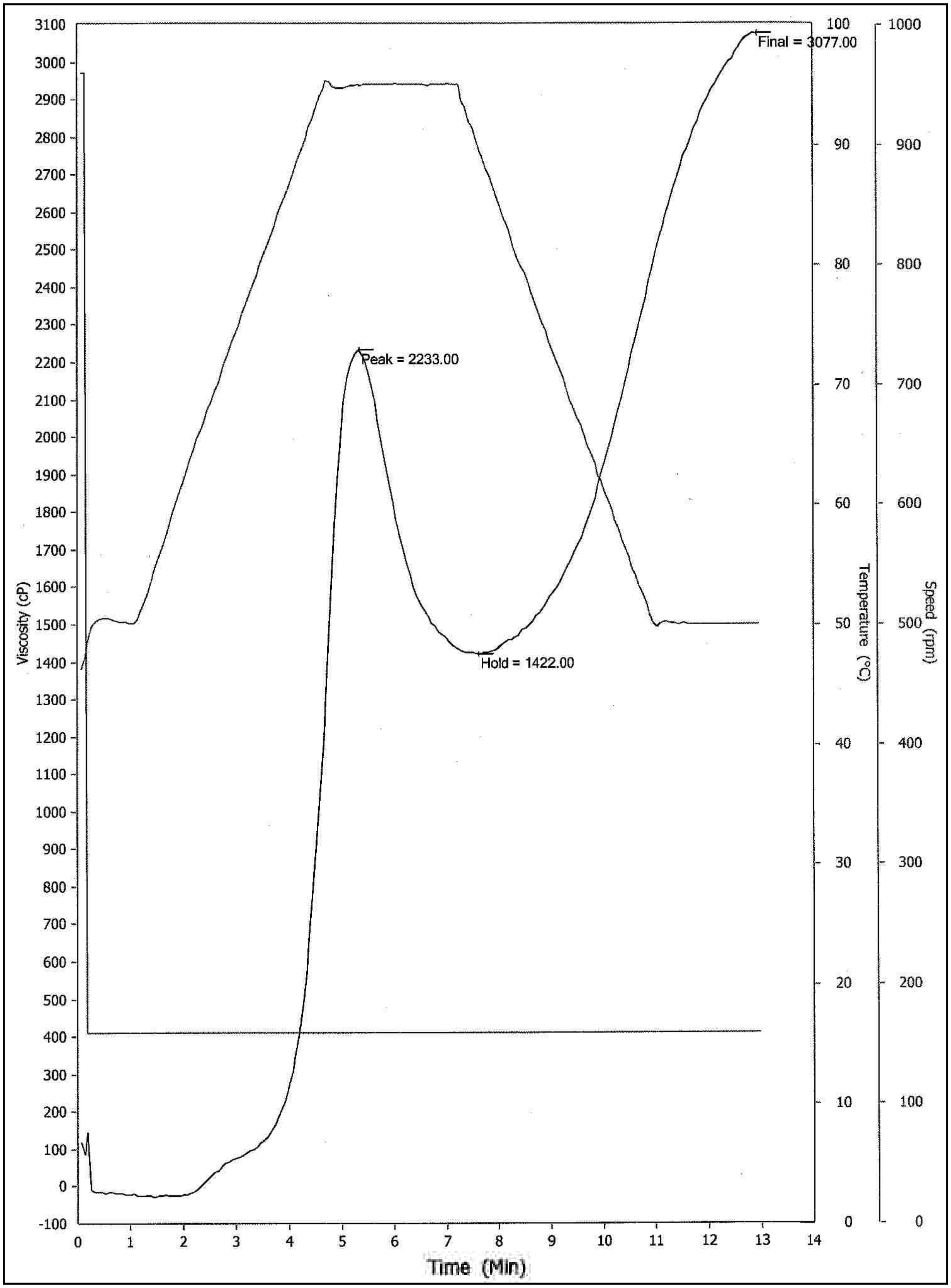

Figure D.2 Amylograph for the Control Flour Mixture B

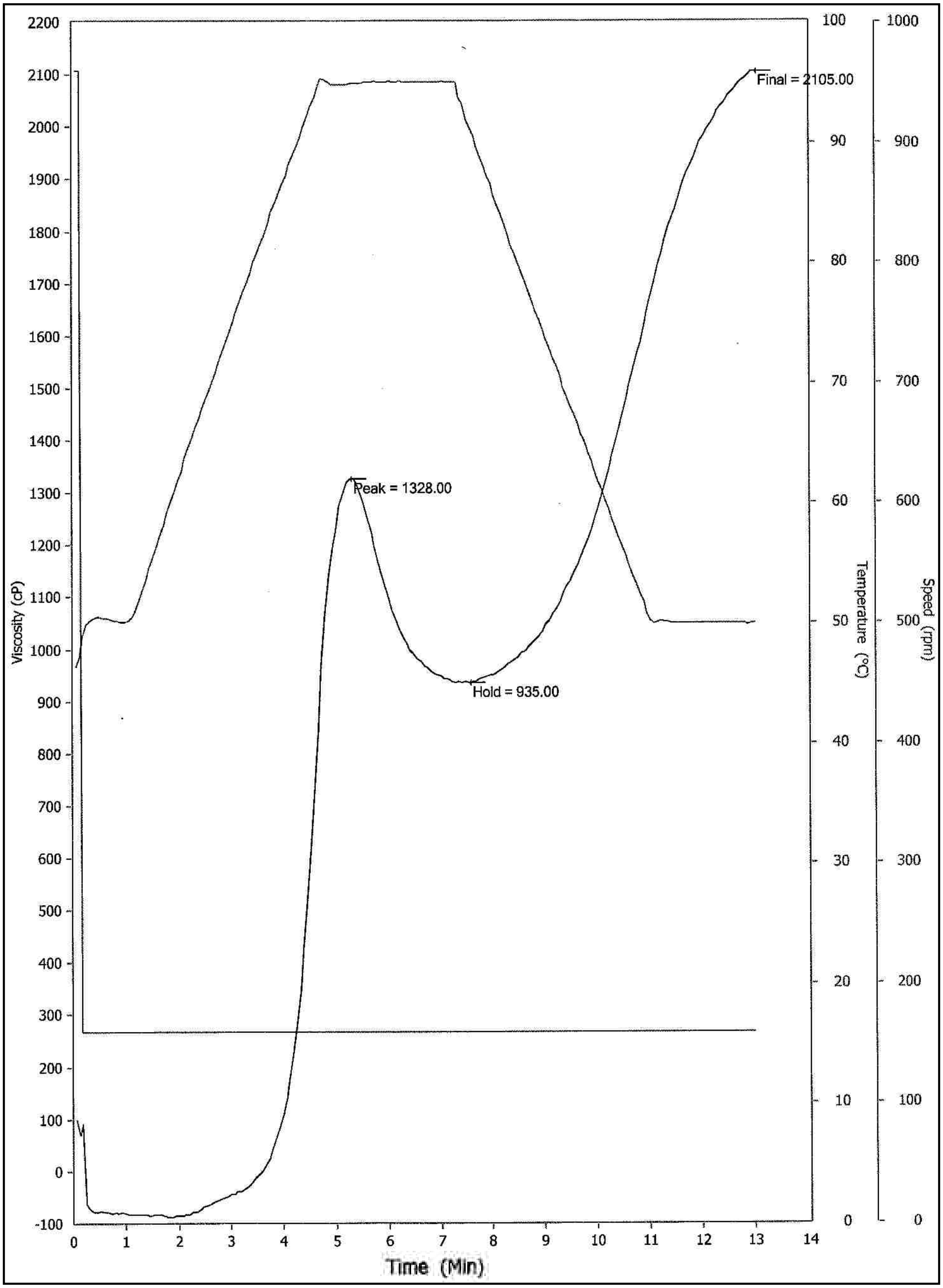

Figure D.3 Amylograph for the 20/80 Pinto Bean Flour Mixture A

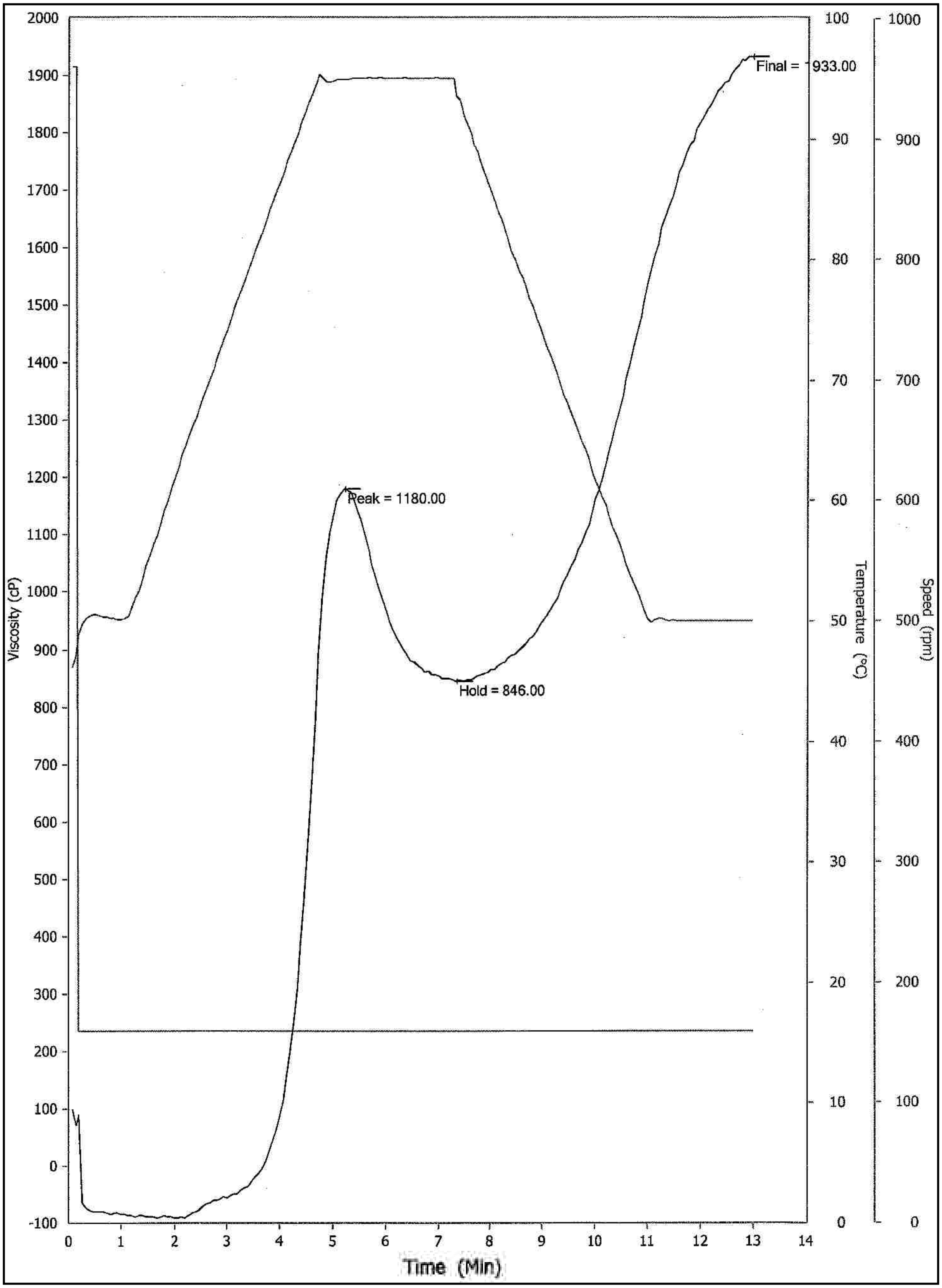

Figure D.4 Amylograph for the 20/80 Pinto Bean Flour Mixture B

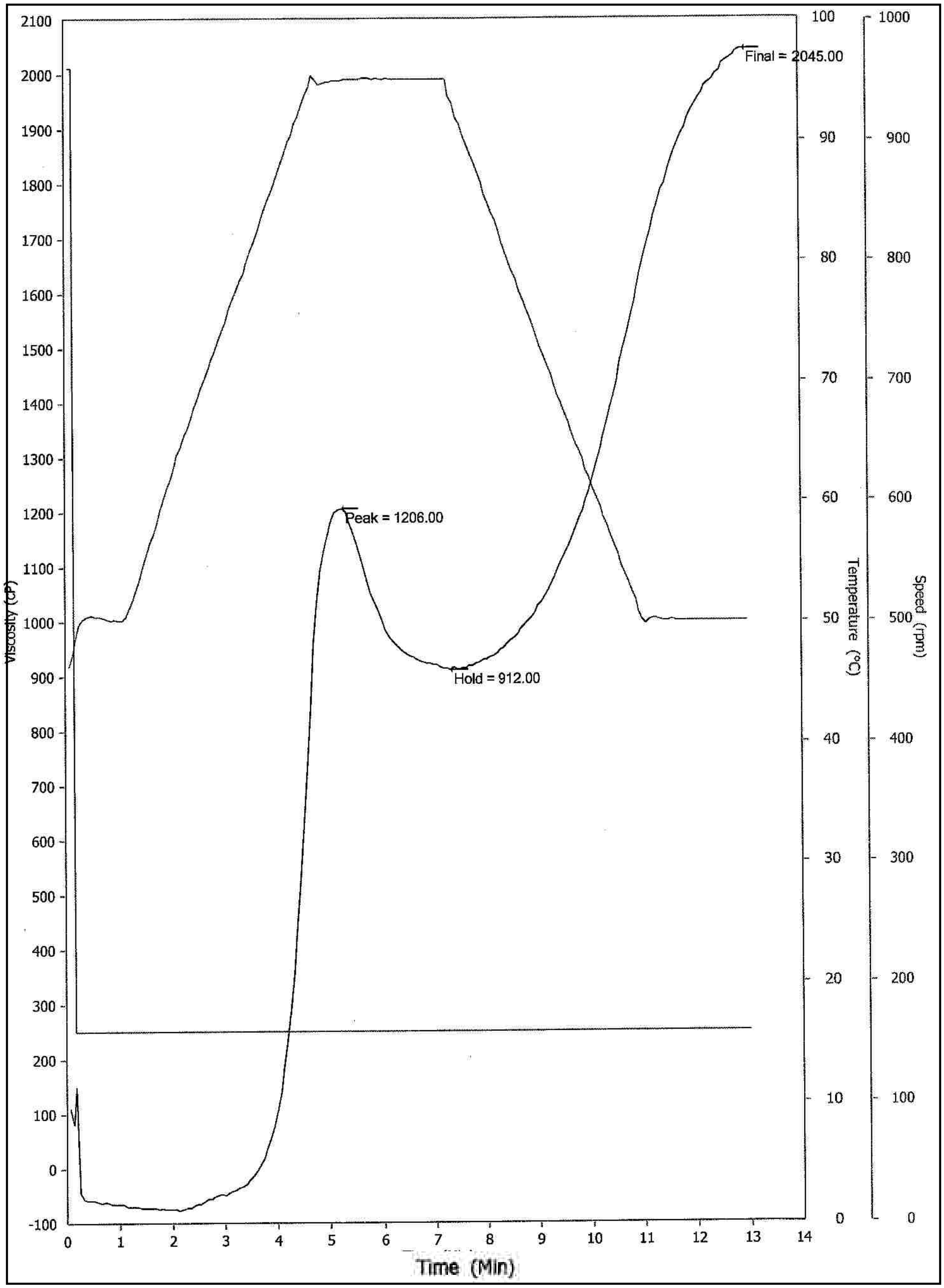

Figure D.5 Amylograph for the 25/75 Pinto Bean Flour Mixture A

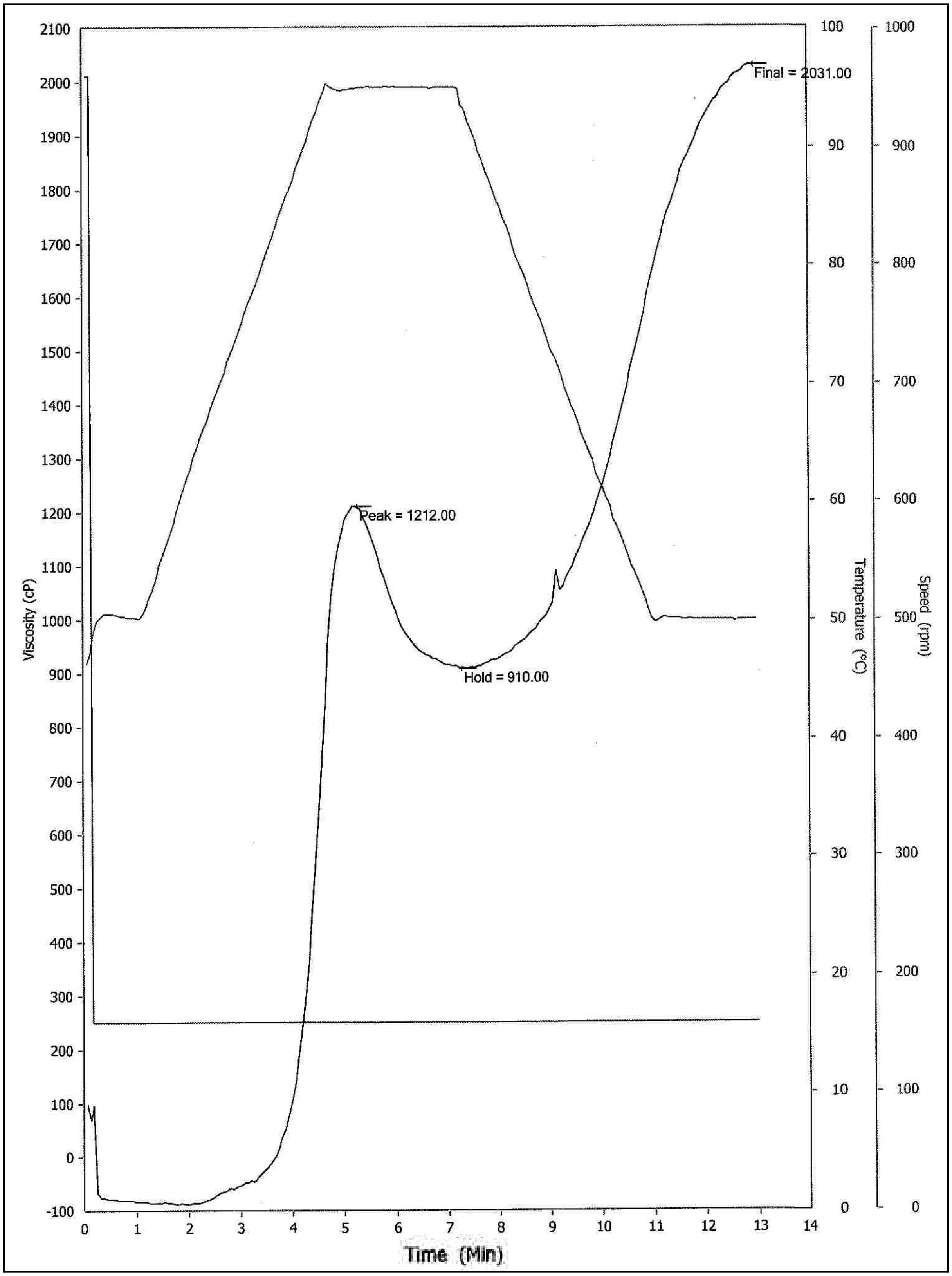

Figure D.6 Amylograph for the 25/75 Pinto Bean Flour Mixture B

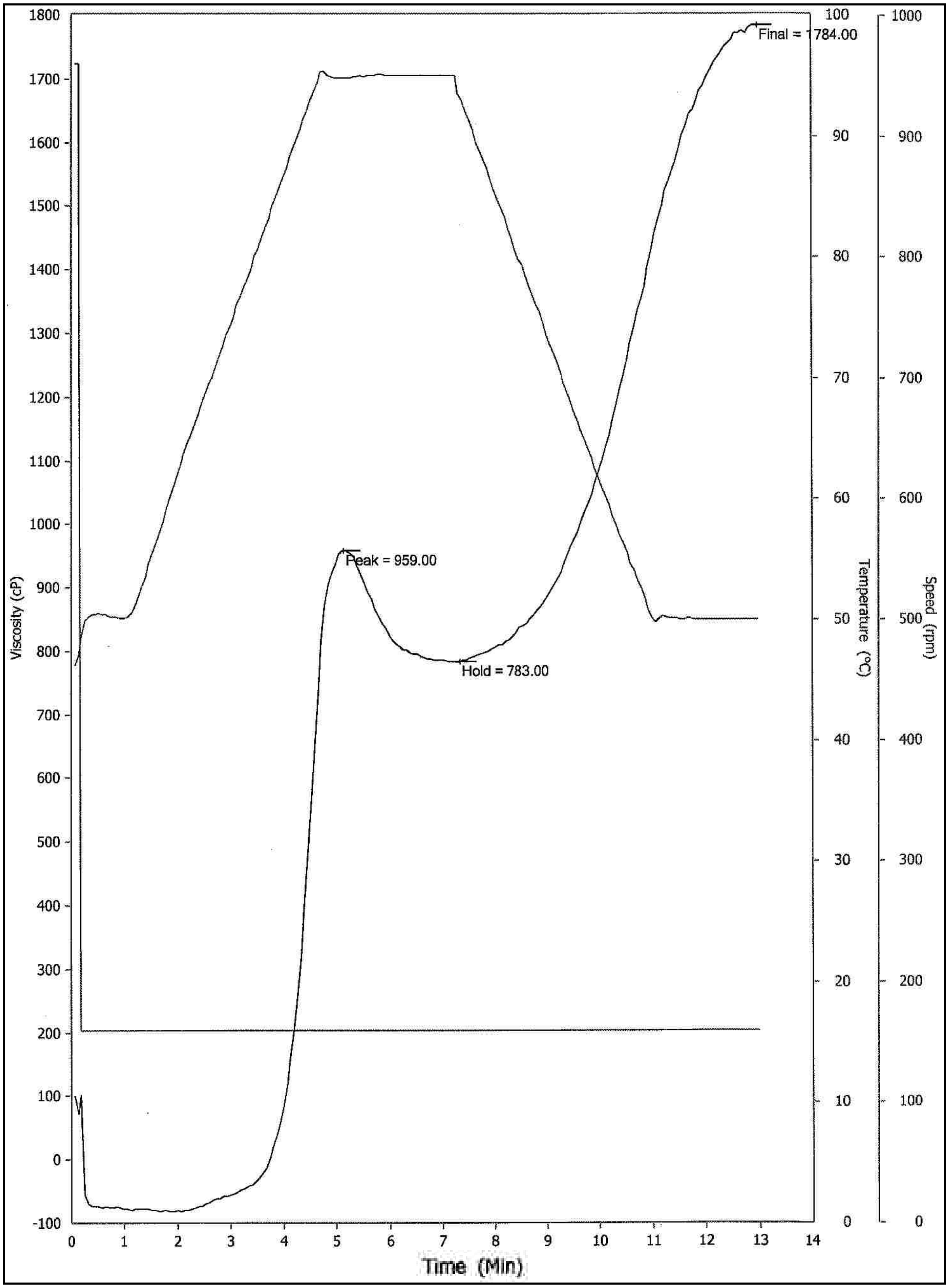

Figure D.7 Amylograph for the 30/70 Pinto Bean Flour Mixture A

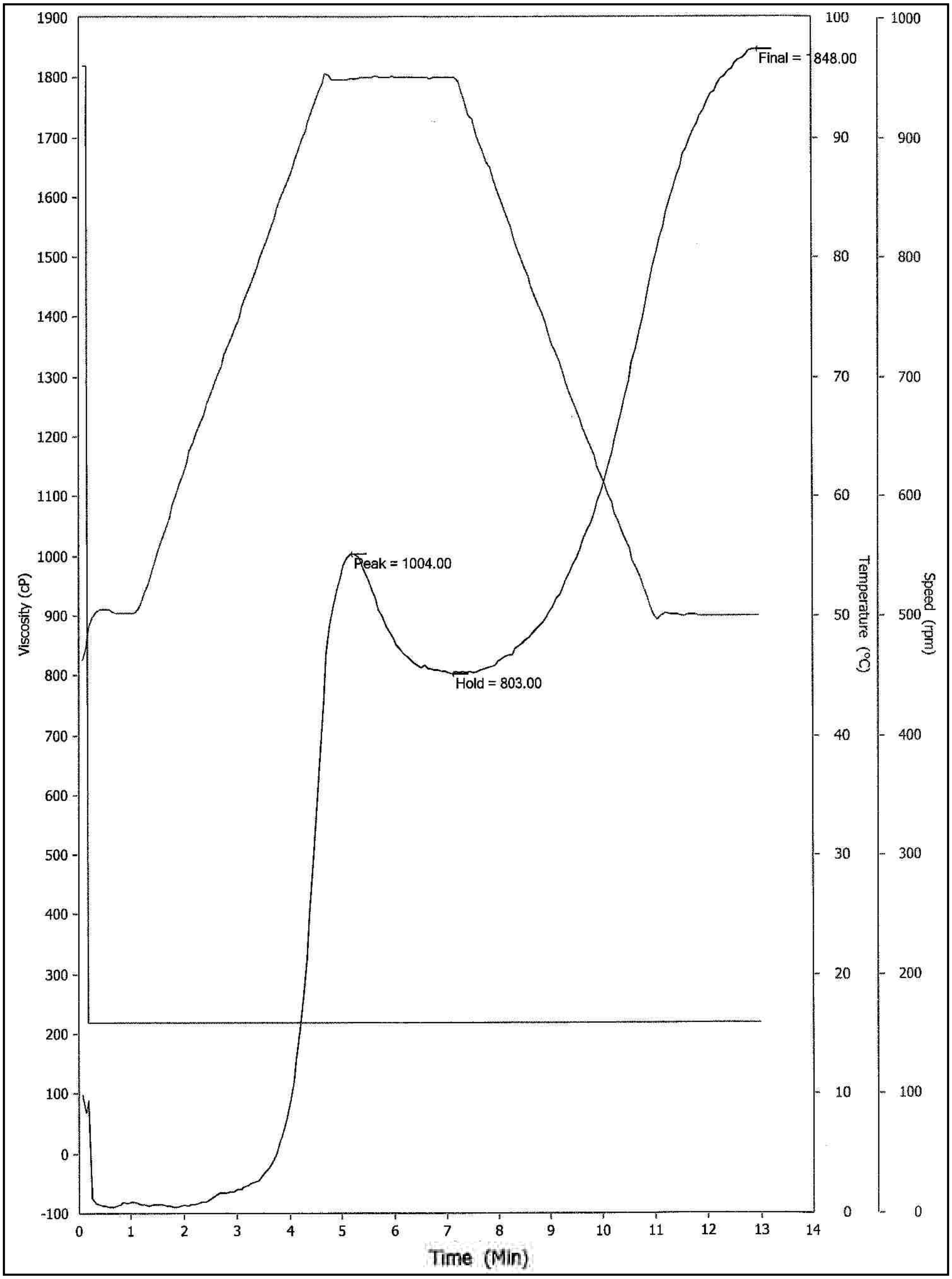

Figure D.8 Amylograph for the 30/70 Pinto Bean Flour Mixture B

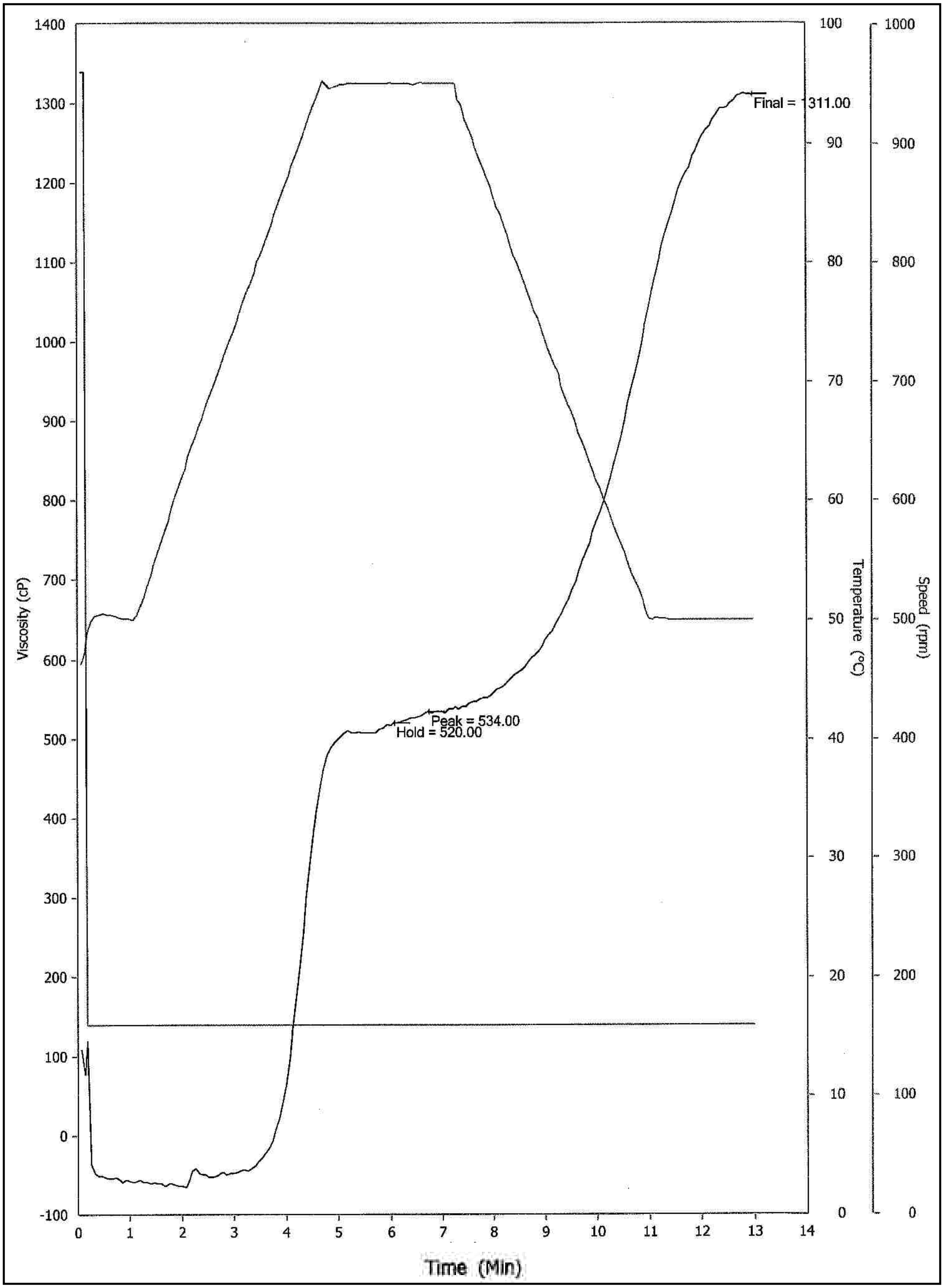

Figure D.9 Amylograph for the 50/50 Pinto Bean Flour Mixture A

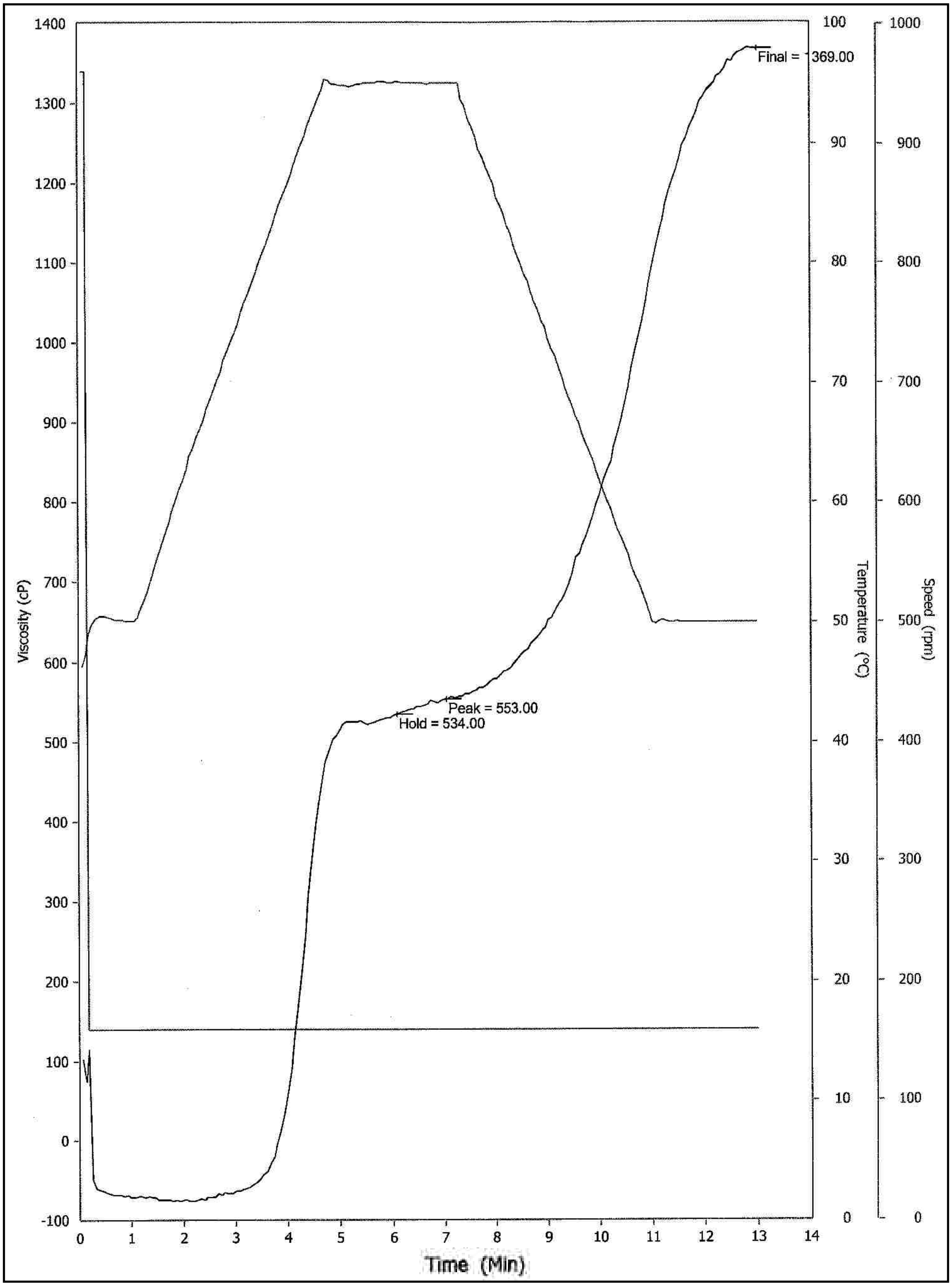

Figure D.10 Amylograph for the 50/50 Pinto Bean Flour Mixture B

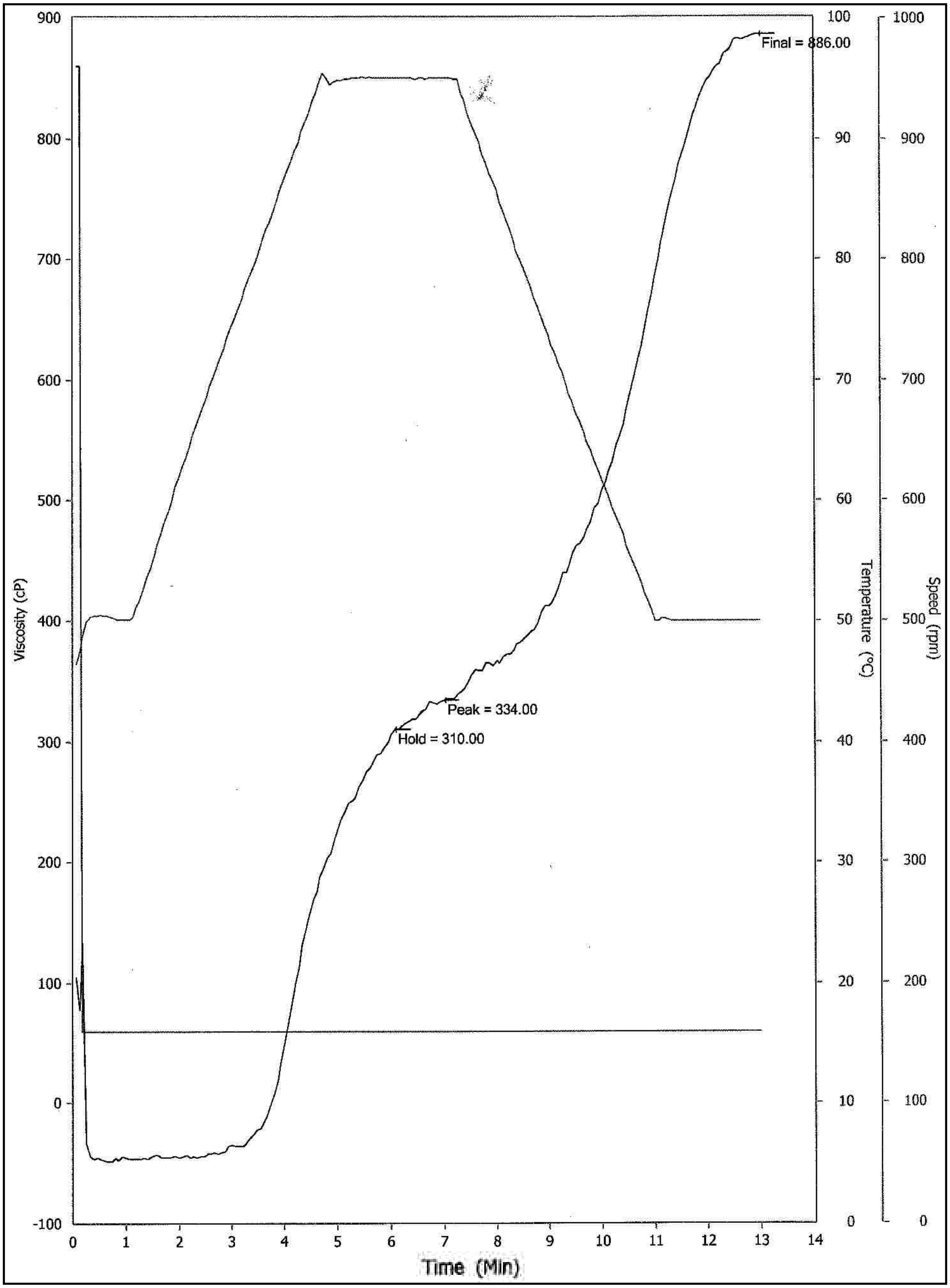

Figure D.11 Amylograph for the 75/25 Pinto Bean Flour Mixture A

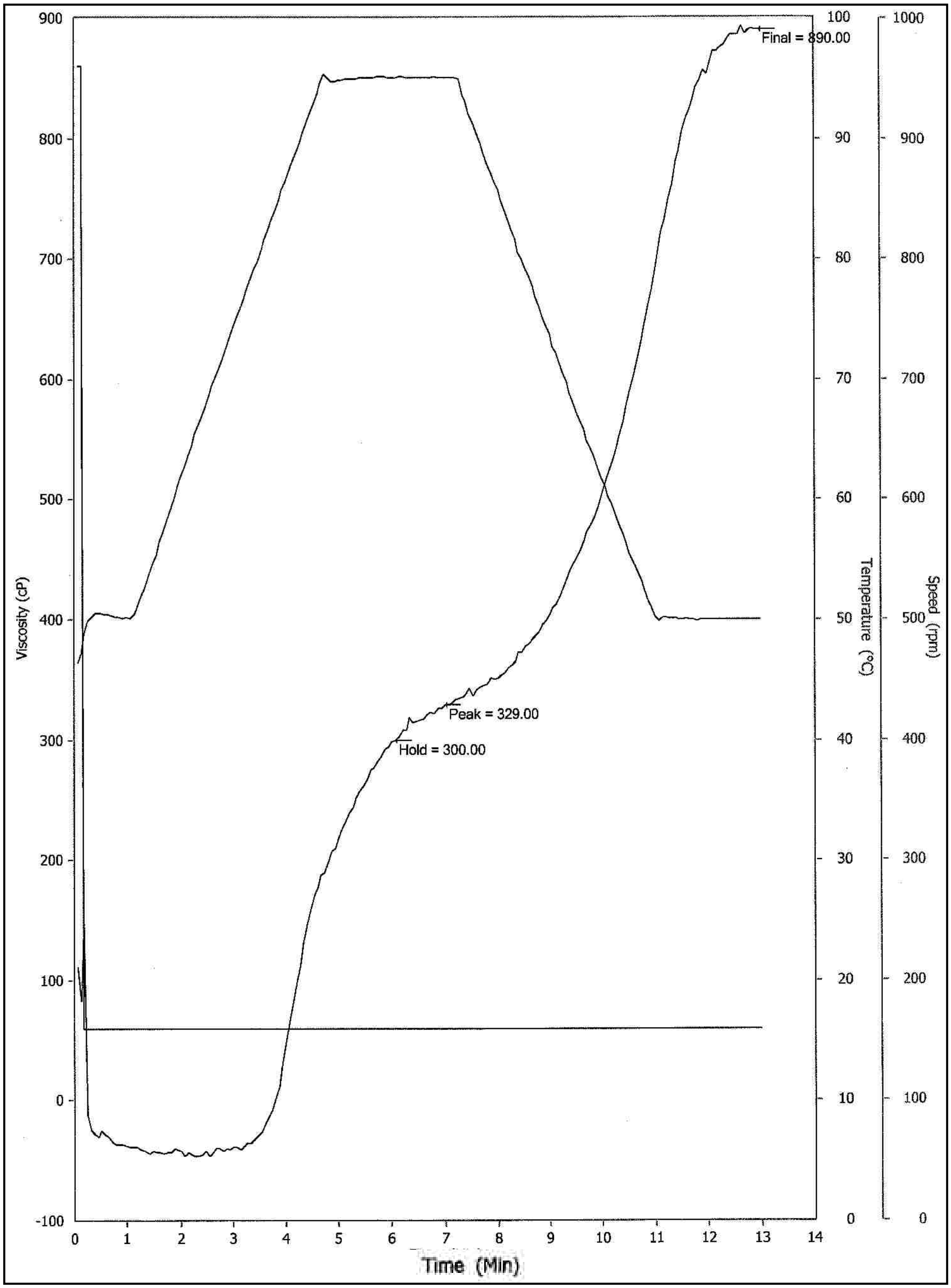

Figure D.12 Amylograph for the 75/25 Pinto Bean Flour Mixture B

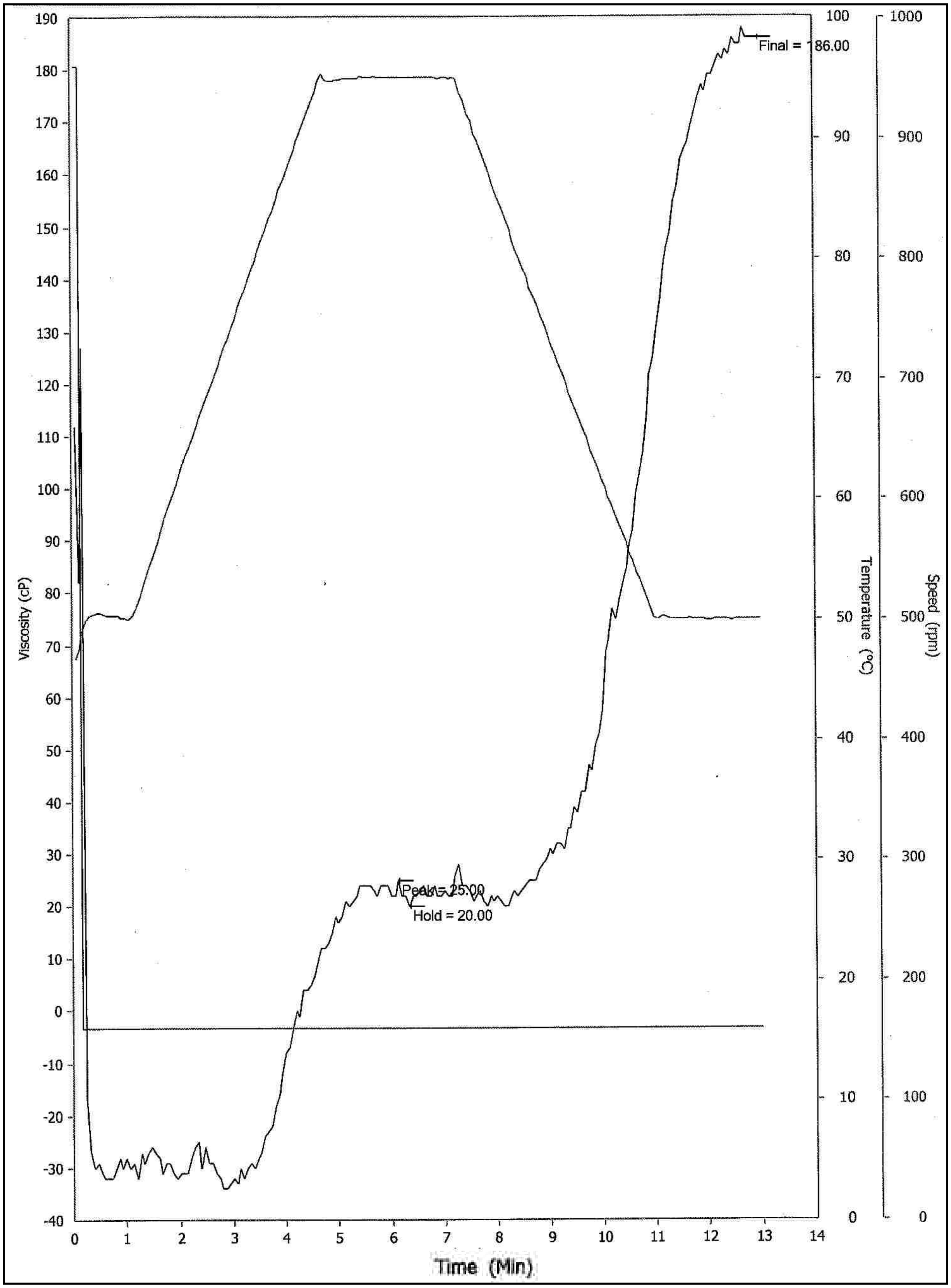

Figure D.13 Amylograph for the 100/0 Pinto Bean Flour Mixture

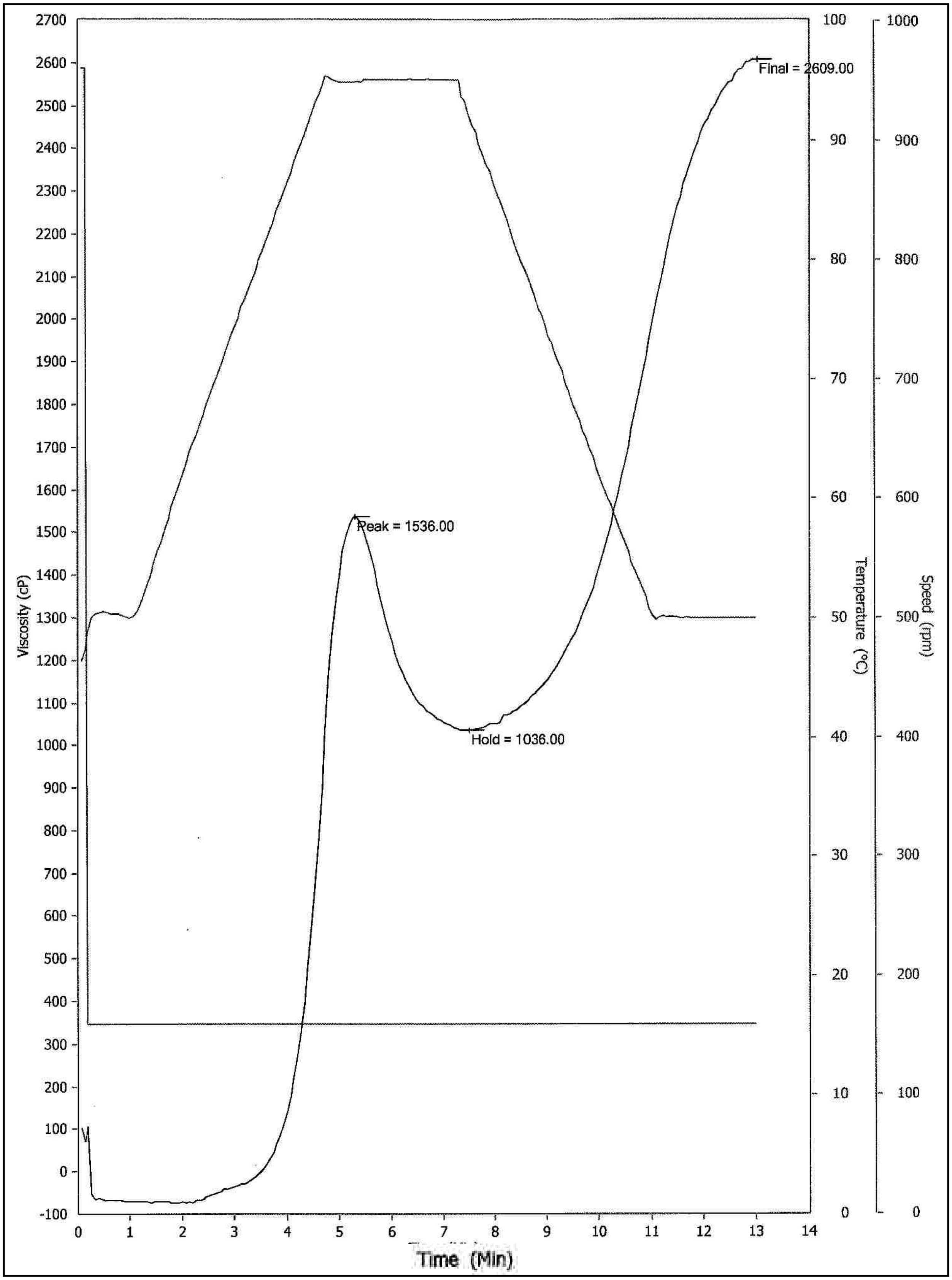

Figure D.14 Amylograph for the 20/80 Navy Bean Flour Mixture A

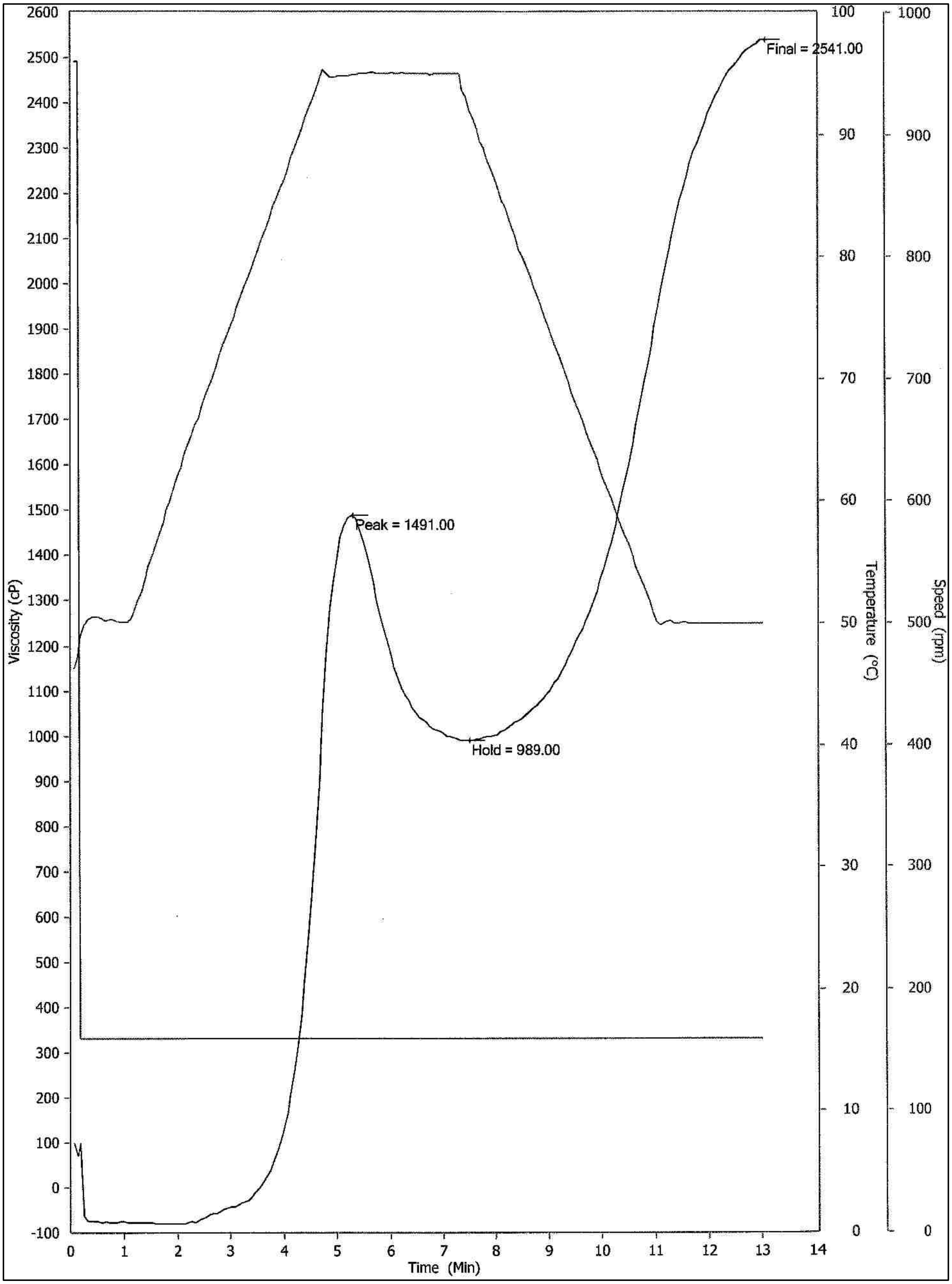

Figure D.15 Amylograph for the 20/80 Navy Bean Flour Mixture B

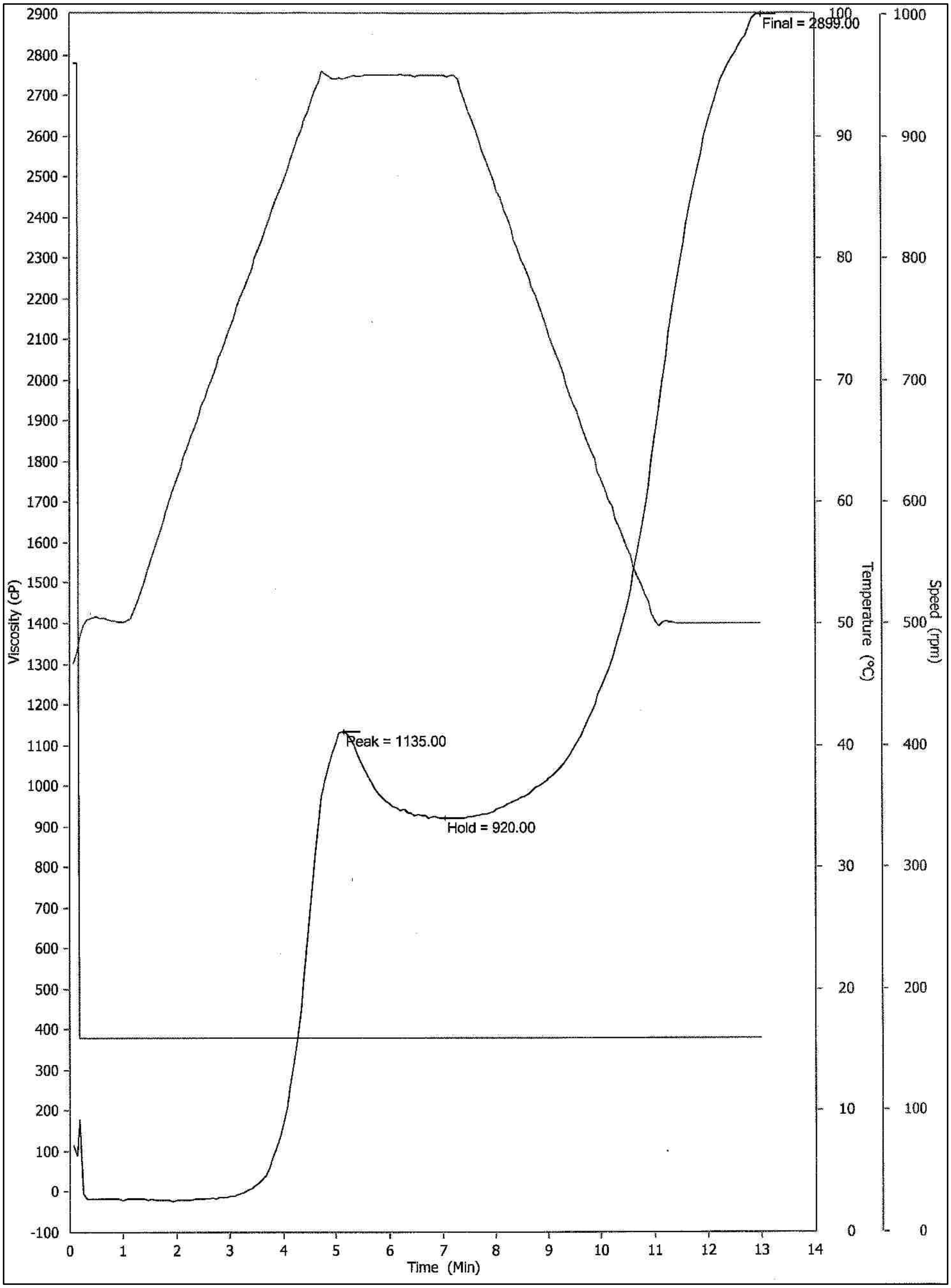

Figure D.16 Amylograph for the 25/75 Navy Bean Flour Mixture A

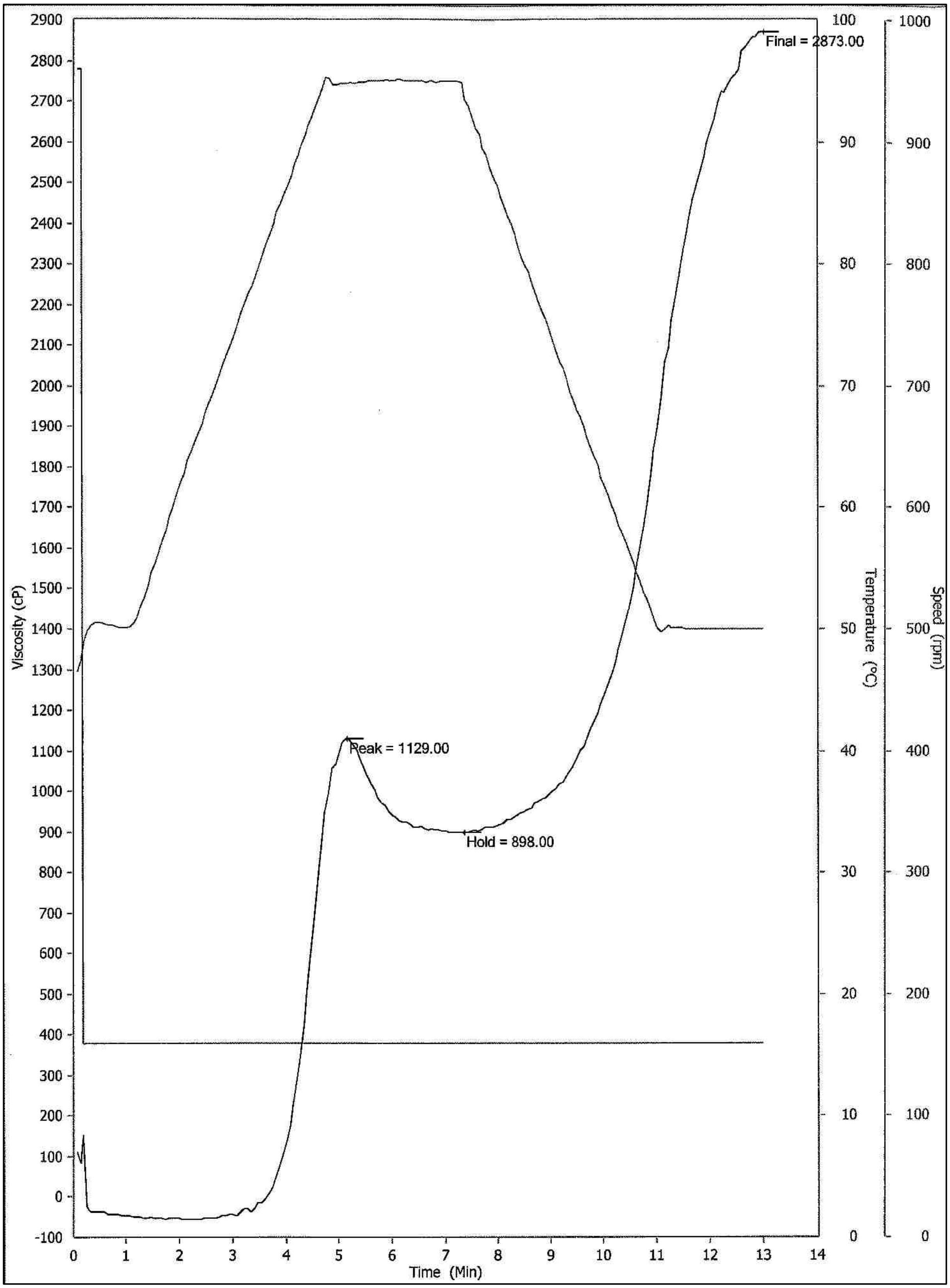

Figure D.17 Amylograph for the 25/75 Navy Bean Flour Mixture B

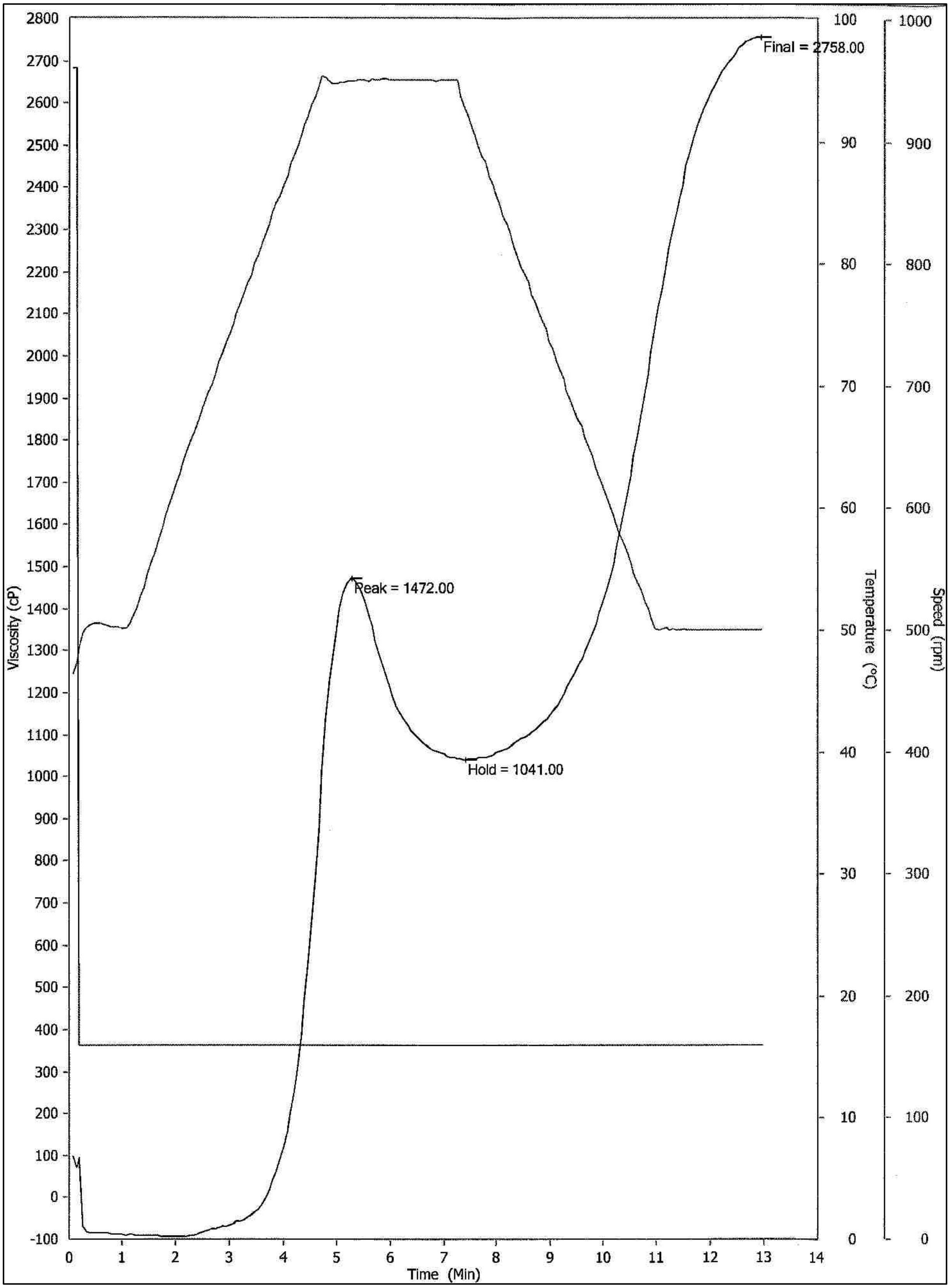

Figure D.18 Amylograph for the 30/70 Navy Bean Flour Mixture A

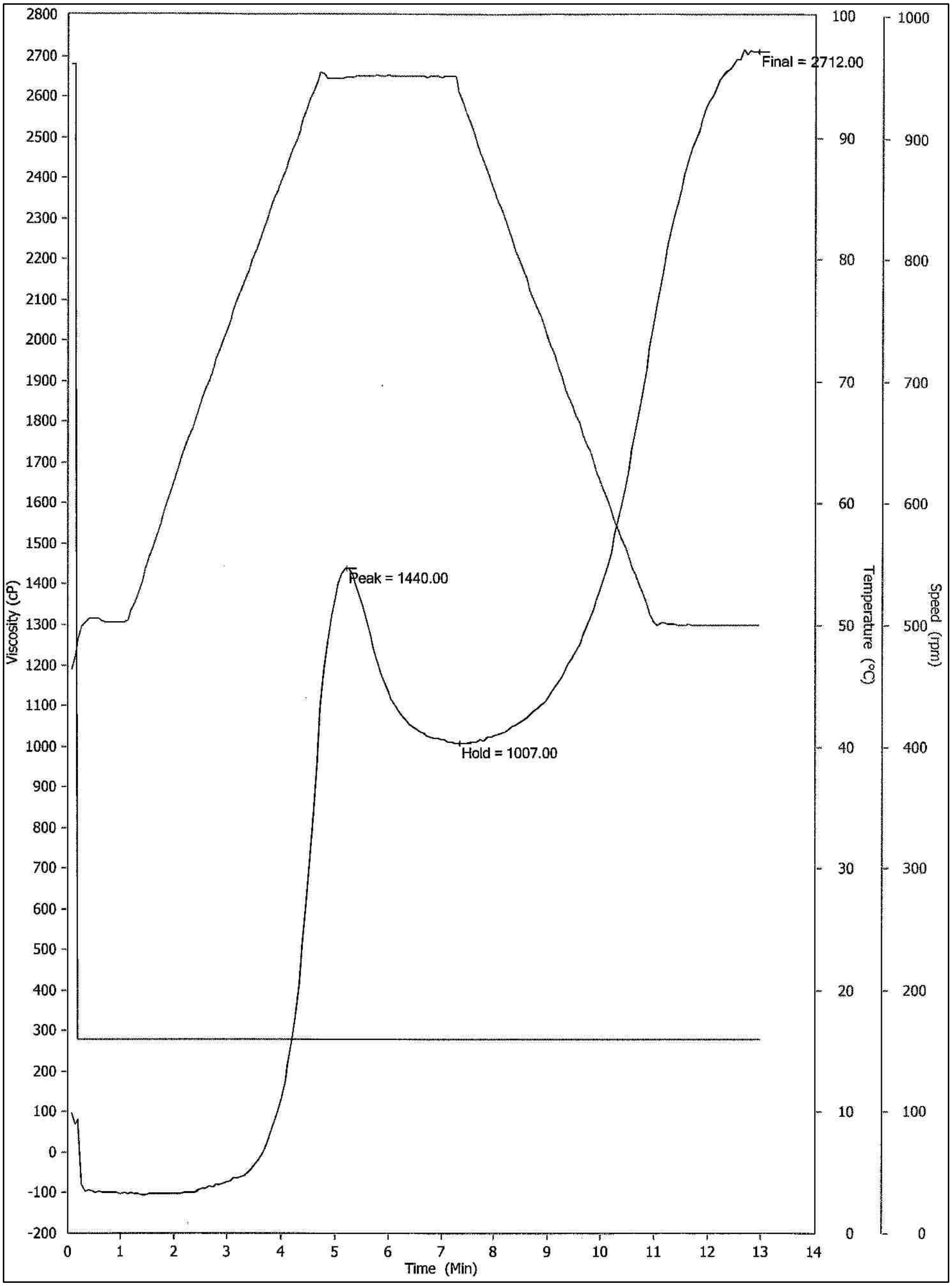

Figure D.19 Amylograph for the 30/70 Navy Bean Flour Mixture B

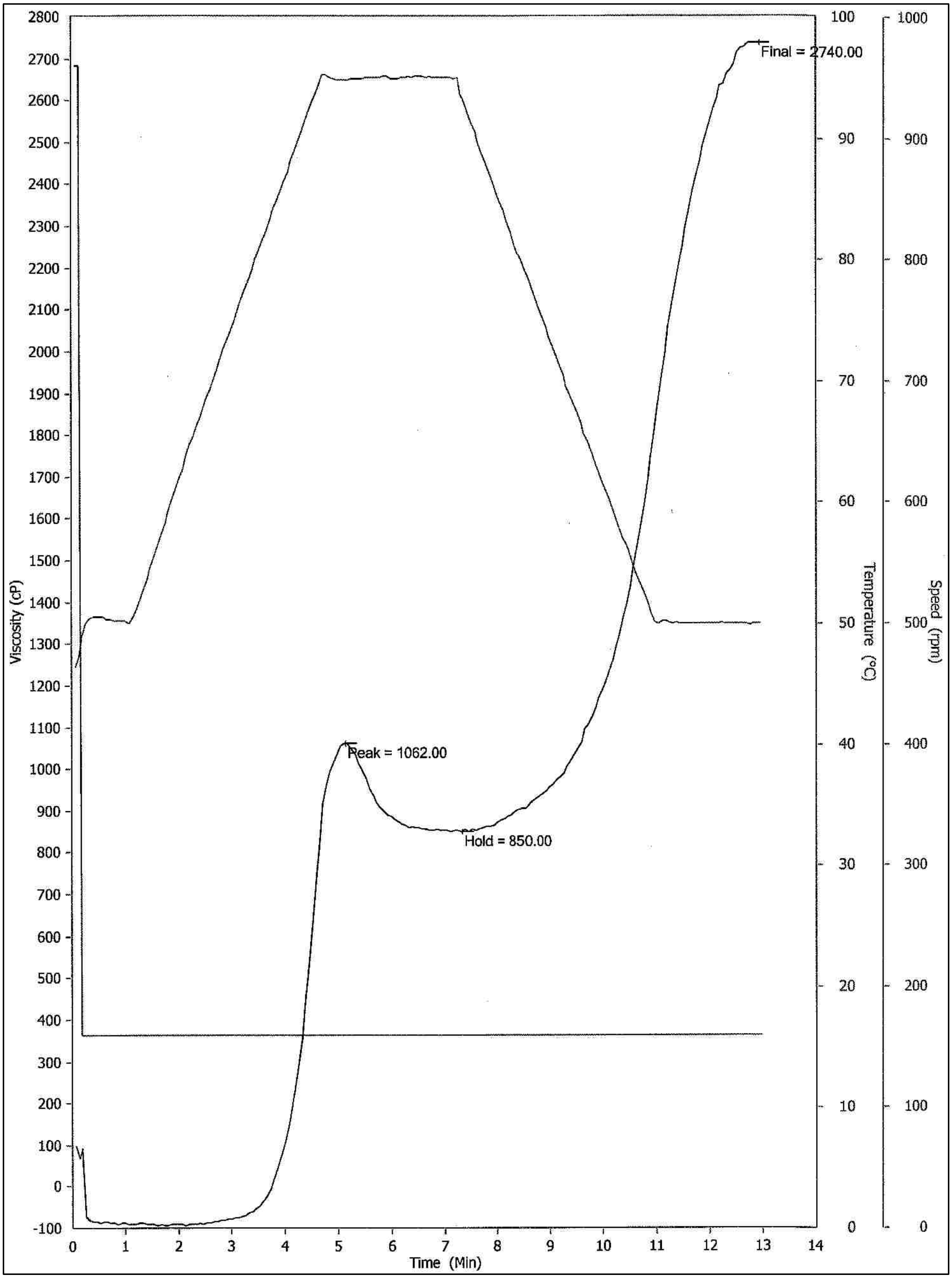

Figure D.20 Amylograph for the 50/50 Navy Bean Flour Mixture A

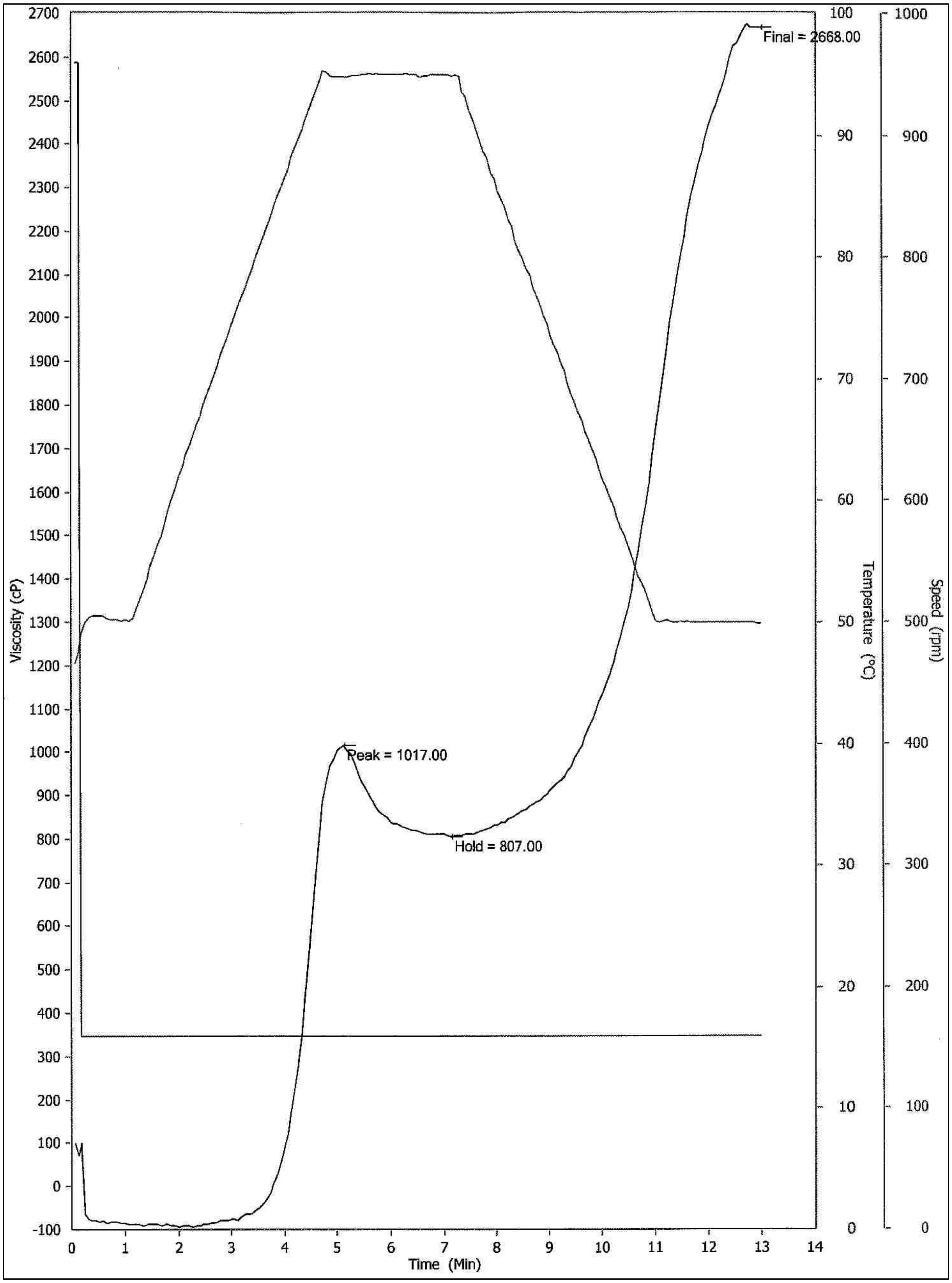

Figure D.21 Amylograph for the 50/50 Navy Bean Flour Mixture B

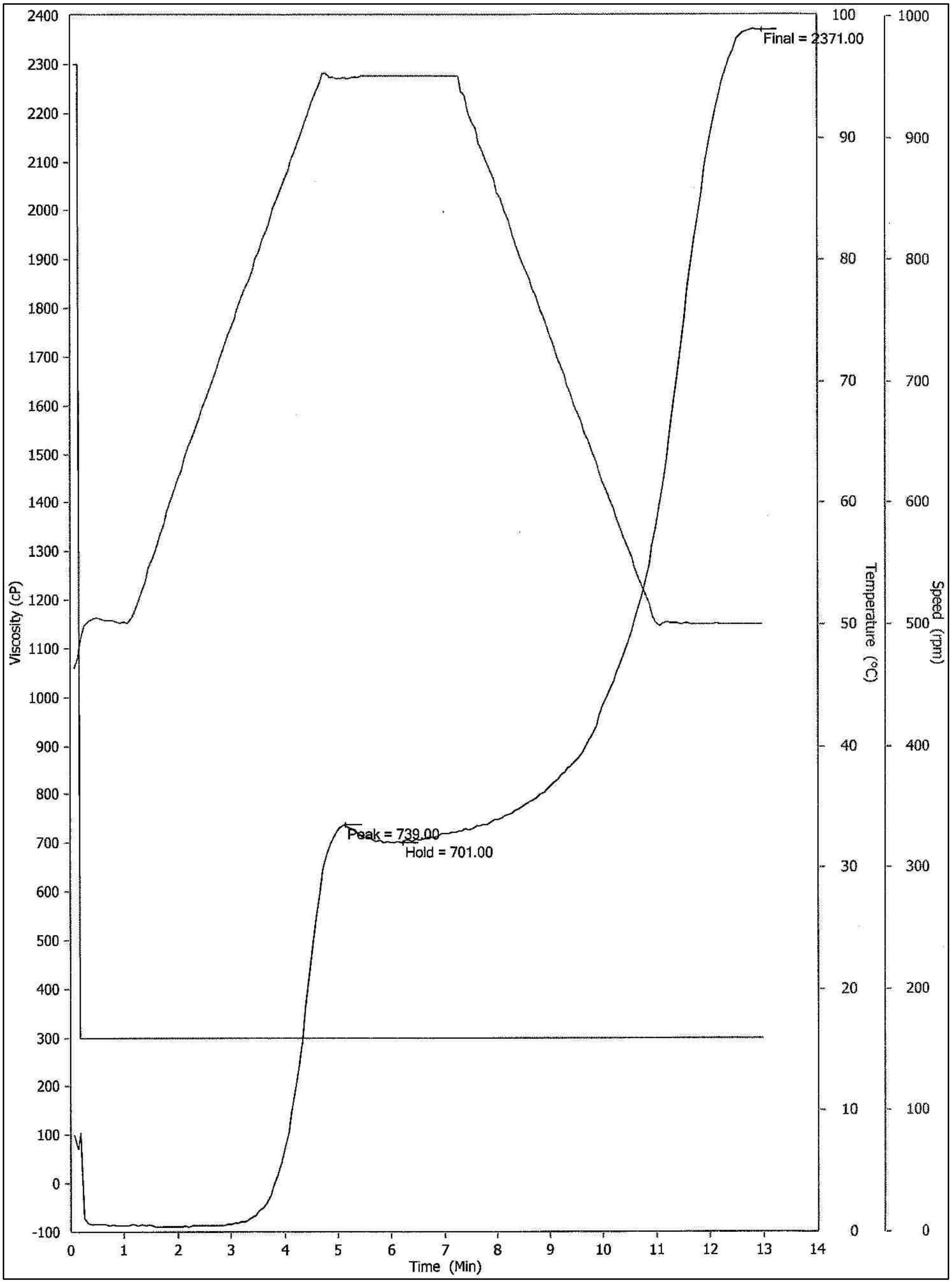

Figure D.22 Amylograph for the 75/25 Navy Bean Flour Mixture A

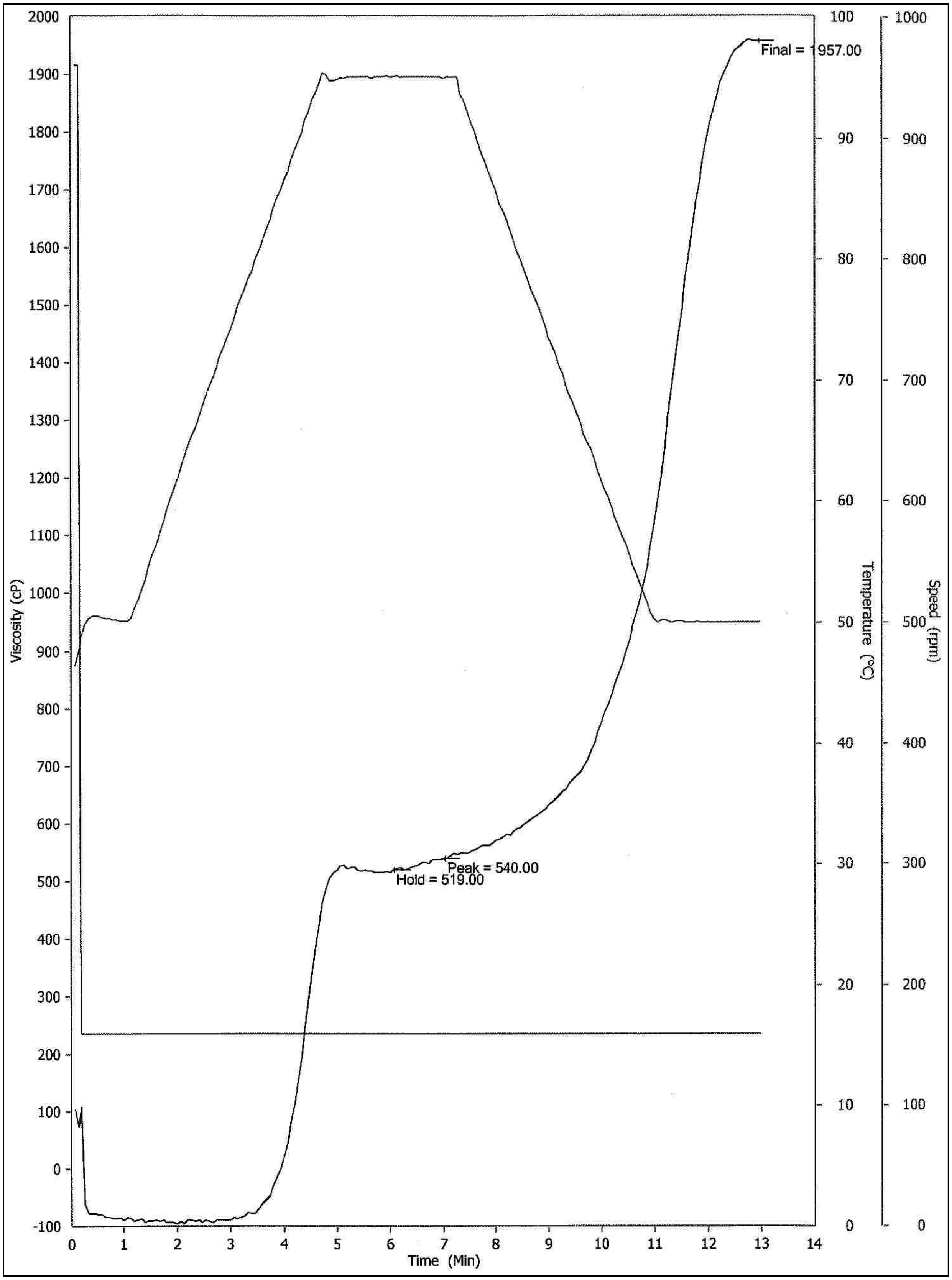

Figure D.23 Amylograph for the 75/25 Navy Bean Flour Mixture B

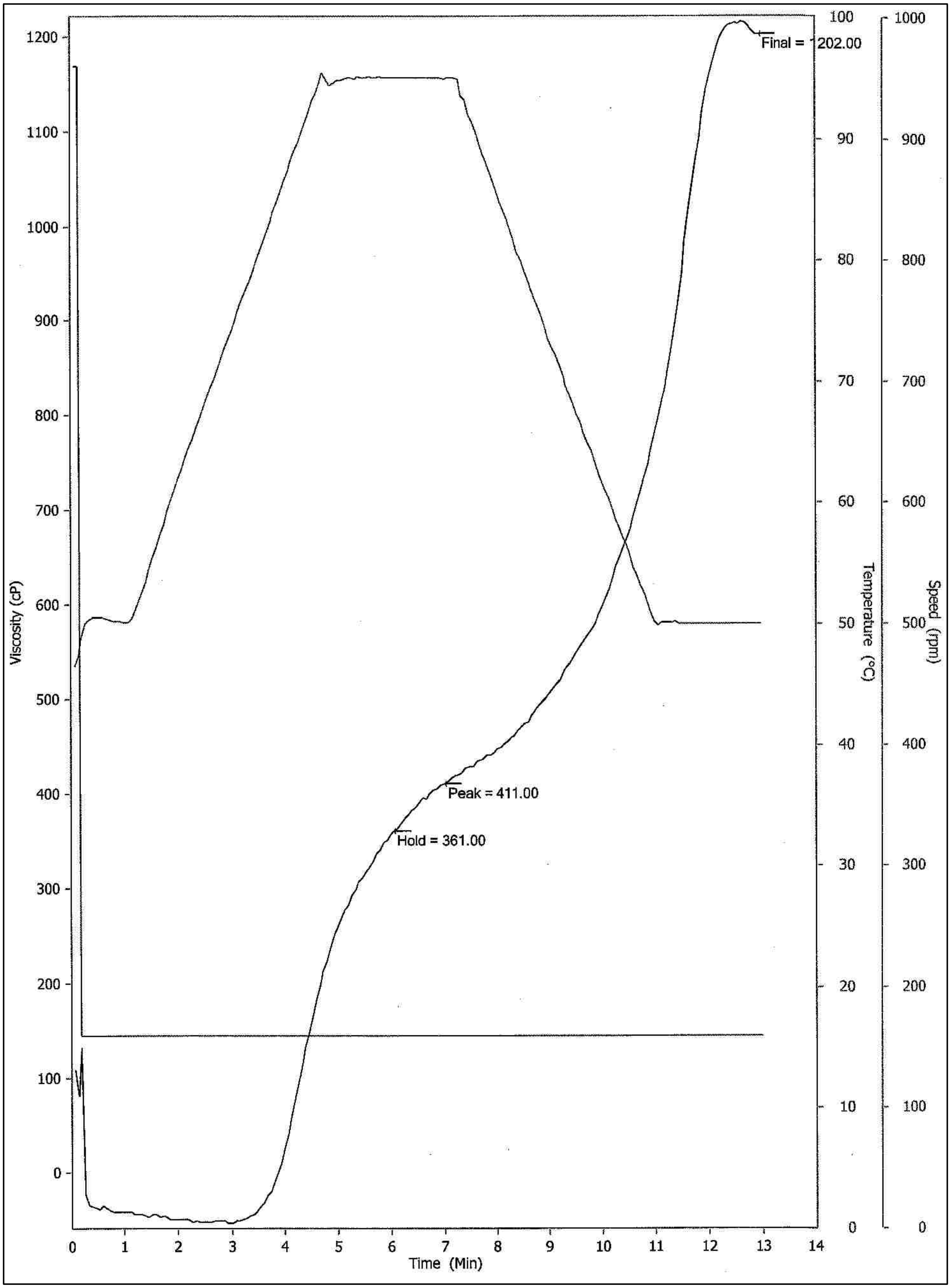

Figure D.24 Amylograph for the 100/0 Navy Bean Flour Mixture

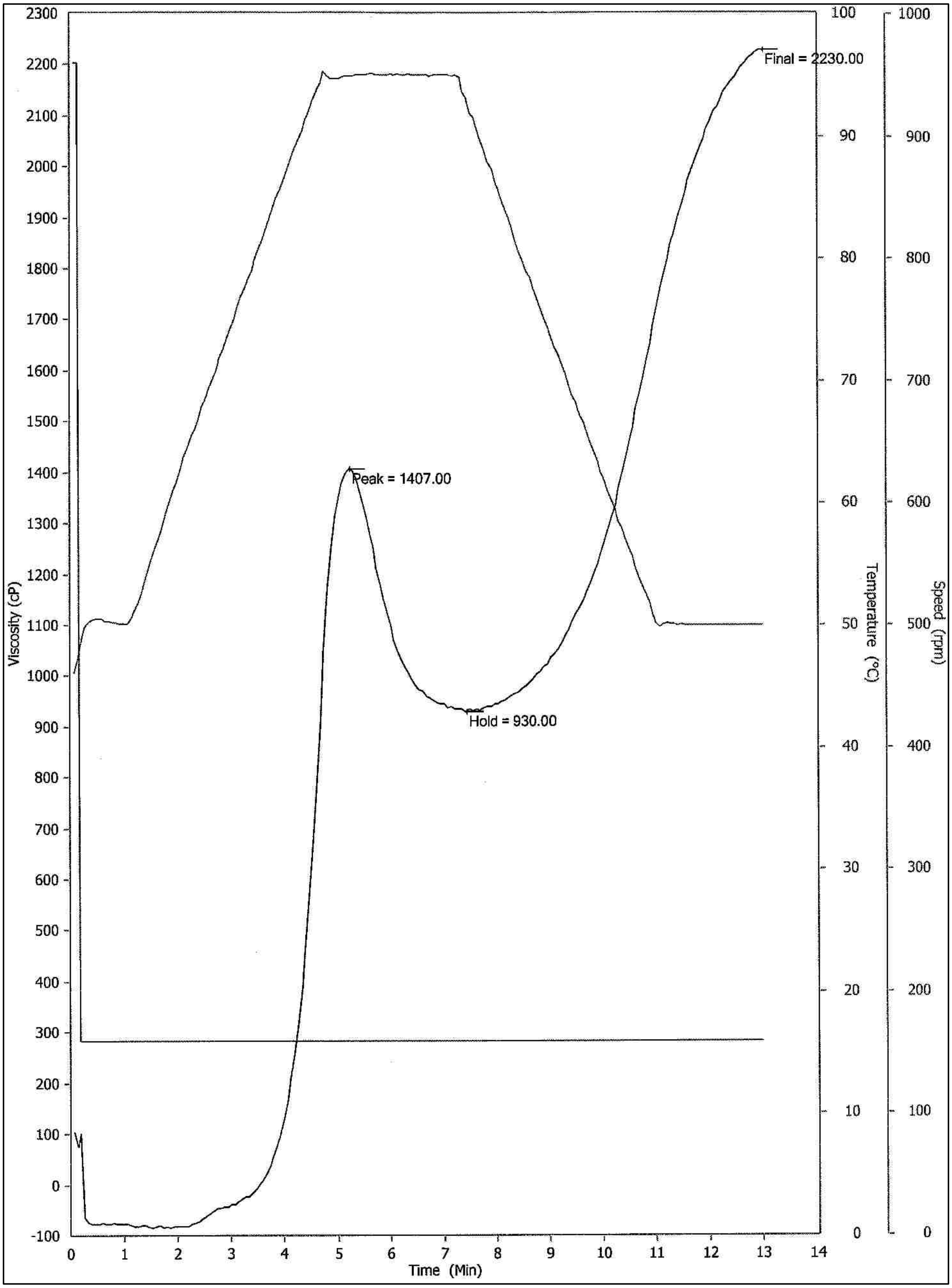

Figure D.25 Amylograph for the 20/80 Black Bean Flour Mixture A

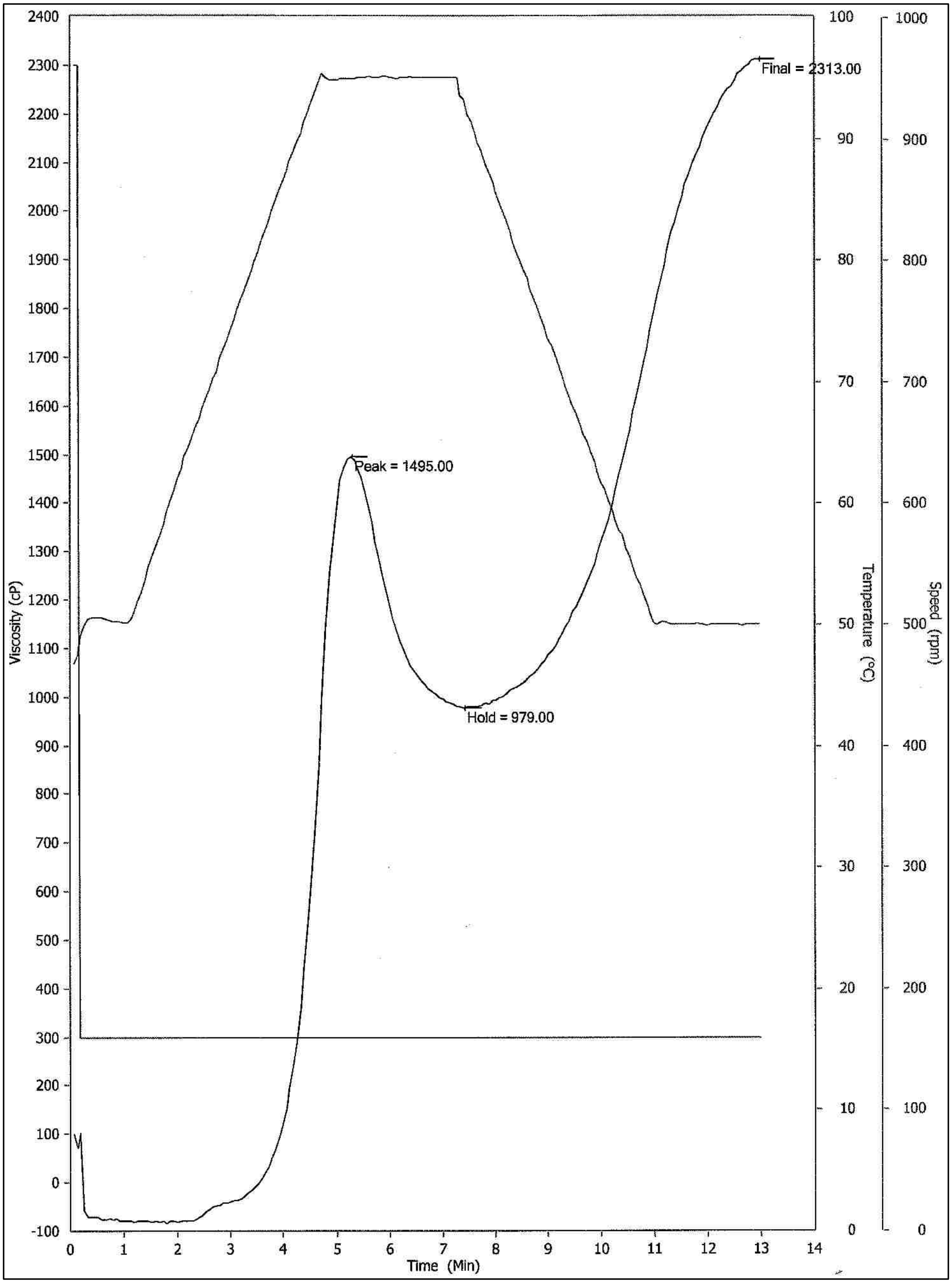

Figure D.26 Amylograph for the 20/80 Black Bean Flour Mixture B

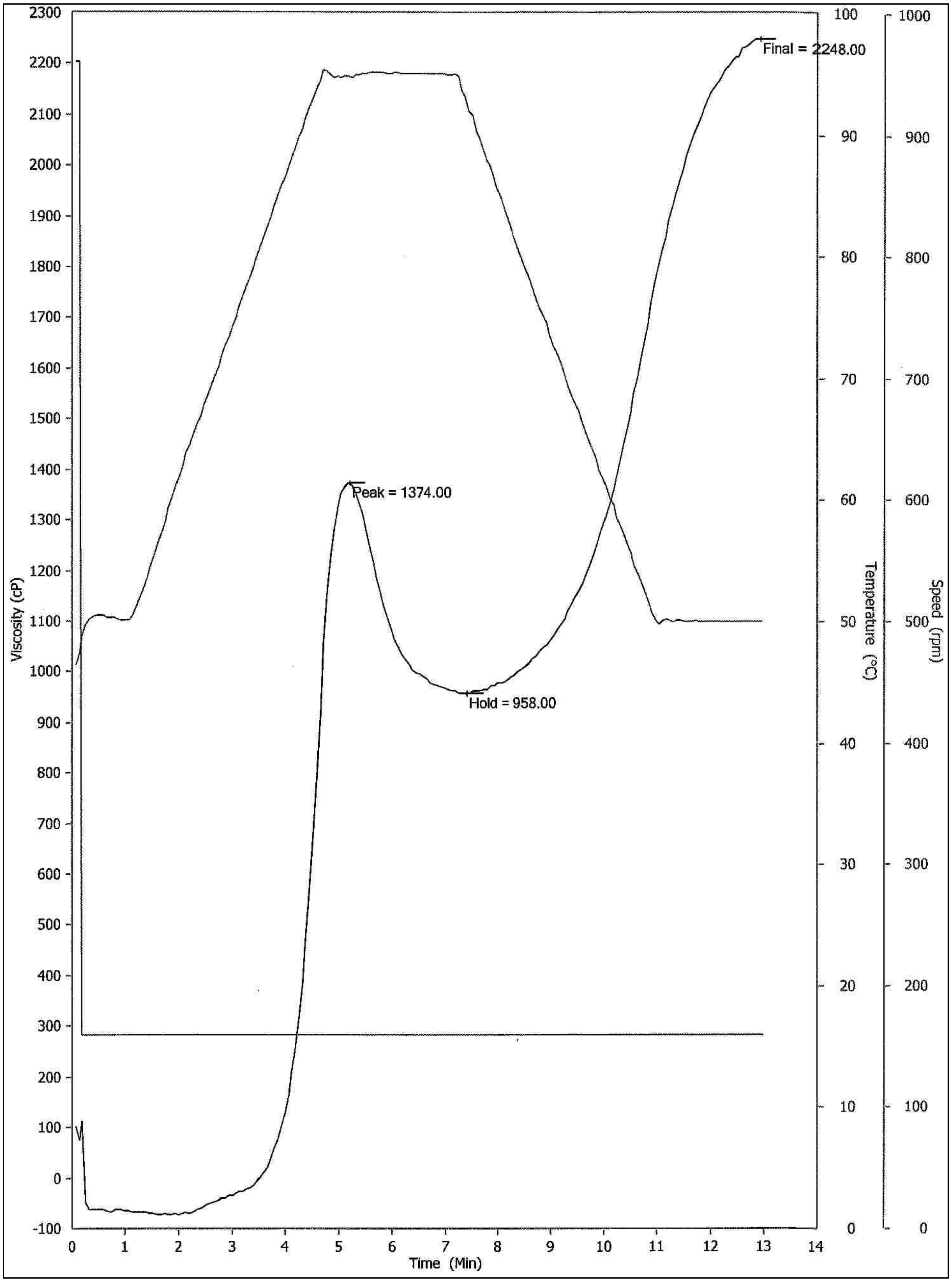

Figure D.27 Amylograph for the 25/75 Black Bean Flour Mixture A

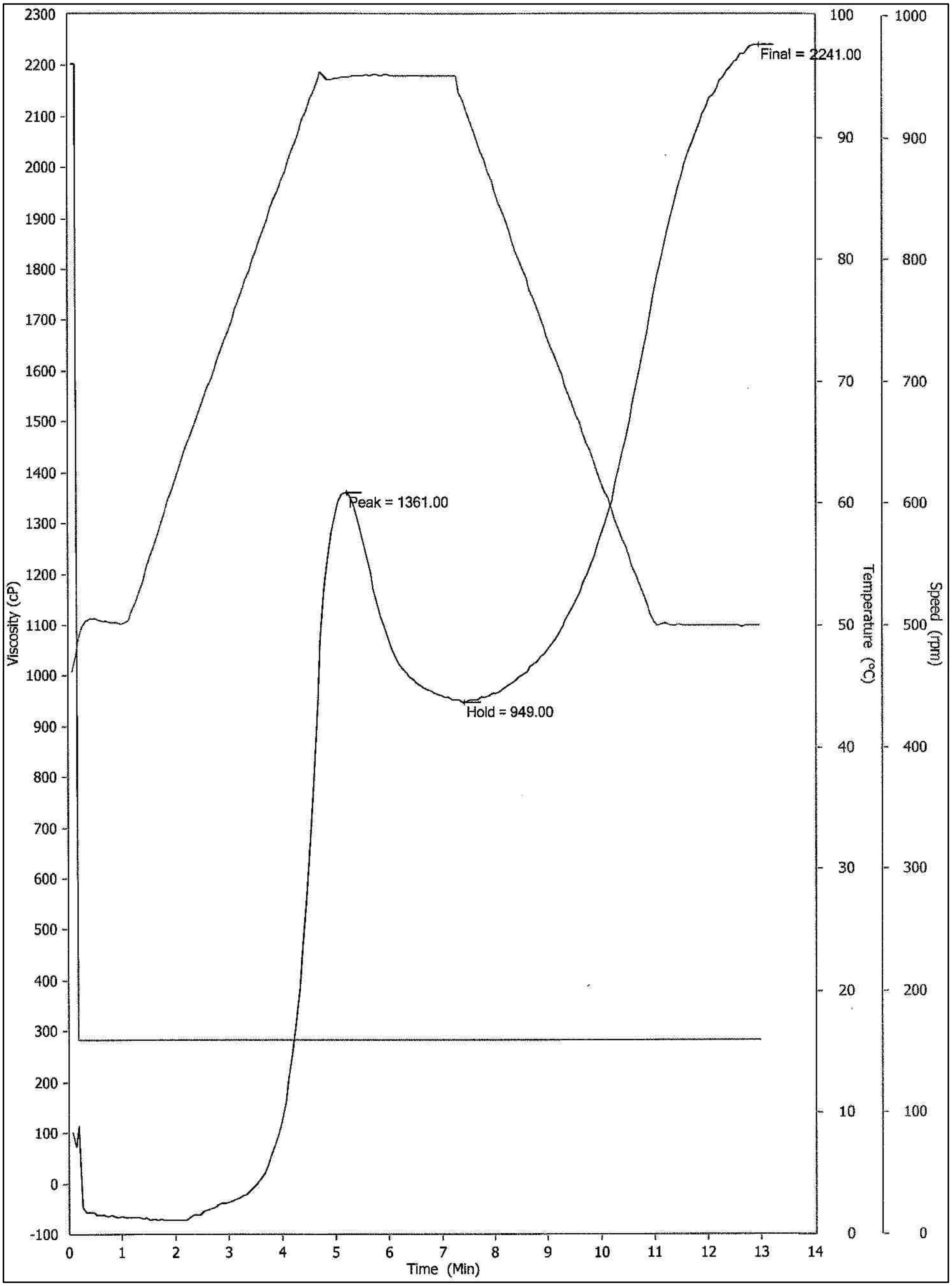

Figure D.28 Amylograph for the 25/75 Black Bean Flour Mixture B

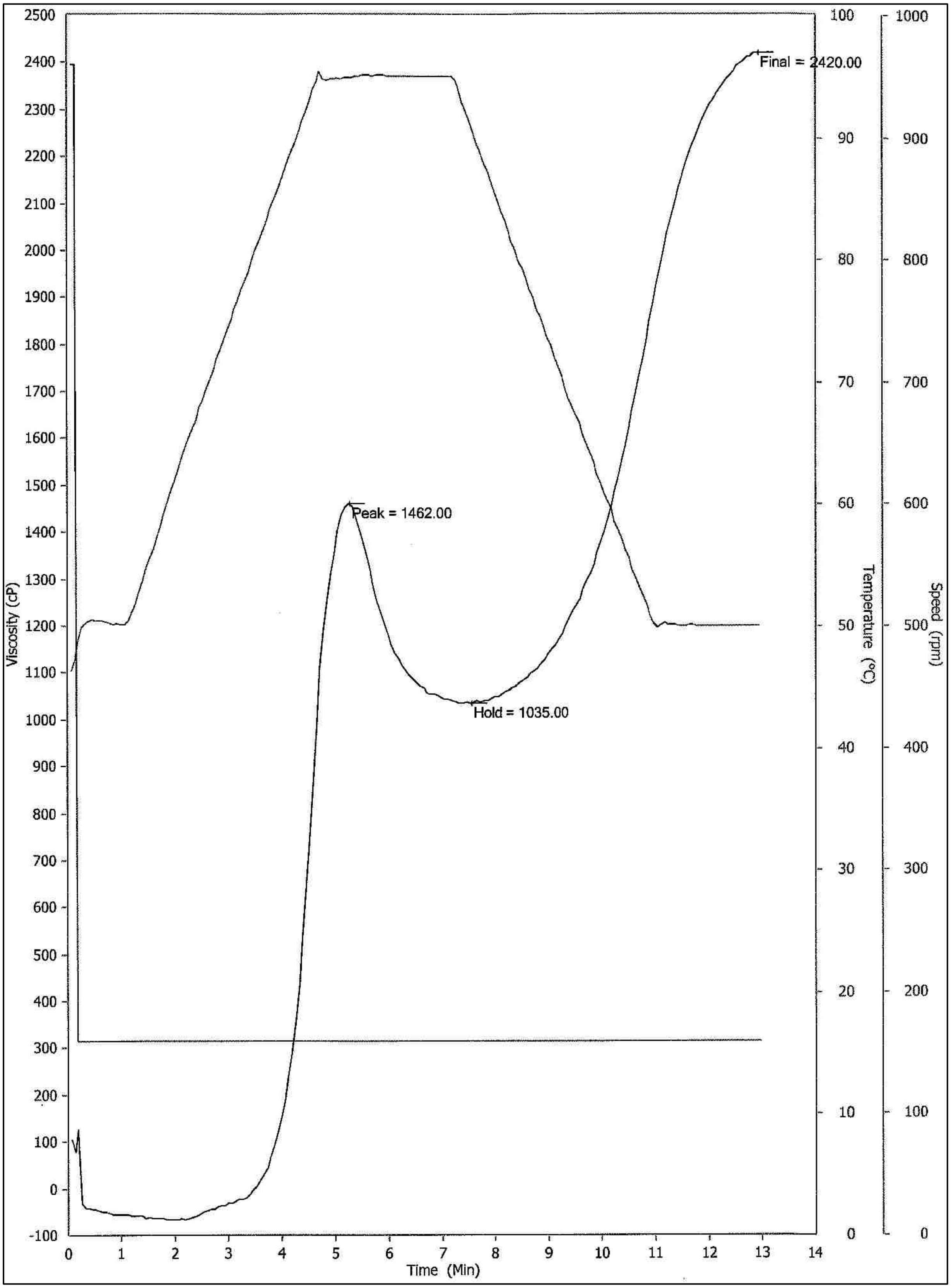

Figure D.29 Amylograph for the 30/70 Black Bean Flour Mixture A

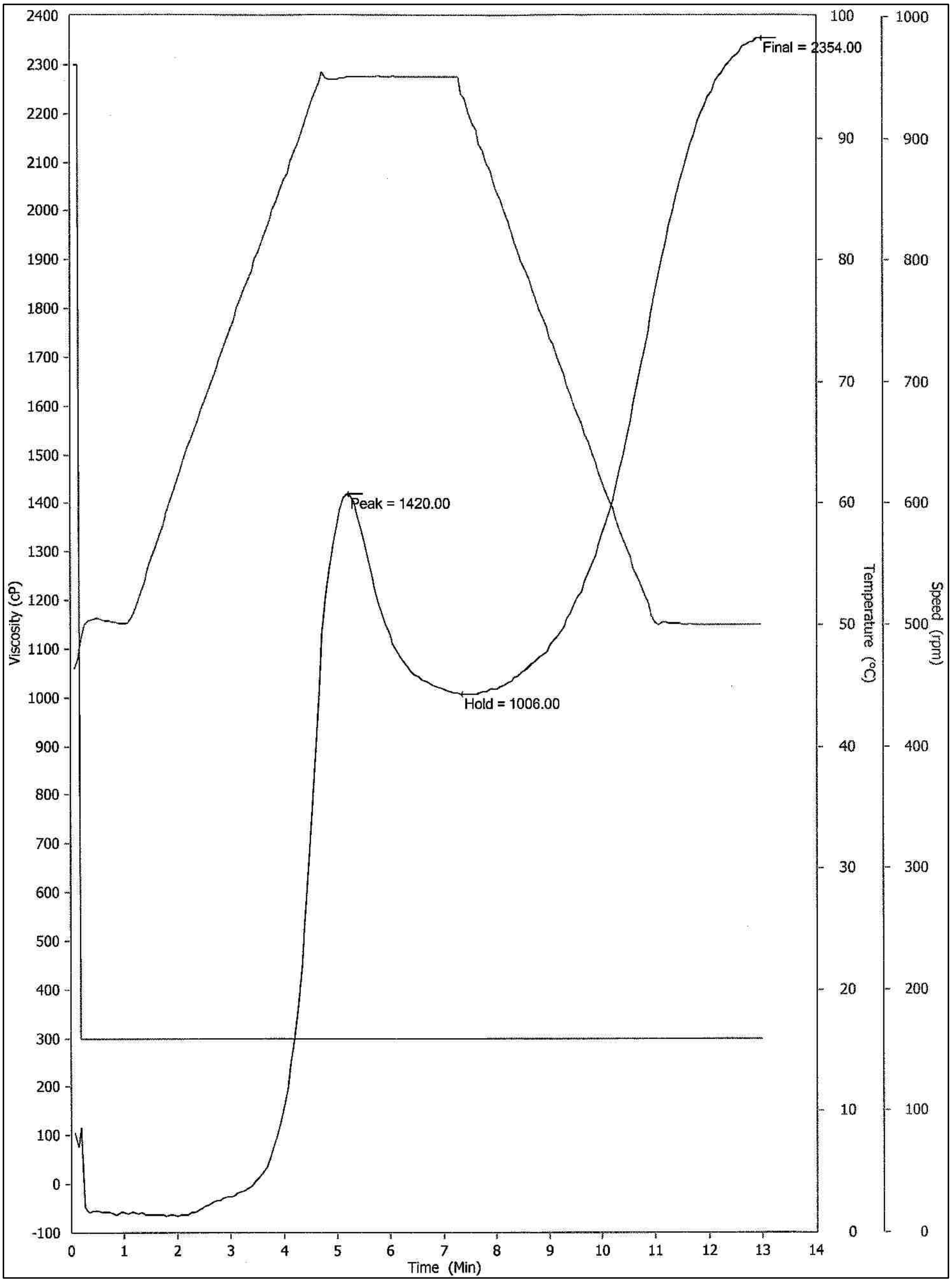

Figure D.30 Amylograph for the 30/70 Black Bean Flour Mixture B

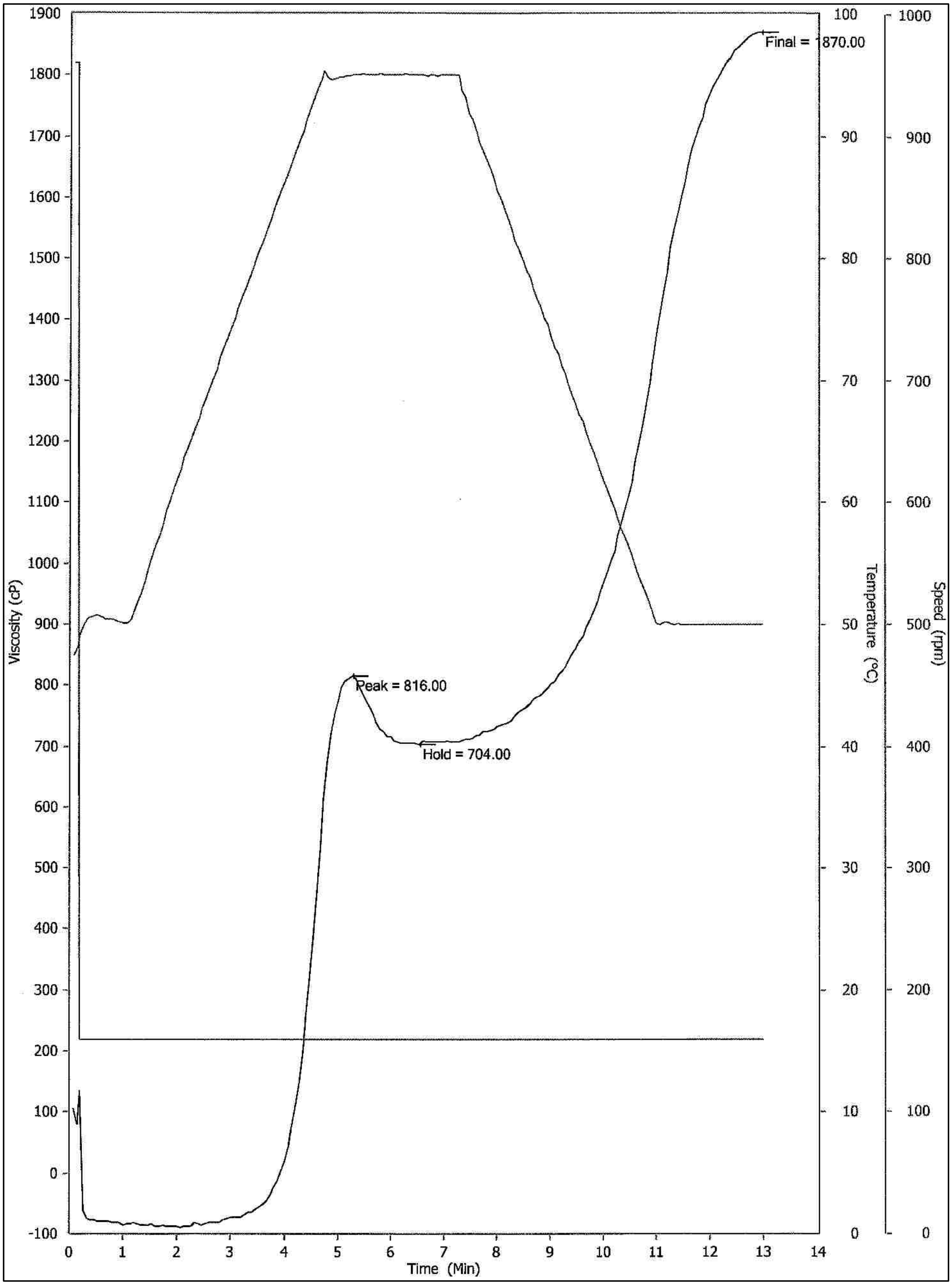

Figure D.31 Amylograph for the 50/50 Black Bean Flour Mixture A

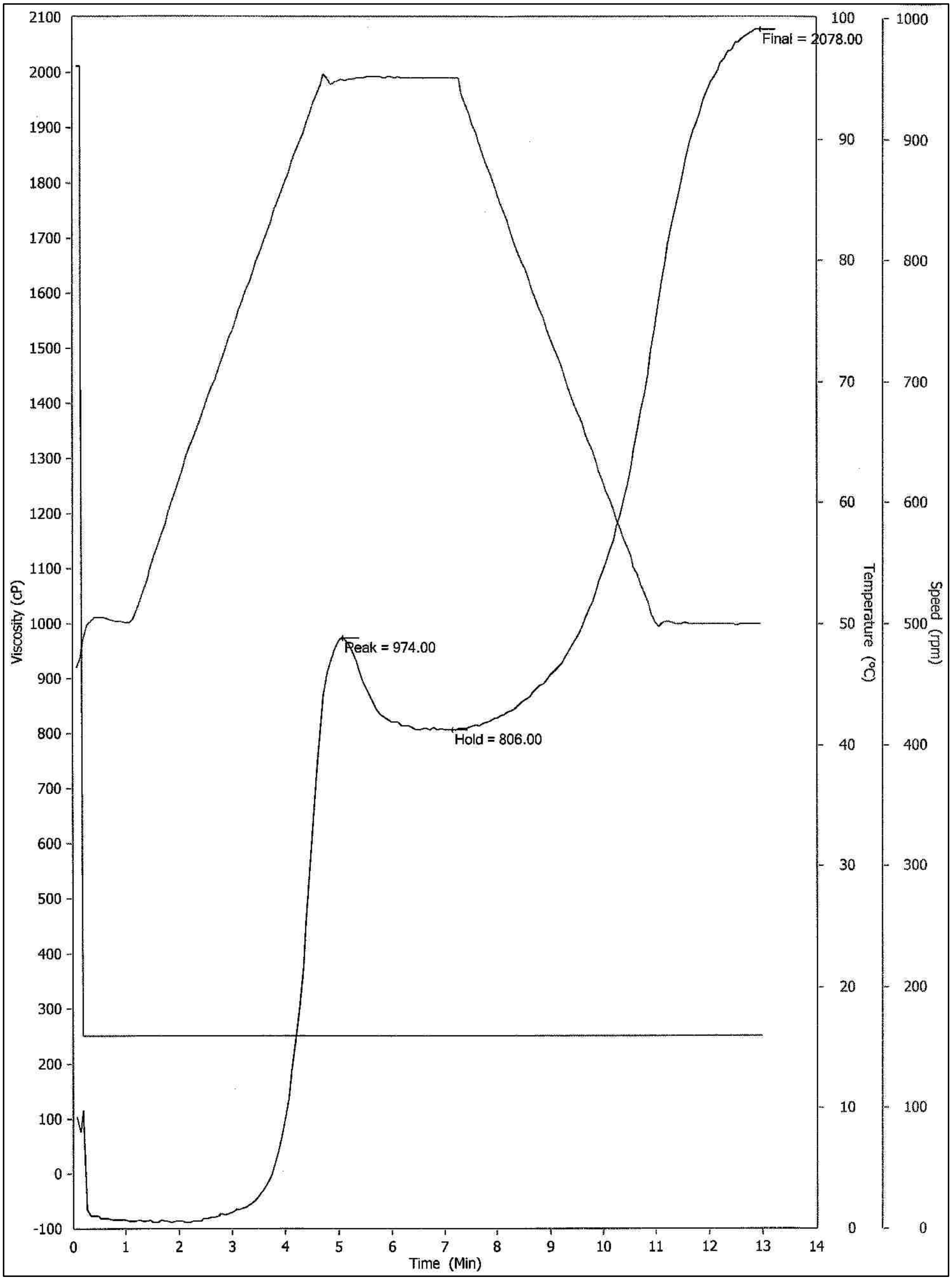

Figure D.32 Amylograph for the 50/50 Black Bean Flour Mixture B

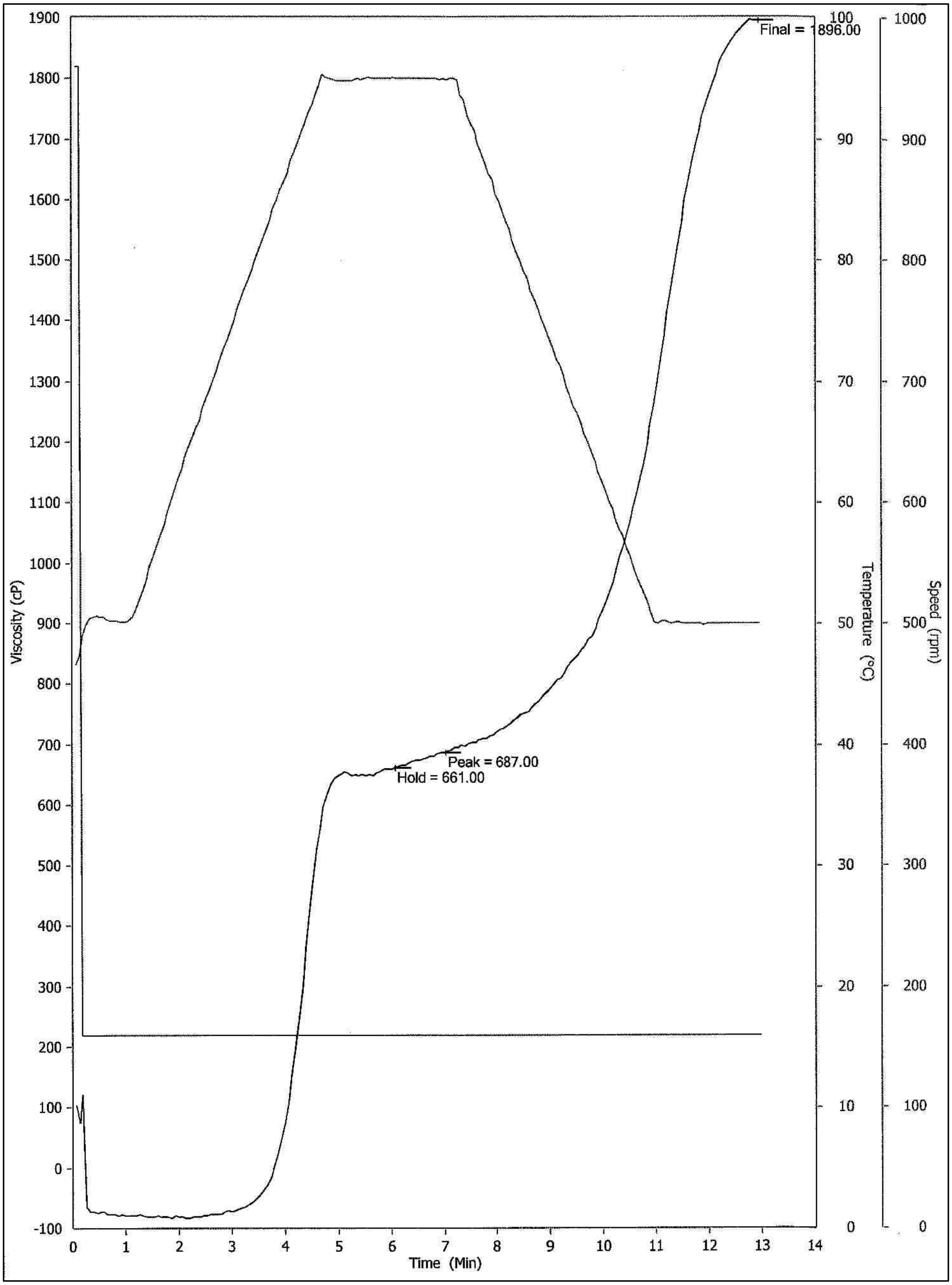

Figure D.33 Amylograph for the 75/25 Black Bean Flour Mixture A

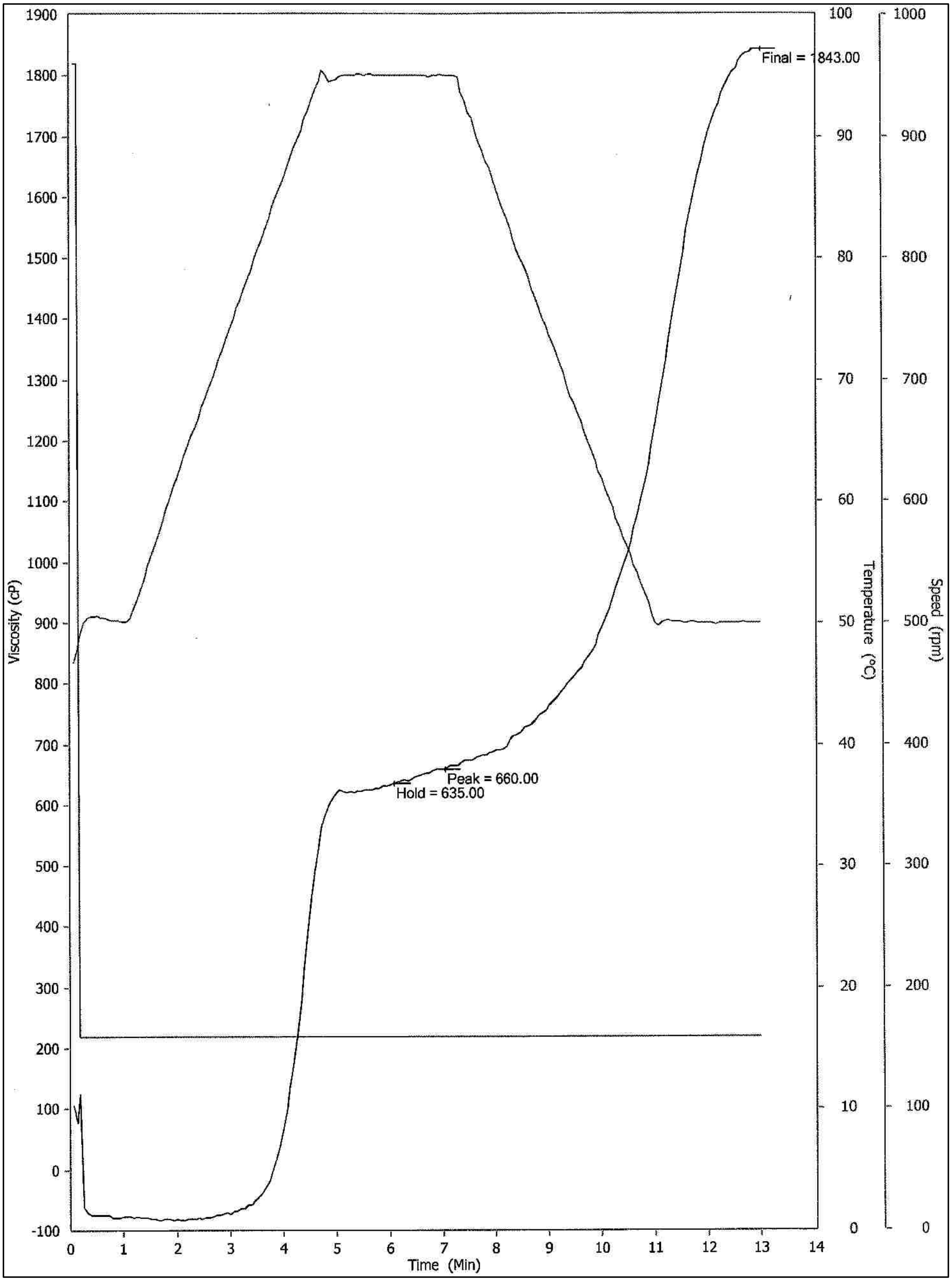

Figure D.34 Amylograph for the 75/25 Black Bean Flour Mixture B

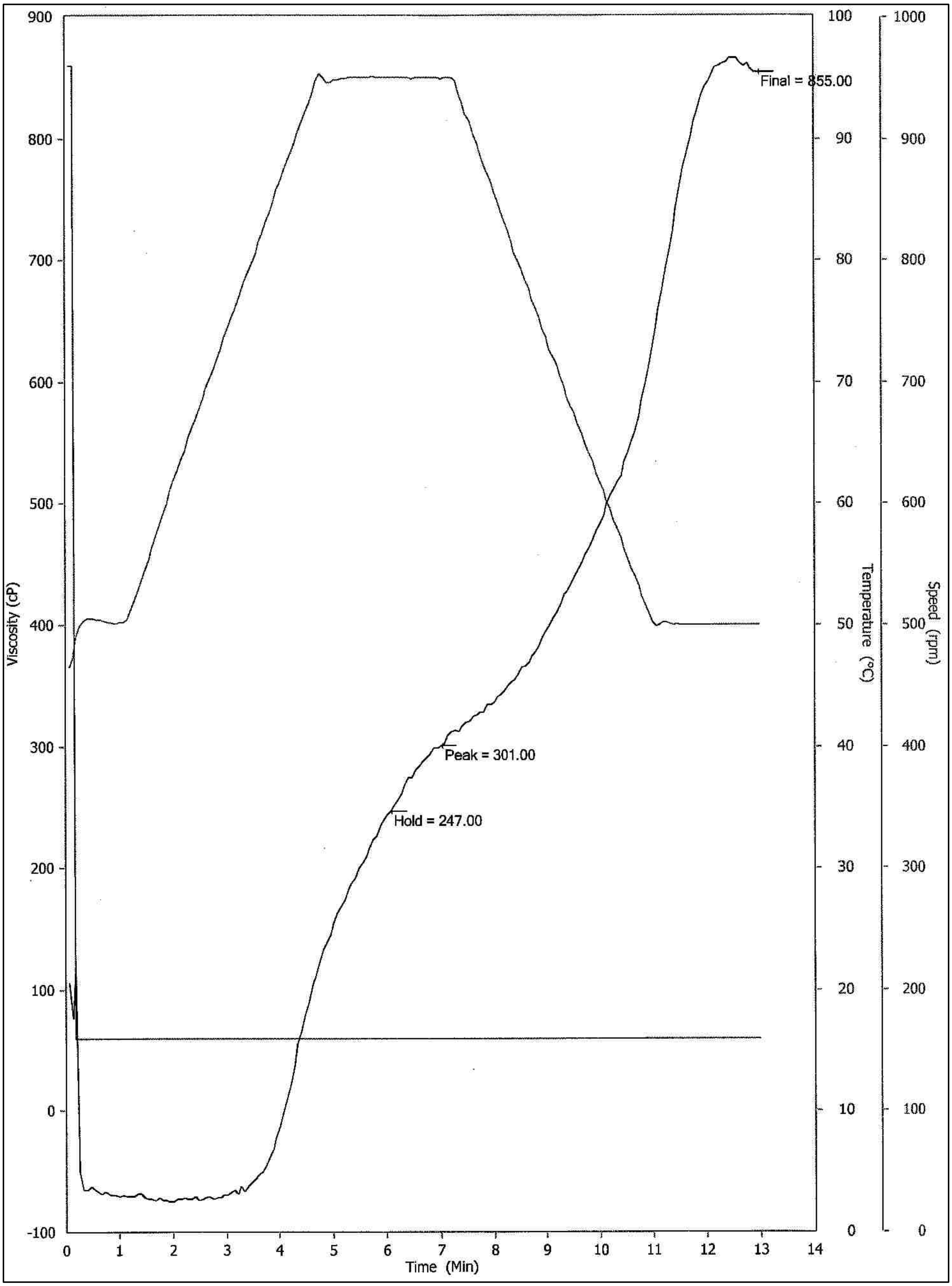

Figure D.35 Amylograph for the 100/0 Black Bean Flour Mixture

APPENDIX E: NUTRITIONAL ANALYSIS

A calculated proximate analysis was performed on four flour blends and three ravioli types as described in Chapter 4. The full details of this analysis are included in the following pages. Nutrition information for the ‘00’ flour used was entered manually from the nutrition label on the product. The information for the navy bean flour was acquired from the nutritional analysis provided by Best Cooking Pulses, Inc. A nutrient analysis showing the nutritional data for these two ingredients are included in the following pages. A full analysis of the control, 50% navy bean/50% control, and 75% navy bean/25% control flours and the three ravioli types is also included in the following pages. Each analysis includes a nutrient facts report, giving unrounded amounts of each type of nutrient in the product nutrition facts panels. The recipe nutrition summary shows the amounts of each type of nutrient, vitamin, and mineral in the products. The recipe report gives the amount of nutrient from each ingredient in the recipe.

Ingredient **'00' FLOUR**

Nutrient Analysis

Measure: 30.00 gram(s)

Source: Axxya systems

Category:

Manufacturer:

Nutrient	Value	Unit	Nutrient	Value	Unit	Percentage of Kcals	
Weight	30.000	g	Total Carbohydrate	23.000	g	Protein	12.0 %
Calories	100.000	kcal	Dietary Fiber, Total	0.500	g	Carbohydrate	92.0 %
Fat, Total	0.000	g	Protein	3.000	g	Fat, total	0.0 %
Calories from Fat	0.000	kcal	Cholesterol	0.000	mg	Alcohol	0.0 %
Saturated Fat	0.000	g	Sodium	0.000	mg		
Monounsaturated Fat	0.000	g	Vitamin A (RE)	0.000	mcg		
Calories from Sat Fat	0.000	kcal	Vitamin C	0.000	mg		
Polyunsaturated Fat	0.000	g	Calcium	0.000	mg		
Sugar, Total	0.500	g	Iron	0.000	mg		

Figure E.1 '00' Flour Nutrient Analysis

Ingredient **NAVY BEAN FLOUR**

Nutrient Analysis

Measure: 100.00 gram(s) **Category:**

Source: Axxya systems **Manufacturer:**

Nutrient	Value	Unit	Nutrient	Value	Unit	Percentage of Kcals	
Weight	100.000	g	Sodium	0.500	mg	Protein	28.7 %
Calories	357.000	kcal	Vitamin A (RE)	10.000	mcg	Carbohydrate	68.4 %
Fat, Total	2.180	g	Vitamin C	1.000	mg	Fat, total	5.5 %
Calories from Fat	19.620	kcal	Vitamin B 1 (Thiamin)	0.580	mg	Alcohol	0.0 %
Sugar, Total	3.140	g	Vitamin B2 (Riboflavin)	0.160	mg		
Total Carbohydrate	61.030	g	Vitamin B6 (Pyridoxine)	0.210	mg		
Dietary Fiber, Total	23.600	g	Calcium	155.000	mg		
Protein	25.600	g	Iron	7.600	mg		
Cholesterol	1.000	mg	Potassium	1,705.000	mg		

E.2 Navy Bean Flour Nutrient Analysis

Recipe **CONTROL FLOUR**

Nutrient Facts Report

Yield: 1.0 (1.0 serving(s))
No. Ingredients: 2

Category:
Manufacturer:

Ingredients

1. 50. gram(s) Flour, Semolina, Enriched
2. 50 gram(s) '00' Flour

Nutrition Facts

Serving Size 1.000 serving(s) (100g)

Amount Per Serving

Calories	346.667	**Calories from Fat**	4.725
Fat, Total	0.525 g		
Saturated Fat	0.075 g		
	0.0		
Cholesterol	0.000 mg		
Sodium	0.501 mg		
Total Carbohydrate	74.749 g		
Dietary Fiber, Total	2.783 g		
Sugar, Total	1.752 g		
Protein	11.340 g		
Vitamin A (RE)	0.000 mcg	Calcium	8.501 mg
Vitamin C	0.000 mg	Iron	2.180 mg

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E.3 Control Flour Nutrient Facts Report

Recipe CONTROL FLOUR

Recipe Nutrition Summary

Yield: 1.0 (1.0 serving(s))
No. Ingredients: 2
Manufacturer:
Category:

Ingredients

1. 50. gram(s) Flour, Semolina, Enriched
2. 50 gram(s) '00' Flour

Macronutrients

Calories	346.667	kcal
Fat, Total	0.525	g
Saturated Fat	0.075	g
Monounsaturated Fat	0.062	g
Polyunsaturated Fat	0.216	g
Sugar, Total	1.752	g
Total Carbohydrate	74.749	g
Dietary Fiber, Total	2.783	g
Protein	11.340	g
Alcohol	0.000	g
Cholesterol	0.000	mg

Vitamins & Minerals

Sodium	0.501	mg
Folate (Total)	91.501	mcg
Vitamin A (RE)	0.000	mcg
Vitamin C	0.000	mg
Vitamin D (ug)	0.000	mcg
Vitamin B 1 (Thiamin)	0.406	mg
Vitamin B2 (Riboflavin)	0.285	mg
Vitamin B6 (Pyridoxine)	0.051	mg
Vitamin B12 (Cobalamin)	0.000	mcg
Pantothenic Acid	0.290	mg
Potassium	93.000	mg
Calcium	8.501	mg
Phosphorus	68.000	mg
Magnesium	23.501	mg
Iron	2.180	mg
Copper	0.095	mg
Manganese	0.309	mg
Selenium	44.701	mcg
Zinc	0.525	mg

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E.4 Control Flour Recipe Nutrition Summary

Recipe CONTROL FLOUR

Recipe Report

Yield: 1.0 (1.0 serving(s))

Category:

No. Ingredients: 2

Manufacturer:

Cost:

Preparation

Preparation Method:

Cooking Time: :

Preparation Time:

Cooking Temp:

Ingredients

Ingredient	Weight	Calories	Protein	Total Carbohydrate	Fat, Total	Cholesterol	Saturated Fat	Sodium	Dietary Fiber, Total	Sugar, Total	Moisture	Trans Fatty Acid
50. gram(s) Flour, Semolina, Enriched	50.000	180.000	6.340	36.416	0.535	0.000	0.075	0.501	1.950	0.919	6.335	
50 gram(s) '00' Flour	50.000	166.667	5.000	38.333	0.000	0.000	0.000	0.000	0.833	0.833		

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E.5 Control Flour Recipe Report

Recipe **50/50 NAVY BEAN FLOUR**

Nutrient Facts Report

Yield: 1.0 (1.0 serving(s))
No. Ingredients: 2
Category:
Manufacturer:

Ingredients

1	1.00 serving(s) Control Flour
2	100.00 gram(s) Navy Bean Flour

Nutrition Facts

Serving Size 1.000 serving(s) (200g)

Amount Per Serving

Calories	703.667	**Calories from Fat**	24.345
Fat, Total	2.705 g		
Saturated Fat	0.075 g		
	0.0		
Cholesterol	1.000 mg		
Sodium	1.001 mg		
Total Carbohydrate	135.779 g		
Dietary Fiber, Total	26.383 g		
Sugar, Total	4.892 g		
Protein	36.940 g		
Vitamin A (RE)	10.000 mcg	Calcium	163.501 mg
Vitamin C	1.000 mg	Iron	9.780 mg

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E.6 50% Navy Bean/50% Control Flour Nutrient Facts Report

Recipe **50/50 NAVY BEAN FLOUR**

Recipe Nutrition Summary

Yield: 1.0 (1.0 serving(s))
No. Ingredients: 2
Manufacturer:

Category:

Ingredients

1	1.00 serving(s) Control Flour
2	100.00 gram(s) Navy Bean Flour

Macronutrients

Calories	703.667	kcal
Fat, Total	2.705	g
Saturated Fat	0.075	g
Monounsaturated Fat	0.062	g
Polyunsaturated Fat	0.216	g
Sugar, Total	4.892	g
Total Carbohydrate	135.779	g
Dietary Fiber, Total	26.383	g
Protein	36.940	g
Alcohol	0.000	g
Cholesterol	1.000	mg

Vitamins & Minerals

Sodium	1.001	mg
Folate (Total)	91.501	mcg
Vitamin A (RE)	10.000	mcg
Vitamin C	1.000	mg
Vitamin D (ug)	0.000	mcg
Vitamin B 1 (Thiamin)	0.986	mg
Vitamin B2 (Riboflavin)	0.445	mg
Vitamin B6 (Pyridoxine)	0.261	mg
Vitamin B12 (Cobalamin)	0.000	mcg
Pantothenic Acid	0.290	mg
Potassium	1,798.000	mg
Calcium	163.501	mg
Phosphorus	68.000	mg
Magnesium	23.501	mg
Iron	9.780	mg
Copper	0.095	mg
Manganese	0.309	mg
Selenium	44.701	mcg
Zinc	0.525	mg

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E.7 50% Navy Bean/50% Control Flour Recipe Nutrition Summary

Recipe **50/50 NAVY BEAN FLOUR**

Recipe Report

Yield: 1.0 (1.0 serving(s))

Category:

No. Ingredients: 2

Manufacturer:

Cost:

Ingredients

Ingredient	Weight	Calories	Fat, Total	Saturated Fat	Sugar, Total	Total Carbohydrate	Dietary Fiber, Total	Protein	Cholesterol	Sodium	Moisture	Trans Fatty Acid
1.00 serving(s) Control Flour	100.000	346.667	0.525	0.075	1.752	74.749	2.783	11.340	0.000	0.501	6.335	
100.00 gram(s) Navy Bean Flour	100.000	357.000	2.180		3.140	61.030	23.600	25.600	1.000	0.500		

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E.8 50% Navy Bean/50% Control Flour Recipe Report

Recipe **75/25 FLOUR**

Nutrient Facts Report

Yield: 1.0 (1.0 100grams)
No. Ingredients: 2

Category:
Manufacturer:

Ingredients

1	75 gram(s) Navy Bean Flour
2	25 gram(s) Control Flour

Nutrition Facts

Serving Size 1.000 100grams (100g)

Amount Per Serving

Calories	354.417	**Calories from Fat**	15.896
Fat, Total	1.766 g		
Saturated Fat	0.019 g		
	0.0		
Cholesterol	0.750 mg		
Sodium	0.500 mg		
Total Carbohydrate	64.460 g		
Dietary Fiber, Total	18.396 g		
Sugar, Total	2.793 g		
Protein	22.035 g		
Vitamin A (RE)	7.500 mcg	Calcium	118.375 mg
Vitamin C	0.750 mg	Iron	6.245 mg

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E.9 75% Navy Bean/25% Control Flour Nutrient Facts Report

Recipe **75/25 FLOUR**

Recipe Nutrition Summary

Yield: 1.0 (1.0 100grams)
No. Ingredients: 2
Manufacturer:

Category:

Ingredients

1	75 gram(s) Navy Bean Flour
2	25 gram(s) Control Flour

Macronutrients

Calories	354.417	kcal
Fat, Total	1.766	g
Saturated Fat	0.019	g
Monounsaturated Fat	0.016	g
Polyunsaturated Fat	0.054	g
Sugar, Total	2.793	g
Total Carbohydrate	64.460	g
Dietary Fiber, Total	18.396	g
Protein	22.035	g
Alcohol	0.000	g
Cholesterol	0.750	mg

Vitamins & Minerals

Sodium	0.500	mg
Folate (Total)	22.875	mcg
Vitamin A (RE)	7.500	mcg
Vitamin C	0.750	mg
Vitamin D (ug)	0.000	mcg
Vitamin B 1 (Thiamin)	0.537	mg
Vitamin B2 (Riboflavin)	0.191	mg
Vitamin B6 (Pyridoxine)	0.170	mg
Vitamin B12 (Cobalamin)	0.000	mcg
Pantothenic Acid	0.073	mg
Potassium	1,302.000	mg
Calcium	118.375	mg
Phosphorus	17.000	mg
Magnesium	5.875	mg
Iron	6.245	mg
Copper	0.024	mg
Manganese	0.077	mg
Selenium	11.175	mcg
Zinc	0.131	mg

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E.10 75% Navy Bean/25% Control Flour Recipe Nutrition Summary

Recipe **75/25 FLOUR**

Recipe Report

Yield: 1.0 (1.0 100grams)

Category:

No. Ingredients: 2

Manufacturer:

Cost:

Preparation

Preparation Method:

Cooking Time: :

Preparation Time:

Cooking Temp:

Ingredients

Ingredient	Weight	Calories	Fat, Total	Sugar, Total	Total Carbohydrate	Dietary Fiber, Total	Protein	Cholesterol	Sodium	Saturated Fat	Trans Fatty Acid	Moisture
75 gram(s) Navy Bean Flour	75.000	267.750	1.635	2.355	45.773	17.700	19.200	0.750	0.375			
25 gram(s) Control Flour	25.000	86.667	0.131	0.438	18.687	0.696	2.835	0.000	0.125	0.019		1.584

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E.11 75% Navy Bean/25% Control Flour Recipe Report

Recipe **CONTROL RAVIOLI**

Nutrient Facts Report

Yield: 3.0 (1.0 100grams)
No. Ingredients: 6

Category:
Manufacturer:

Ingredients

1	120.9 gram(s) Control Flour
2	72.7 gram(s) Egg, Raw
3	0.7 gram(s) Salt, Table
4	6.4 gram(s) Oil, Olive
5	70 gram(s) Cheese, Ricotta, Whole Milk
6	28.3 gram(s) Cheese, Parmesan, Shredded

Nutrition Facts

Serving Size 1.000 100grams (100g)

Amount Per Serving

Calories	273.88	**Calories from Fat**	92.624
Fat, Total	10.292 g		
Saturated Fat	4.673 g		
Trans Fatty Acid	0.009 g		
Cholesterol	109.204 mg		
Sodium	305.700 mg		
Total Carbohydrate	31.435 g		
Dietary Fiber, Total	1.125 g		
Sugar, Total	0.947 g		
Protein	13.859 g		
Vitamin A (RE)	88.797 mcg	Calcium	184.188 mg
Vitamin C	0.000 mg	Iron	1.492 mg

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E.12 Control Ravioli Nutrient Facts Report

Recipe **CONTROL RAVIOLI**

Recipe Nutrition Summary

Yield: 3.0 (1.0 100grams)
No. Ingredients: 6
Manufacturer:

Category:

Ingredients

1	120.9 gram(s) Control Flour
2	72.7 gram(s) Egg, Raw
3	0.7 gram(s) Salt, Table
4	6.4 gram(s) Oil, Olive
5	70 gram(s) Cheese, Ricotta, Whole Milk
6	28.3 gram(s) Cheese, Parmesan, Shredded

Macronutrients

Calories	273.880	kcal
Fat, Total	10.292	g
Saturated Fat	4.673	g
Monounsaturated Fat	4.153	g
Polyunsaturated Fat	0.930	g
Sugar, Total	0.947	g
Total Carbohydrate	31.435	g
Dietary Fiber, Total	1.125	g
Protein	13.859	g
Alcohol	0.000	g
Cholesterol	109.204	mg
Trans Fatty Acid	0.009	g

Vitamins & Minerals

Sodium	305.700	mg
Folate (Total)	51.993	mcg
Vitamin A (RE)	88.797	mcg
Vitamin C	0.000	mg
Vitamin D (ug)	0.580	mcg
Vitamin K	1.799	mcg
Vitamin B 1 (Thiamin)	0.181	mg
Vitamin B2 (Riboflavin)	0.306	mg
Vitamin B6 (Pyridoxine)	0.081	mg
Vitamin B12 (Cobalamin)	0.428	mcg
Pantothenic Acid	0.589	mg
Vitamin E (mg)	0.256	mg
Potassium	104.961	mg
Calcium	184.188	mg
Phosphorus	182.195	mg
Magnesium	19.825	mg
Iron	1.492	mg
Copper	0.065	mg
Manganese	0.135	mg
Selenium	31.196	mcg
Zinc	1.100	mg

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E.13 Control Ravioli Recipe Nutrition Summary

Recipe **CONTROL RAVIOLI**

Recipe Report

Yield: 3.0 (1.0 100grams)

Category:

No. Ingredients: 6

Manufacturer:

Cost:

Preparation

Preparation Method:

Cooking Time: :

Preparation Time:

Cooking Temp:

Ingredients

Ingredient	Weight	Calories	Fat, Total	Saturated Fat	Sugar, Total	Total Carbohydrate	Dietary Fiber, Total	Protein	Cholesterol	Sodium	Moisture	Trans Fatty Acid
120.9 gram(s) Control Flour	120.900	419.120	0.635	0.091	2.118	90.372	3.365	13.710	0.000	0.606	7.659	
72.7 gram(s) Egg, Raw	72.700	103.961	6.914	2.273	0.269	0.523	0.000	9.131	270.444	103.234	55.361	0.028
0.7 gram(s) Salt, Table	0.700	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	271.306	0.001	
6.4 gram(s) Oil, Olive	6.400	56.576	6.400	0.884	0.000	0.000	0.000	0.000	0.000	0.128	0.000	
70 gram(s) Cheese, Ricotta, Whole Milk	70.000	121.800	9.086	5.806	0.189	2.128	0.000	7.882	35.700	58.800	50.191	
28.3 gram(s) Cheese, Parmesan, Shredded	28.300	117.445	7.737	4.919	0.255	0.968	0.000	10.714	20.376	479.968	7.075	

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E.14 Control Ravioli Recipe Report

Recipe **50/50 NAVY BEAN RAVIOLI**

Nutrient Facts Report

Yield: 3.0 (1.0 100grams)

No. Ingredients: 8

Category:

Manufacturer:

Ingredients

1	60.45 gram(s) Control Flour
2	60.45 gram(s) Navy Bean Flour
3	72.7 gram(s) Egg, Raw
4	6.4 gram(s) Oil, Olive
5	0.7 gram(s) Salt, Table
6	2 gram(s) Water, Tap, Drinking
7	70 gram(s) Cheese, Ricotta, Whole Milk
8	28.3 gram(s) Cheese, Parmesan, Shredded

Nutrition Facts

Serving Size 1.000 100grams (100g)

Amount Per Serving

Calories	274.136	**Calories from Fat**	95.000
Fat, Total	10.556 g		
Saturated Fat	4.627 g		
Trans Fatty Acid	0.009 g		
Cholesterol	108.679 mg		
Sodium	303.695 mg		
Total Carbohydrate	28.471 g		
Dietary Fiber, Total	5.299 g		
Sugar, Total	1.219 g		
Protein	16.631 g		
Vitamin A (RE)	90.215 mcg	Calcium	212.405 mg
Vitamin C	0.201 mg	Iron	2.571 mg

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E.15 50% Navy Bean/50% Control Ravioli Nutrient Facts Report

Recipe **50/50 NAVY BEAN RAVIOLI**

Recipe Nutrition Summary

Yield: 3.0 (1.0 100grams)
No. Ingredients: 8
Manufacturer:

Category:

Ingredients

1	60.45 gram(s) Control Flour
2	60.45 gram(s) Navy Bean Flour
3	72.7 gram(s) Egg, Raw
4	6.4 gram(s) Oil, Olive
5	0.7 gram(s) Salt, Table
6	2 gram(s) Water, Tap, Drinking
7	70 gram(s) Cheese, Ricotta, Whole Milk
8	28.3 gram(s) Cheese, Parmesan, Shredded

Macronutrients

Calories	274.136	kcal
Fat, Total	10.556	g
Saturated Fat	4.627	g
Monounsaturated Fat	4.113	g
Polyunsaturated Fat	0.881	g
Sugar, Total	1.219	g
Total Carbohydrate	28.471	g
Dietary Fiber, Total	5.299	g
Protein	16.631	g
Alcohol	0.000	g
Cholesterol	108.679	mg
Trans Fatty Acid	0.009	g

Vitamins & Minerals

Sodium	303.695	mg
Folate (Total)	33.271	mcg
Vitamin A (RE)	90.215	mcg
Vitamin C	0.201	mg
Vitamin D (ug)	0.577	mcg
Vitamin K	1.787	mcg
Vitamin B 1 (Thiamin)	0.214	mg
Vitamin B2 (Riboflavin)	0.279	mg
Vitamin B6 (Pyridoxine)	0.113	mg
Vitamin B12 (Cobalamin)	0.426	mcg
Pantothenic Acid	0.527	mg
Vitamin E (mg)	0.254	mg
Potassium	428.003	mg
Calcium	212.405	mg
Phosphorus	167.328	mg
Magnesium	14.980	mg
Iron	2.571	mg
Copper	0.045	mg
Manganese	0.072	mg
Selenium	22.012	mcg
Zinc	0.988	mg

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E.16 50% Navy Bean/50% Control Ravioli Recipe Nutrition Summary

Recipe 50/50 NAVY BEAN RAVIOLI

Recipe Report

Yield: 3.0 (1.0 100grams)

Category:

No. Ingredients: 8

Manufacturer:

Cost:

Ingredients

Ingredient	Weight	Calories	Fat, Total	Saturated Fat	Sugar, Total	Total Carbohydrate	Dietary Fiber, Total	Protein	Cholesterol	Sodium	Moisture	Trans Fatty Acid
60.45 gram(s) Control Flour	60.450	209.560	0.317	0.045	1.059	45.186	1.682	6.855	0.000	0.303	3.830	
60.45 gram(s) Navy Bean Flour	60.450	215.807	1.318		1.898	36.893	14.266	15.475	0.605	0.302		
72.7 gram(s) Egg, Raw	72.700	103.961	6.914	2.273	0.269	0.523	0.000	9.131	270.444	103.234	55.361	0.028
6.4 gram(s) Oil, Olive	6.400	56.576	6.400	0.884	0.000	0.000	0.000	0.000	0.000	0.128	0.000	
0.7 gram(s) Salt, Table	0.700	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	271.306	0.001	
2 gram(s) Water, Tap, Drinking	2.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.080	2.004	
70 gram(s) Cheese, Ricotta, Whole Milk	70.000	121.800	9.086	5.806	0.189	2.128	0.000	7.882	35.700	58.800	50.191	
28.3 gram(s) Cheese, Parmesan, Shredded	28.300	117.445	7.737	4.919	0.255	0.968	0.000	10.714	20.376	479.968	7.075	

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E.17 50% Navy Bean/50% Control Ravioli Recipe Report

Recipe **75/25 NAVY BEAN RAVIOLI**

Nutrient Facts Report

Yield: 3.0 (1.0 100grams)
No. Ingredients: 8

Category:
Manufacturer:

Ingredients

1	30.225 gram(s) Control Flour
2	90.675 gram(s) Navy Bean Flour
3	72.7 gram(s) Egg, Raw
4	0.7 gram(s) Salt, Table
5	6.4 gram(s) Oil, Olive
6	70 gram(s) Cheese, Ricotta, Whole Milk
7	28.3 gram(s) Cheese, Parmesan, Shredded
8	5.20 gram(s) Water, Tap, Drinking

Nutrition Facts

Serving Size 1.000 100grams (100g)

Amount Per Serving

Calories	272.279	**Calories from Fat**	95.480
Fat, Total	10.609 g		
Saturated Fat	4.571 g		
Trans Fatty Acid	0.009 g		
Cholesterol	107.635 mg		
Sodium	300.542 mg		
Total Carbohydrate	26.809 g		
Dietary Fiber, Total	7.311 g		
Sugar, Total	1.344 g		
Protein	17.872 g		
Vitamin A (RE)	90.260 mcg	Calcium	224.758 mg
Vitamin C	0.298 mg	Iron	3.082 mg

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E.18 75% Navy Bean/25% Control Ravioli Nutrient Facts Report

Recipe **75/25 NAVY BEAN RAVIOLI**

Recipe Nutrition Summary

Yield: 3.0 (1.0 100grams)
No. Ingredients: 8
Manufacturer:
Category:

Ingredients

1	30.225 gram(s) Control Flour
2	90.675 gram(s) Navy Bean Flour
3	72.7 gram(s) Egg, Raw
4	0.7 gram(s) Salt, Table
5	6.4 gram(s) Oil, Olive
6	70 gram(s) Cheese, Ricotta, Whole Milk
7	28.3 gram(s) Cheese, Parmesan, Shredded
8	5.20 gram(s) Water, Tap, Drinking

Macronutrients

Calories	272.279	kcal
Fat, Total	10.609	g
Saturated Fat	4.571	g
Monounsaturated Fat	4.063	g
Polyunsaturated Fat	0.850	g
Sugar, Total	1.344	g
Total Carbohydrate	26.809	g
Dietary Fiber, Total	7.311	g
Protein	17.872	g
Alcohol	0.000	g
Cholesterol	107.635	mg
Trans Fatty Acid	0.009	g

Vitamins & Minerals

Sodium	300.542	mg
Folate (Total)	23.829	mcg
Vitamin A (RE)	90.260	mcg
Vitamin C	0.298	mg
Vitamin D (ug)	0.571	mcg
Vitamin K	1.768	mcg
Vitamin B 1 (Thiamin)	0.229	mg
Vitamin B2 (Riboflavin)	0.264	mg
Vitamin B6 (Pyridoxine)	0.127	mg
Vitamin B12 (Cobalamin)	0.421	mcg
Pantothenic Acid	0.493	mg
Vitamin E (mg)	0.251	mg
Potassium	583.667	mg
Calcium	224.758	mg
Phosphorus	158.811	mg
Magnesium	12.498	mg
Iron	3.082	mg
Copper	0.035	mg
Manganese	0.041	mg
Selenium	17.339	mcg
Zinc	0.925	mg

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E.19 75% Navy Bean/25% Control Ravioli Recipe Nutrition Summary

Recipe **75/25 NAVY BEAN RAVIOLI**

Recipe Report

Yield: 3.0 (1.0 100grams)
Category:
No. Ingredients: 8
Manufacturer:
Cost:

Ingredients

Ingredient	Weight	Calories	Fat, Total	Saturated Fat	Sugar, Total	Total Carbohydrate	Dietary Fiber, Total	Protein	Cholesterol	Sodium	Moisture	Trans Fatty Acid
30.225 gram(s) Control Flour	30.225	104.780	0.159	0.023	0.530	22.593	0.841	3.428	0.000	0.151	1.915	
90.675 gram(s) Navy Bean Flour	90.675	323.710	1.977		2.847	55.339	21.399	23.213	0.907	0.453		
72.7 gram(s) Egg, Raw	72.700	103.961	6.914	2.273	0.269	0.523	0.000	9.131	270.444	103.234	55.361	0.028
0.7 gram(s) Salt, Table	0.700	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	271.306	0.001	
6.4 gram(s) Oil, Olive	6.400	56.576	6.400	0.884	0.000	0.000	0.000	0.000	0.000	0.128	0.000	
70 gram(s) Cheese, Ricotta, Whole Milk	70.000	121.800	9.086	5.806	0.189	2.128	0.000	7.882	35.700	58.800	50.191	
28.3 gram(s) Cheese, Parmesan, Shredded	28.300	117.445	7.737	4.919	0.255	0.968	0.000	10.714	20.376	479.968	7.075	
5.20 gram(s) Water, Tap, Drinking	5.215	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.209	5.210	

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E.20 75% Navy Bean/25% Control Ravioli Recipe Report

VITA

Christopher D. Ringuette was born in Louisiana to a family dedicated to the Cajun cuisine. He gained a love for cooking from his late grandfather, Collins A. Liner. Upon graduation from high school, Christopher began working in the restaurant industry, gaining eight years of experience. This work continued throughout his undergraduate program until he received his Bachelors of Science in the Culinary Arts from Nicholls State University in 2014. He then transitioned to food science, earning his Master's degree from Louisiana State University in 2016. He also gained three years of experience in culinary research and development during his time in college. Christopher Ringuette is currently employed as a research chef in the Baton Rouge area.