DEVELOPING A GLUTEN, SOY, DAIRY, AND NUT FREE ENERGY BAR WITH A SUGGESTED HACCP PLAN

By

BAYAN ALTOAIMI

Bachelor of Science in Food Science and Human Nutrition

King Saud University

Riyadh, Saudi Arabia

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Thesis Approved:

Dr. Timothy Bowser

Thesis Adviser

Dr. William McGlynn

Dr. Mark Payton

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Abstract: The purpose of energy bars is to provide people with energy to help them perform various tasks in their lives in a better way. There are several types of energy bars in the market nowadays; however, there are some people who are allergic to gluten, nut, soy, and dairy and, unfortunately, there is no energy bar that can suit their needs. As a result, this study attempted to develop an energy bar that is gluten, nut, soy, and dairy free. A comparison between the developed energy bar in this study and a commercial bar was made. Sixty-six panelists were recruited from students, faculty and staff on contract of Oklahoma State University and were voluntarily participated in the study. They were asked to taste the two samples and evaluate eight important attributes including stickiness to touch, color, chewiness, flavor, sweetness, adhesiveness to teeth, texture and overall acceptance using a nine-point hedonic scale. Proximate analysis of both samples was determined. A suggested HACCP plan for industries intend to produce this energy bar was proposed. Results indicated that there was a significance difference ($p<0.05$) in chewiness, adhesiveness to teeth, and stickiness between the developed energy bar and the commercial bar. No difference was found in the remaining quality attributes. The developed energy bar was higher in carbohydrate and moisture and lower in protein, ash, and fat comparing to the commercial bar. In addition, the HACCP plan had one CCP that could be overcome using an X-ray detection system.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Energy bars (also known as energy snacks, fruit bars, space food sticks, and protein bars) have been indicated to have many health benefits, and have been more and more accepted by the public. The purpose of energy bars is to provide people with energy to help them perform various tasks in their lives in a better way. One study, for example, Manore and Thompson (2000), pointed out that people eat energy bars in order to enhance athletic performance, to prevent or treat injuries, to improve physical appearance, to lose weight, and to be accepted by peers. Energy bars are usually made with natural ingredients. Some bars are used as a dietary supplement since some of them have a good percentage of vitamins and minerals that comply with the Percent Daily Value (%DV).

One good feature of energy bars is that they can be conveniently eaten before, during, or after an exercise. In addition, they can be consumed as a daily snack. Energy bars are easy to carry and readily available. Various types of energy bars exist in the markets where they are meant to serve different needs (for example, high-performance athletes, health-conscience individuals, dieter, travelers, active women, active children, and on-the-go individuals), and with different flavors (for example, almond brownie, chocolate, black cherry almond, and salted caramel).

The modern history of energy bars can be traced to the 1960s. Since that time, it can be said that energy bars went through three different stages. Those stages are energy bars classified for astronauts, for athletes, and for the public. Energy bars are claimed to have achieved a rapid growth in the last decade. It is expected that this market could reach around $8.3 billion by 2016 (MarketResearch, 2012).

Because energy bars have all these advantages, companies such as Kellogg's and LARABAR started to produce them using a variety of ingredients and flavors. However, the product that I am suggesting is gluten, dairy, nut, and soy free. It contains: dates, oats, brown rice protein, and pea protein. In addition, the suggested energy bar is a 100% plant-based product with wholesome ingredients.

The objectives of this study are:

1. To develop an energy bar that is free of dairy, gluten, nut, and soy ingredients.
2. To develop an energy bar that is plant-based.
3. To analyze the final product and a similar commercial bar for fat, protein, moisture, ash, and water activity and compare the results.
4. To compare the suggested product to a similar commercial bar by making sensory quality evaluation.
5. To establish a HACCP plan for producing the suggested energy bar.

The results from this study, hopefully, will help people who are allergic to gluten, soy, milk, and/or nuts to be able to eat energy bars without having concerns about their health.

CHAPTER II

REVIEW OF LITERATURE

2.1. Introduction

In this chapter, I aim to provide an orientation to my thesis project. Firstly, I will provide a short summary for the history of energy bars. Next, I will highlight the important stages that energy bars went through since they were invented. After that, I will provide information about dates, oats, brown rice protein, and pea protein. In addition, I will highlight the origin concept of the hazard analysis and critical control point (HACCP) system. I will talk about HACCP in terms of its concept and origin. Finally, because my study is based on a suggested energy bar, I will list some of the fruit-based energy bars advantages and health benefits.

2.2. History of energy bars

The history of energy bars goes back to the ancient Greece. Pastéli, which is made with sesame seeds, honey, and sometimes nuts, is claimed to be the first energy bar ever made (Kotsiris & Kotsiris, 2014). The ancient Greeks believed that honey and sesame seeds had healing properties; therefore, the Greeks combined them and came up with Pastéli. The modern history of energy bars (sometimes they are known by energy snack, fruit bar, fruit stick, food stick, and energy stick) can be traced to the 1960s. Since that time, it can be said that energy bars went through three different development stages. Those stages are energy bars for: astronauts, athletes, and, the public.

2.2.1.Energy bars for astronauts

Energy bars were developed to help astronauts while they are in the space. The first energy bars were called “Space Food Sticks” and were released in the 1960s (Nudi, 2014). They were developed by NASA, the U.S. Air Force, and the Pillsbury Company (Gordon, 1973). Two reasons lead to the creation of the energy bars at that time.

The first reason was that astronauts were expected to circle the earth for 60 days with the possibility of extending that period of time to 85 days (Gordon, 1973). The quantity of food aboard the workshop was expected to last for 56 days only. Therefore, energy bars were created because they were nutritionally balanced and their light weight would not adversely affect the weight of the command module.

The second reason was that food energy bars can be eaten through an airtight port in the astronaut's helmet. The purpose of that airtight port was to provide astronauts with essential food in case of emergency (Billings, 2002). In such situations, astronauts would have balanced nutrition. In the mid-1970s when the energy crisis started and the space program started focusing on other issues, energy bars lost popularity (Lefcowitz, 2007).

2.2.2.Energy bars for athletes

Sutton (2011) claims that in 1983, a Canadian runner could not maintain his lead in a marathon. After that incident, the runner and his wife, a world-class runner and a nutrition specialist, started looking for energy food that could help athletes while competing. After spending three years in making and testing different formulations, they reached the ideal energy bar for athletes. It was commercially released in 1986 by Brian Maxwell and was named Power Bar (Nudi, 2014). This bar was low in fat and moderate protein, fiber and carbohydrate. Their friends, who tasted the bar, mentioned that their performance has improved. After that, Power Bar became widely common among athletes (Sutton, 2011). After few years, other energy bars were released later in the market such as The Clif (CQ) Bar, Deer Valley McHenergy Bar, and Trail Hiker Bar (Doheny, 1994).

2.2.3.Energy bars for the public

Later, ordinary people (not astronauts or athletes) started to consume energy bars because they provided them with energy to perform different daily tasks and that they were convenient and shelf stable. Table 1. shows the results of a study done by Mintel (2013) to identify the reasons that American consumers eat snack, cereal, and nutrition bars, by age. According to Mintel (2012), American consumption of energy bars during the lunch time is higher (82%) compered to breakfast and dinner time (62% and 42%, respectively). As a result, in the U.S., energy bar market has reached six billion dollars and has more than doubled in the past decade (Sutton, 2011). Recently, snack bars has been growing in sales up to 4% from 2013 to 2017, and they are expected to grow more up to 2% (AAFC, 2013).

Table 1. U.S. Consumers, Reasons for Consuming Snack, Cereal and Nutrition Bars, by Age, November 2012, (%). (Mintel, 2013).

	All	18-24	25-34	35-44	45-54	55-64	65+
Base: Internet users aged 18+ who eat cereal/snack	1,368	213	286	276	270	156	170
To curb hunger until the next meal	58	60	53	56	64	63	53
To satisfy a sweet craving	47	57	45	48	46	48	41
For fiber	42	44	38	39	44	46	45
To save time	34	49	39	33	24	32	26
As an energy boost	32	43	35	30	30	34	21
For protein	31	39	35	33	26	25	25
For vitamins and nutrients	29	37	28	26	28	29	24
For weight loss or maintenance	22	30	23	22	23	20	13
To maintain my metabolism	17	20	19	15	17	16	13
To maintain my blood sugar	16	14	20	11	14	21	18
To save money that would otherwise be spent on full meals	12	16	16	9	9	10	8
Other	2	1	1	1	1	1	4
None of the above	3	2	4	2	2	4	4

2.3. Fruit bar production process

The process of bars production is divided into essential and optional stages (Orrego, Salgado, & Botero, 2013). In the essential stage, fruits are washed and then sanitized in chlorinated water (100 ppm). Next, fruits are peeled using knives or peeling machines. The extraction of pulps is done by a pulper or steamers. In order to increase the total solid and the sweetness, sugar is added to the extracted pulp. The outcome product is then spread in trays containing oil coating film. In the packing and labeling step, the fruit bar is sealed using moisture-proof plastic bags. The final product is stored in a dry and cool place.

The optional stage of bars production process includes treatment with sulfur dioxide to reduce browning. Homogenizing step is used to mix different pulps. As some fruits has excess acidity that can affect the taste of the product, deacidification step is used to reduce the acidity and maintain the quality of food bars. Enzyme treatment step is sometimes used to result in softening the final product and to have a higher soluble solid extraction. Some fruit bars need other additives such as citric acid, starch, pectin, to name a few. Drying step is usually done by using solar or convective drying process.

The stages for conventional manufacture of fruit bars as illustrated by Orrego, Salgado, and Botero (2013) are demonstrated in Table 2.

Table 2. The stages for conventional manufacture of fruir bars as described by Orrego et al. (2013).

Stage in process	
Essential	*Optional*
Washing	
Peeling	No peeling in some cases
	Treatment with sulfur dioxide
Pulping	
	Homogenizing
	Heating or blanching
	Deacidification
	Enzyme treatment
Addition of sugar	
	Adding other additives
	Concentrating or syruping
Spreading	
	Drying
Packing and labeling	
Storing	

The Entrepreneurship Development Institute of India (2009) simplified the manufacturing process of fruit bars by dividing the process into six major steps. The first step was to thoroughly wash fruits. The pulp was then extracted from the fruit and dried in tray dryers. Later, the product was cooled and cut in pre-determined sizes. The final product was packed using BOPP (Biaxially Oriented Polypropylene) packages. Figure no. 1 shows the process flow chart for food bars.

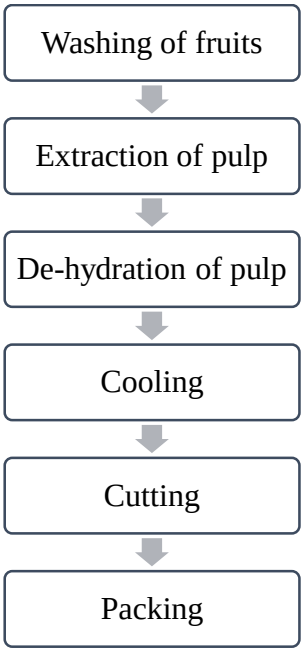

Figure 1. Process flow chart for food bars.

2.4. Shelf life of fruit bars

Fu and Labuza (1993) defined shelf life as "the time period for the product to become unacceptable from sensory, nutritional or safety perspective." Different aspects must be considered when determining the shelf life of a food product. Some of them are: the nature and the composition of the food, the ingredients, the process of the product, the package and storage conditions (Hough, 2010; IFST guidelines, 1993). Sensory shelf life can be determined by answering one of the following questions:

1. How long can a product be stored without noticeable changes in it sensory attributes?
2. How do sensory attributes change on storage?
3. How long can the product be stored before changes in sensory properties render it unacceptable?

(Goddard, 1994)

The recommended shelf life of granola bars is between 6 and 8 months while fruit-filled snack bars have a shelf life of 12 months or longer (Aigster, Duncan, Conforti, & Barbeau, 2011; Corrigan, Hedderley, & Harvey, 2012) Factors that affect the shelf life of a food product are water activity, temperature and atmosphere (Corrigan et al., 2012). These factors mainly depend on the food product and its storage conditions (Corrigan et al., 2012). In addition, changing in textural properties of a protein bar usually affects the shelf life as consumers find the bars unacceptable due to the development of a "hard" texture (Loveday, Hindmarsh, Creamer, & Singh, 2009).

2.4.1. Water activity and moisture content

Schaschke (2014) defines water activity (a_w) as:

> A measure of the amount of water in a substance such as food and expressed as an equilibrium relative humidity. That is, it is the vapor pressure of water in the substance or in a solution divided by the vapor pressure of pure water at a particular temperature.

Values of water activity range from 0 (dry condition) to 1 (pure water). Water activity is a crucial element in food safety in terms of preparing a HACCP plan. In addition, determining water activity of a food product helps predict product shelf life. High levels of water activity increase the likelihood of microbial growth in food products.

Moisture content is defined by Schaschke (2014) as:

> The amount of liquid, usually in the form of water, which is contained within a substance. The relationship is expressed either on a dry basis as the amount of water per unit mass of substance, or on a wet basis as the amount of water per unit mass of substance with water.

Moisture content of a fruit-based bar is essential as it affects the shelf life of the product and product qualities such as taste, stability, texture, etc. (Moreira, Castell-Pérez, & Barrufet, 1999; Parn, Bhat, Yeoh, & Al-Hassan, 2015). Water activity differs from moisture content in terms of the unbound/available water to react with other elements which eventually cause food spoilage and increase bacterial growth that affects the production process (FDA, 1984). Food with the same moisture content does not necessary have the same level of water activity. For

example, cooked beef and salami have the same moisture content (60%), but they differ in the water activity as salami has a lower water activity (0.82) whereas the water activity of cooked beef is 0.98 (Manitoba, 2015).

Most of fruit-based bars are classified as intermediate moisture foods as they have moisture content values between 8% and 15% and a water activity of approximately 0.6 (Orrego, Salgado, & Botero, 2013). Date paste is an intermediate-moisture food as it has a water activity below 0.6 and a moisture content between 20–23% (Ahmed, Ramaswamy, & Khan, 2005).

As I intend to use date fruit, oats, brown rice protein, and pea protein to produce the suggested energy bar, I will review a brief historical background and some nutritional values of those ingredients.

2.5. Ingredients

2.5.1. Date palm

The botanical name of date palm (*Phoenix dactylifera* L.) is claimed to have Greek origins. *Phoenix* means purple or red fruit, and *dactylifera* means finger like shape of the fruit's form (Chao & Krueger, 2007; Zaid & de Wet, 2002). Moreover, dates are perceived as the leading fruit tree in various countries around the world and regarded as an essential source of nutrition and wealth (Al-Turki, 2008).

2.5.1.1.The date palm history

The date palm is considered as one of the oldest cultivated plants (Habib & Ibrahim, 2009). They are claimed to be dating back to perhaps 30-70 million years or more (Mohamed, 2004). Ancient nomads used the fruit of the date palm for its vital components and stability (Al-Farsi, Alasalvar, Morris, Baron, & Shahidi, 2005). Date fruit or its juice were also used in Ancient Egypt in various medicinal remedies (Al-Turki, 2008). In the late 18th or early 19th century, Spanish missionaries started growing date palm trees in California in the United States of America (USA) and on the Mexican border (Nixon & Carpenter, 1978).

2.5.1.2.The date palm culture

There are several conditions that are required in order to be able to plant the date palm. Date palm trees do not grow in shade, they require hot weather (mild winters and hot summers),

according to Morton (1987). Date palm trees can also survive during high temperatures and long periods of drought (Morton, 1987). Date palm trees have the ability to grow in different kinds of soil (for example, clay, sandy) (Klein & Zaid, 2002). The best dates, however, come from the trees that were planted in deep soils and with drainage (Klein and Zaid, 2002).

2.5.1.3.Nutrition facts about dates

Several studies attempted to explore the types of nutrients in dates. Some of those studies provided interesting findings. Dates, for example, are considered a good source of energy because they contain a high percentage of carbohydrate (70–80 %). The human body can easily absorb those carbohydrates because they come in the form of glucose and fructose (Al-Farsi, Alasalvar, Morris, Baron, & Shahidi, 2005; Myhara, Karkalas, & Taylor, 1999).

Al-Farsi, Alasalvar, Al-Abid, Al-Shoaily, Al-Amry & Al-Rawahy (2007) also claimed that dates could be considered as a good source of dietary fiber, phenolics, and antioxidants. Having these ingredients in dates, according to Al-Farsi et al (2007), might lead to the perception that they are a cheap source of natural antioxidants.

Additionally, dates contain a great amount of oleic acid, which can help people avoid cardiovascular disease (Al Juhaimi, Ghafoor, & Ozcan, 2012). Although there are more than 5000 types of dates that are known to exist, only few of them have been known for their importance (Al-Ghamdi, 1996; Al-Hooti et al, 2002). Habib and Ibrahim (2009), for example, found that Barhe and Khulas date seeds (two types of dates) contain: 8.64 and 10.64 % moisture; 0.96 and 1.06 % ash; 5.84 and 5.68 % crude protein; 3.94 and 2.43 % carbohydrate, and 7.92 and 7.52 % crude fat, respectively.

2.5.2. Oats

Oats, *Avena sativa L.*, are a hardy cereal grain with the ability to survive in poor soil conditions that other crops cannot tolerate (Gasparis & Nadolska-Orczyk, 2015).

2.5.2.1.Health benefits of Oats

Bonham (2014) listed several health benefits of oat bran and oatmeal that include being a major source of nutritional fiber that consists of half soluble and half insoluble fibers. One of the elements that exist in the soluble fiber of oats is beta-glucans. Beta-glucans are considered a soluble fiber that helps in lowering blood cholesterol. Being able to control blood glucose and insulin levels is very important in avoiding many of the complications linked to diabetes. Oat beta-glucans help in preventing the rise in blood glucose levels after eating a meal. In addition, they help in postponing the decline in blood glucose levels to pre-meal levels.

Oats have plenty of phytochemicals (plant chemicals). Many phytochemicals are believed to help in lowering the chances of contracting cancer. Eating oats that are rich in soluble fiber on a daily basis could decrease high blood pressure, and, as a result, decreasing the need for anti-hypertensive medication. Similar to other cereal grains, oats are a good source of essential carbohydrates that can provide the body with calories. According to Bonham (2014), oats have the ability to alter metabolism and improve performance when ingested within 45 -60 minutes before starting exercises.

2.5.3. Brown rice protein

Rice, *Oryza savita L.*, is widely consumed in India and other Asian countries (Bagchi, Sharma, Chattopadhyay, 2016). People have started to pay more attention to their health and to the types of food they are eating. As a result, some of them started using powders that are plant-based (those that are non-diary and gluten-free) instead of those that are animal-based. Brown rice protein is considered a vegetarian alternative protein to the widely used whey and soy proteins.

Brown rice protein has a great amount of methionine and cysteine. In order to offer a complete protein, brown rice protein is usually mixed with other protein powders (for example, pea powder). A recent study done by Kalman (2014) claimed that organic brown rice protein isolate could be good substitutes for soy and whey protein concentrates and isolates as brown rice protein is an excellent source of amino acids (78% by weight). A study found that there is no difference between the effect of rice and whey protein isolates in perceived recovery of male athletes after exercise (Joy et al., 2013).

2.5.3.1.Health benefits of brown rice protein

Brown rice protein is believed to enhance muscle formation. It is also famous for helping in repairing bones. Moreover, brown rice protein assists those who want to lose weight because it moderates appetite and balances blood sugar levels.

2.5.4. Pea protein

Pea, *Pisum sativum L.*, is one of the main legumes that is widely consumed because it is rich in protein, fiber, carbohydrate, vitamins, and minerals (Holt & Sosulski, 1979; Adsule & Kadam, 1989). According to Vander Pol, Hristov, Zaman, and Delano (2008), the nutritional benefit of pea is due mainly to the high percentage of protein content which is between 21% and 22%. Pea protein could be an excellent alternative and an effective additive for other proteins (e.g., soy protein) in protein products (Barac, Cabrilo, Pesic, Stanojevic, Zilic, Macej, Ristic, 2010).

2.5.4.1.Heath benefits of pea protein

Pea protein by nature is dairy-free, soy-free, and gluten-free. Similar to brown rice protein, it has various benefits for fitness and health. Some of those benefits are digestibility and the high essential amino acid content (Tömösközi, Lásztity, Haraszi, & Baticz, 2001). When it comes to digestibility, it has been proven that that the digestive retention of pea protein in human beings is regarded very high (Dahl, Foster, & Tyler, 2012). In addition, pea proteins are considered easy to digest in comparison to other proteins such as soybean protein (Tömösközi et al., 2001).

HACCP systems focus on controlling and preventing potential hazards such as chemical, microbial, and physical contaminants in food production. In this section, a HACCP plan for the production of the suggested energy bar is presented.

2.6. Hazard analysis and critical control point (HACCP) system

According to the World Health Organization (1997), hazard analysis and critical control point (HACCP) is "a scientific, rational and systematic approach for the identification, assessment and control of hazards."

2.6.1. HACCP concept

The hazard analysis and critical control point system for food processors focuses on detecting and preventing hazards that may cause foodborne illnesses (Riswadkar, 2000). The main reason for establishing a HACCP system is to find whether food manufacturer has the ability to produce food products that are safe to consume (Mortimore, 2000). HACCP system covers types of potential food safety hazards; biological, chemical, and physical hazards. Most of the emphasis is placed on biological hazards since contamination of one batch of milk with *Salmonella*, for example, may result in a high percentage of affected consumers (Scott & Stevenson, 2006).

2.6.2. Origin of HACCP

In the early 1960s, the Pillsbury Company was the first company to develop the concept of HACCP cooperatively with the National Aeronautics and Space Administration (NASA) to produce safe food for astronauts (Mathew, 2006). According to Scott and Stevenson (2006), the

HACCP system was publicly recognized in 1971 at the National Conference on Food Protection and consisted of three principles:

1. Identification and assessment of hazards associated with growing/harvesting to marketing/preparation.
2. Determination of the critical control points to control any identifiable hazards.
3. Establishment of systems to monitor critical control points.

The initial HACCP system was proposed to solve microbiological issues that occurred with low acid canned food (i.e. mushroom) which led to the deceleration of Low Acid Canned Foods by the Food and Drug Authority (FDA) in 1974 (Riswadkar, 2000). Pillsbury Company presented their HACCP system at that conference and afterwards started to train FDA personnel in the elements of HACCP system (Khan, 2010; Scott & Stevenson, 2006).

2.7. Fruit-based energy bars advantages and health benefits

Energy bars are perceived as a convenient ready-to-eat food. They do not require any preparation and may be stored at room temperature. They suit the need for people who missed a meal, as they are a nutritious alternative food. Energy bars can be easily found in convenience stores and vending machines. There are many different bars for unique diets (i.e. low carb, organic, kosher, etc.) and exercise needs (i.e. pre-workout or post-workout) (Clark, 2006).

In addition, they have a balanced nutritional profile with major and minor nutritional components (Ryland, Vaisey-Genser, Arntfield, & Malcolmson, 2010). Fruit-based bars can be a nutritious food with an exceptional source of dietary fiber and other food components which are required to meet the daily nutritional requirements (Parn et al., 2015). Epidemiological studies suggest that there is a tendency among people who eat fruit regularly to be less susceptible to chronic diseases (Block, Patterson, & Subar, 1992; Joshipura et al., 2001; Rimm et al., 1996).

According to Tang, Shi, and Aleid (2013), date fruit has antioxidant, anti-inflammatory, gastrointestinal-protective, antimutagenic, hepatoprotective, nephroprotective, gonadotropic, and anticancer activities. In addition, it has shown potential benefit in preventing and controlling diabetes mellitus and cardio- and cerebrovascular diseases (CCVD) (Tang et al., 2013).

2.8.Summary

In this chapter, I provided an orientation to my thesis project. I first showed the history of energy bars. I, for example, highlighted the important stages that energy bars went through since they were invented until the recent days. Furthermore, I provided information about the ingredients in my suggested energy bar. I also discussed the hazard analysis and critical control point (HACCP) system in terms of its concept and origin. Finally, I numerated some of the fruit-based energy bars advantages and health benefits.

CHAPTER III

METHODOLOGY

3.1. Introduction

In this chapter, I will first talk about how I developed a HACCP plan for the manufacturing of energy bars. After that, I will describe the product and process flow diagram that I used in this study. Next, I will talk about the proximate analysis of a commercial protein bar and the developed energy bar; namely: fat, moisture, ash, protein, and carbohydrate. Moreover, I will point out the process followed to determine the water activity. Finally, I will state how the sensory properties of the developed bar were evaluated.

3.2. Development of HACCP plan

A suggested HACCP plan was developed for industries that intend to produce food bars that contain dates, oats, and brown rice and pea protein powders. The plan covers the data regarding food safety starting from receiving materials to distributing the final product. The plan includes a process flow diagram, HACCP work sheet, and identification of critical control points. In addition, a certified HACCP auditor reviewed the HACCP plan for my suggested product.

3.3. Description of product and process flow diagram

The study was conducted in Robert M. Kerr Food & Agriculture Products Center, Oklahoma State University, Stillwater, OK. The ingredients used in preparing the energy bar are date fruit, oats, brown rice protein powder, and pea protein powder. Sukkari date was used in this study and was purchased from a Saudi local market (Buraidah, Saudi Arabia). Pea protein 85% and organic oryzatein 80% ultra brown rice protein were obtained from Pure Bulk (Roseburg, OR) and Axiom Foods (Los Angeles, CA), respectively. Quaker quick 1-minute oats (Chicago, IL) were purchased from Walmart (Stillwater, OK). The formulation used in the study is given in Table 3.

Table 3. Energy bar formulation.

Ingredients	**% w/w**
Dates	62
Oats	20
Water	10
Brown rice protein powder	5
Pea protein powder	3
Total	100

This formulation was developed after several trial-and-error attempts. Brown rice protein powder and pea protein powder were added in higher percentages (15% and 5%, respectively). A pilot study was conducted to obtain comments and suggestions from panelists. Panelists commented that they could taste an undesirable flavor due to the protein powders. The formulation was then modified by decreasing the percentage of the protein powders.

A second pilot study was completed on a new formulation that included: 62% dates; 15% oats; 15% water; 5% brown rice protein powder; and, 3% pea protein powder. Panelists commented that the bar was too moist and that the portion of oats was too low. Based on these comments, the formulation was modified by decreasing the water content to 10% and increasing the percentage of oats to 20.

Date seeds were extracted manually. Hard and broken dates were discarded. The remaining deseeded dates and water were added to a Nutri Bullet grinder (model NB 101S, NutriBullet, LLC) and processed until a date paste was obtained. Protein and oats were mixed in a mixer (model K5SS, KitchenAid, USA) and the date paste was added to the mixer.

After a homogenous mixture was obtained, shortening was spread on the bottom and the sides of a 20×20 cm aluminum pan and the mixture was then spread on the pan. Shortening was not listed as an ingredient since it was used at an insignificant level. It is classified by FDA (2004) as a processing aid that has a functional effect in the processing, but not in the food. The product baked in a conventional oven at 149 °C for 25 minutes.

After cooling to room temperature, the energy bars were cut and each portion of the bars was packed using vacuum packaging (Ultravac, Koch, U.S.A). The cut portion is shown in Figure 2 and the vacuum packaged product is shown in Figure 3. The process flow diagram of making the bars is illustrated in Figure 4. The developed energy bars were stored at ambient temperature and used on day 0 for moisture, ash, and protein analyses, on day 14 for fat analysis, and on day 7 for the sensory evaluation.

Figure 2. Sample of energy bar after cutting.

Figure 3. The vacuum packed energy bars.

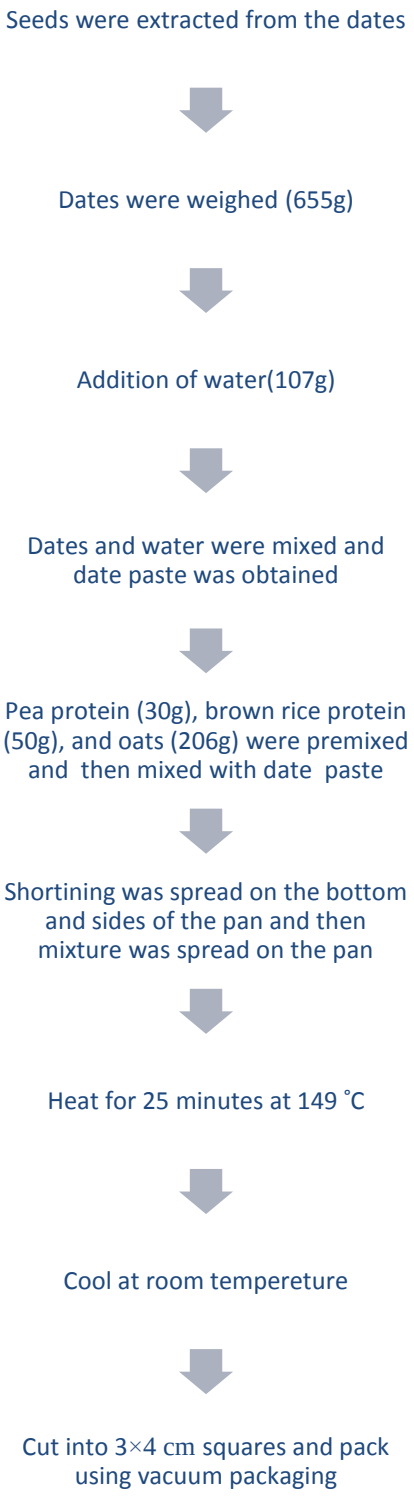

Figure 4. Energy bar process flow diagram used in this study.

3.4. Chemical analysis

3.4.1.Proximate analysis

Moisture, ash, and protein analyses for both samples were completed on day 0 in the general nutrition lab in the Animal Science building, Oklahoma State University, Stillwater, OK. Fat analysis was completed on day 14 in the oil and oilseed chemistry lab in the Robert M. Kerr Food and Agricultural Product Center, Oklahoma State University, Stillwater, OK. All the analyses were performed in duplicate.

3.4.1.1.Moisture content

Two grams of each sample were dried at 100 ºC ± 2 for 16-18 hours using a gravity oven (model GO1350A, Lindberg/Blue, Asheville, NC, USA) (Robert and Bradley, 2010). Moisture content was calculated as follows:

$$\% \text{ Moisture (wt/wt)} = \left[\frac{(B-C)}{(B-A)}\right] \times 100$$

Where: A= weigh of empty pan (g)

B= weigh of pan plus sample (g)

C= weigh of pan plus the dried sample (g)

B – A = sample weight (g)

B – C = loss of weight after drying (g)

3.4.1.2.Ash

Samples were burned in a muffle furnace (model FA1740, Sybron Furnatrol /Thermolyne, Dubuque, IA, USA) at 550 ºC for 18 hours. Ash content was determined in accordance with the method described by Marshal (2010) based on dry matter.

3.4.1.3.Crude protein

The Kjeldal method (2400 Kjeltec Auto Analyzer Unit, FOSS, Hillerød, Denmark) was used to determine the total nitrogen content of the material as described by Chang (2010). Crude protein was calculated by multiplying the percent nitrogen by the general protein conversion factor of 6.25. The formula used was as follows:

% Protein = % N × 6.25

3.4.1.4.Crude fat

Fat percentages for both samples were determined according to AOAC Official Method 991.36 (1992). The Soxhlet extraction method was performed using petroleum ether.

3.4.1.5.Total carbohydrate

Total carbohydrate was calculated by difference (Norajit, Gu, & Ryu, 2011) as follows:

Carbohydrate content = 100 - (ash + fat + moisture + protein).

3.4.2.Determination of water activity (a_w)

Water activity was determined in triplicate for both samples using an Aqua Lab (model Series 3, Decagon Devices, Inc., Pullman, WA, USA) Water Activity Meter at 24.6 ºC. The mean of the three measurements of each sample was calculated.

3.5. Sensory evaluation

Two-sample acceptance test was performed to determine to what extent the product was liked by consumers which will help in the improvement and development of the product and will assess market potential. A questionnaire was developed using a nine-point hedonic scale as described by Peryam and Pilgrim (1957), where (9) means like extremely, (8) like very much, (7) like moderately, (6) like slightly, (5) neither like nor dislike, (4) dislike slightly, (3) dislike moderately, (2) dislike very much and (1) dislike extremely. Eight important attributes were evaluated by the panelists including stickiness to touch, color, chewiness, flavor, sweetness, adhesiveness to teeth, texture and overall acceptance. Two demographic questions (gender and age group) were used in the questionnaire (see appendix D).

A comparison between the developed energy bar in this study and a commercial bar was made. The commercial bar used was the Larabar ALT Protein Peanut Butter Cookie (Denver, CO). The ingredients of the commercial bar, in order of predominance, were dates; peanuts; pea protein; brown rice flour; brown rice syrup; and, sunflower oil.

3.5.1.Procedure

Sixty-six panelists (40 males and 26 females) were recruited from students, faculty and staff on contract of Oklahoma State University. The methods used to recruit subjects were by using the Oklahoma State University e-mail addresses service and by distributing flyers on the campus (see appendix C). The location for the sensory panel was in the test panel room (room 149) in the Robert M. Kerr Food and Agricultural Product Center, Oklahoma State University, Stillwater, OK. Sensory evaluation testing was conducted by seating the participants in individual compartments (in a temperature controlled room at 21 ˚C).

Each participant was provided with a consent form (see appendix B). The consent form was read to participants and questions asked by participants were answered. All participants were given a copy of the consent form to keep for their records. Each panelist received a sample of the developed energy bar, a sample of the commercial bar, and a copy of the questionnaire (see appendix D). In addition, each panelist was provided with an unsalted cracker and water in order to cleanse their palate between samples. Samples were cut into approximately 10×10 mm square shapes and were served on white paper plates labeled with three-digit random numbers and were served in randomized order.

3.6. Statistical analysis

The proximate analysis data were analyzed using Microsoft Excel 2013 (Microsoft, Redmond, Washington) using analysis of variance (ANOVA). Means and standard deviations were reported. A randomized complete block design was conducted in this study to analyze the sensory evaluation data using SAS Version 9.4 (SAS Institute, Cary, NC). The analysis was controlled for the panelist. The data were analyzed depending on the eight attributes and the 9-point hedonic scale using ANOVA. Means and standard errors were reported.

3.7. Summary

In this chapter, I have provided a general overview about the methodology employed in my thesis project. Firstly, I talked about how I developed a HACCP plan. Next, I described the product and process flow diagram. In addition, I talked about the proximate analysis used in my study. After that, I pointed out the process followed to determine the water activity in the two samples. Finally, I stated the procedure of how sensory attributes were evaluated.

CHAPTER IV

RESULTS AND DISCUSSION

4.1. Introduction

In this chapter, I will talk about the results of the commercial and developed products and the discussion of those results. I first will talk about the suggested HACCP plan that should be followed when manufacturing energy bars. I will also describe the product and the production process.

Moreover, the content of both bars will be analyzed. After that, I will compare and contrast the developed bar with the commercial one. Additionally, I will discuss the water activity in both bars. Finally, I will highlight the sensory panel analysis results.

4.2. HACCP

The suggested HACCP plan is for industries that intend to produce energy bars that contain date fruit, oats, and plant-based protein (not including any of the big-eight food allergens). Prerequisite programs (such as sanitation programs and maintenance programs) are necessary to be implemented by industries to insure a safe production. Processing machines that will be mentioned later in this section are suggested as examples and are not required to be specifically used.

4.2.1.Description of the Product

The date fruit energy bar consists of four prepackaged ingredients: date fruit; oats; pea protein; and, brown rice protein. Water activity is the control for pathogen growth in this product. The developed energy bar has a water activity of 0.66. Because of the low water activity, the bars are safe and do not pose any microbiological spoilage threat except for the possibility of yeast and mold growth that should only be considered when shelf life circumstances must be met (USDA, 2015). The product is intended to serve consumers who need a quick and healthy food source to boost their energy. High Impact Polystyrene (HIPS) packaging could be used for this product. All the ingredients used in producing the energy bar are shelf stable at ambient temperature.

4.2.2.Energy bar process

To understand the energy bar production process, please refer to the process flow diagram in Figure 5. This section describes the process of making an energy bar. All ingredients are stored in a secure area at ambient temperature. During processing, dates are transferred to the processing area and dumped into the seed extractor (model JM-DCT, Wenzhou Longwan JImei Machinery, Zhejiang, China) to remove seeds. Dates are transferred to the mixing tank using a positive displacement pump and distilled water is added to obtain a date paste. It is recommended that the seed extractor, or the piping between the seed extractor and the mixing tank, include a strainer in order to separate seeds or seed pieces from the paste. Protein and oats are transferred to the processing area and are weighed and added to the mix tank. After mixing all the ingredients together, the mixture is portioned and transferred into trays then moved to the convection oven. The portioned mixture is heated for 25 minutes at 149 °C to the desired consistency. After heating, the trays are transferred to a tunnel for cooling to room temperature.

After cooling, the portions are transferred to the production line for cutting into a bar shape. The bars pass through an X-ray unit (X33 Series of X-ray Inspection Systems, Bulk Variant, Mettler-Toledo, LLC, Columbus, OH, USA). If the X-ray machine detects any foreign materials, it will stop the production line and sound an alarm. A quality check of the X-ray machine is conducted every 30 minutes by physically passing a test bar (that includes a foreign object) through the X-ray machine. If the machine gives a notification then it is working well. The bars are then wrapped using a horizontal flow wrapper (Fin Seal Wrapper, Campbell Wrapper Corporation, De Pere, WI, USA). Bars that are defective (e.g., have not shaped well) are transferred to rework area for reprocessing.

The received packaging materials are stored in the storage area and then transferred to labeling and packaging steps during processing. The remaining bars are packed; two dozen of the finished product are transferred into boxes. A group of ten boxes is added to a larger case. Cases are stored at ambient temperature in the warehouse. Energy bars are shipped to retail markets via trucks at ambient temperature.

4.2.3.Suggested packaging

Since the texture of the energy bar is soft, it is suggested that it should be packaged small, bite-sized portions. In other words, this energy bar should fall into a tray-packaging-food category. In addition, being in this recommended size will help in portion control. The portion control category was up 5.32 percent during the first four months of 2015 (Peckenpaugh, 2015). Consumers nowadays tend to be more aware of their health needs and the type and quantities of food they chose to eat; therefor, they are cautious about their food selection.

4.2.4.Hazard Analysis and HACCP plan

A hazard analysis was conducted on the manufacturing process for the developed energy bar according to Scott and Stevenson (2006). Results of the analysis are given in Table 4. A proposed HACCP plan for the developed energy bar is shown in table 5. The HACCP plan was formulated by following the HACCP seven principles (Mortimore, 2000).

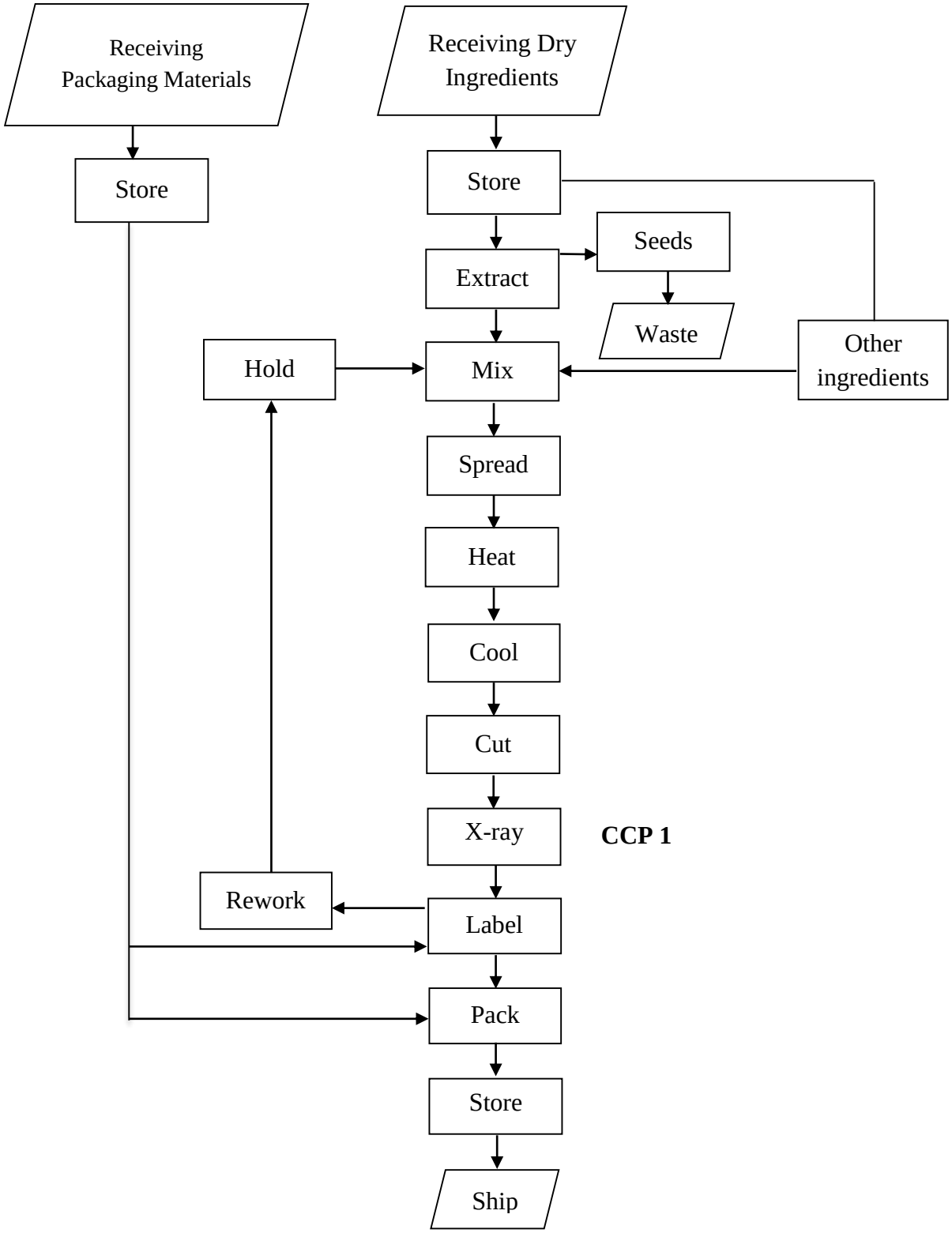

Figure 5. Energy Bars Process Flow Diagram.

Table 4. Hazard analysis for production of the developed energy bars.

Hazard Analysis

Process Step	Potential Food Safety Hazards	Does this potential hazards need to be addressed in HACCP Plan? (Yes/No)	Why?	If Yes in Column 3, what measures could be applied to prevent, eliminate or reduce the hazards being addressed in the HACCP plan?	Is this step a critical control point (CCP)?
Receiving dry ingredients	Biological *Salmonella*	No	*Salmonella* can be found in date fruit.	Letter of guarantee is requested from supplier to assure that date fruits are free from contaminants.	No
	Chemical	No			
	Physical	No			
Store	Biological	No			
	Chemical	No			
	Physical	No			
Extract	Biological	No			
	Chemical	No			
	Physical *Seeds*	Yes	Seed contamination is likely to occur and could cause injuries.	X-ray unit is used later	No
Mix	Biological	No			
	Chemical	No			
	Physical	No			

Process Step	Potential Food Safety Hazards	Does this potential hazards need to be addressed in HACCP Plan? (Yes/No)	Why?	If Yes in Column 3, what measures could be applied to prevent, eliminate or reduce the hazards being addressed in the HACCP plan?	Is this step a critical control point (CCP)?
Spread	Biological	No			
	Chemical	No			
	Physical	No			
Heat	Biological	No			
	Chemical	No			
	Physical	No			
Cool	Biological	No			
	Chemical	No			
	Physical	No			
Cut	Biological	No			
	Chemical	No			
	Physical	No			
X-ray inspection	Biological	No			
	Chemical	No			
	Physical *Seeds, metal*	Yes	Seeds contamination from date fruit and metal contamination from production machines or supplier are likely to occur.	Operable X-ray unit inspection system	Yes. CCP1

Process Step	Potential Food Safety Hazards	Does this potential hazards need to be addressed in HACCP Plan? (Yes/No)	Why?	If Yes in Column 3, what measures could be applied to prevent, eliminate or reduce the hazards being addressed in the HACCP plan?	Is this step a critical control point (CCP)?
Receiving packaging materials	Biological	No			
	Chemical	No			
	Physical	No			
Store	Biological	No			
	Chemical	No			
	Physical	No			
Label	Biological	No			
	Chemical	No			
	Physical	No			
Rework	Biological	No			
	Chemical	No			
	Physical	No			
Pack	Biological	No			
	Chemical	No			
	Physical	No			
Store	Biological	No			
	Chemical	No			
	Physical	No			
Ship	Biological	No			
	Chemical	No			
	Physical	No			

Table 5. HACCP plan for the developed energy bar.

HACCP Plan

Critical Control Point	Hazards to be addressed in HACCP Plan	Critical limit for each control measure	Monitoring				Corrective Action	Verification activities	Record keeping procedure
			What	How	Frequency	Who			
CCP1 X-ray unit	Seeds, metal, any foreign objects	Energy bars pass through the X-ray unit with proper sensitivity	Bars pass through X-ray machine X-ray inspection system detects seeds, metal, and other foreign objects	Visual observation that the unit is run and bars are passing through Test the machine efficiency (sensitivity test) using fake contaminated bars	Continuance Once every 30 minutes	Packaging operator Packaging operator	If the machine does not work properly, bars from the last acceptable check will be held and will be rechecked after the machine is repaired Contaminated bars will be collected and will be discarded	Quality manager reviews and approves records daily Quality manager observes packaging operator when running sensitivity test once a day Calibrating is done as manufacturer suggests	Packaging operator logs with verifications of observations and record review Corrective action reports with verifications of evaluation and disposition of product X-ray unit calibration logs

4.3. Proximate analysis

The proximate analyses of the developed energy bar and the commercial bar were found to be significantly different ($p < 0.05$; see Table 6). Moisture content (%) for the commercial bar showed less value (7.5 %) in comparison to the developed energy bar (14.6 %). The higher moisture content of the developed energy bar can be attributed to the addition of water during preparation of the bars. Similar studies reported that Sukkari date falls in the category of intermediate moisture food with a moisture content between 15.75% and 18.77% (Habib & Ibrahim, 2011; Tang et al., 2013).

Ash content (%) for the commercial bar was higher than the developed energy bar with values of 2.56 % and 1.96 %, respectively. Assirey (2015) determined ash content of 10 types of date fruit and pointed out that it ranged between 1.68% and 3.94%. As Sukkari date was used in this study, it is possible that a different type of date was used in the commercial bar. Parn et al. (2015) reported the ash content for Sukkari date bar was between 1.86% and 1.92 % which was relatively close to the ash content of the developed energy bar used in this study (1.96 %). Higher ash content in the commercial bar might also be as a result of using peanut which was reported to contain 2.01 – 2.05% ash (Özcan & Seven, 2003). As the commercial bar was marketed as protein bar, it contained 23.52 % crude protein. This higher percentage of crude protein compared to the developed energy bar (which was 9.12 %) can be attributed to a higher addition of pea protein powder and the use of peanuts in the commercial bar.

Crude fat content in the developed energy bar was much lower (0.35%) than the commercial bar, as expected. The bar developed in this study contained ingredients that were relatively low in fat. Dates, in general, have a fat concentration between 0.1% and 0.9% (Tang et

al., 2013). Sukkari date fruit was reported to have about 0.19% of crude fat (Habib & Ibrahim, 2011). The use of peanuts and sunflower oil in the production of the commercial bar contributed to the increasing of fat concentration in this bar. As the developed bar in this study was aimed to boost body energy, it should have a high level of carbohydrate content which was achieved in the results. The commercial bar had a lower carbohydrate content of 51 % compared to the developed one, which had 74%.

Table 6: Proximate analysis means and standard deviations of the commercial bar (control) and the developed energy bar (treatment). (g/100g).

	Moisture	**Ash**	**Protein**	**Fat**	**Carbohydrate**
Control	7.54 ± 0.01	2.56 ± 0.02	23.52 ± 4.16	14.82 ± 0.07	51.54 ± 4.09
Treatment	14.62 ± 0.36	1.96 ± 0.01	9.16 ± 0.57	0.32 ± 0.01	74.00 ± 0.23
P-value	0.0013	0.0001	0.0399	0.0001	0.0162

4.4. Water activity

Water activity is an important factor with regards to food stability. Most bacteria grow in a minimum water activity of 0.85. The mean water activity of three replicates of the two samples were calculated. The commercial bar had a mean water activity of 0.57. The water activity for the developed energy bar had a higher mean value of 0.66. Growth of yeasts such as *Saccharomyces rouxii* and molds such as *Monascus bisporus* might occur in the developed energy bar as it had a 0.66 water activity. To control the growth of yeasts and molds, water activity should be reduced to 0.60 or less by adding a preservative (e.g. citric acid) or by exposing the product to mild heat (Troller & Christian, 1978).

4.5. Sensory analysis

Sensory panel analysis results are reported in Table 7. Panelists' acceptance of color, flavor, sweetness, and texture between the developed energy bar and the commercial bar showed no difference ($p > 0.05$). However, there was a significant difference ($p < 0.05$) in the stickiness. Dowson and Aten (1962) pointed out that the most challenging quality aspect in dates was the undesirable stickiness. In order to remove stickiness from dates, Schiller and Maier (1959) suggested that dates may be treated by spraying them with a 6% cold-water-soluble starch solution or by immersing the dates in a 3% methyl cellulose solution. In addition, oat bran powder could be sprinkled on date surface to counteract stickiness.

Adhesiveness to teeth was also found to be significantly different ($p < 0.05$). Some of the panelists commented that the commercial bar was more crumbly and that peanuts stuck to their teeth. Chewiness was significantly different ($p < 0.05$) between the two samples as the developed energy bar had a softer texture due to the domination of dates which attributed to more chewiness. Similar studies reported the same results as date fruits have high chewiness and adhesiveness attributes (Besbes, Drira, Blecker, Deroanne, & Attia, 2009; Masmoudi et al., 2010; Tang, et al., 2013).

The overall acceptance of the commercial and developed energy bars showed no difference which indicated that the developed energy bar might fare well in competition with other existing energy bars that are produced by large industries. In addition, the developed energy bar might receive a high acceptance by those who are allergic to nut, gluten, soy, and dairy. It also showed that the developed energy bar has a future in the energy bar market and according to some panelists, the developed energy bar will be successful in future markets

Table 7: Sensory quality evaluation means and standard errors of the commercial bar (control) and the developed energy bar (treatment).

	Stickiness	**Color**	**Chewiness**	**Flavor**	**Sweetness**	**Adhesiveness**	**Texture**	**Overall Acceptance**
Control	6.82 (0.20)	6.98 (0.15)	5.98 (0.22)	6.77 (0.20)	6.94 (0.17)	5.80 (0.22)	6.41 (0.22)	6.67 (0.18)
Treatment	5.94 (0.23)	7.05 (0.18)	6.77 (0.22)	6.77 (0.20)	6.77 (0.18)	6.58 (0.24)	6.65 (0.22)	6.88 (0.19)
P-value	0.0013	0.7034	0.0181	1.0000	0.4753	0.0140	0.3896	0.3761

4.6. Summary

In this chapter, I talked about the results of my product and the discussion of those results. I first talked about the suggested HACCP plan that the interested industries should follow while producing the energy bars. I also described the product and the production process. Moreover, the content of my product was analyzed. After that, I compared and contrasted my product with the commercial one. Additionally, I referred to the water activity in the developed energy bar and the commercial bar. Finally, I highlighted the sensory panel analysis results.

CHAPTER V

CONCLUSIONS

The findings of this study indicate the following:

1. The developed energy bar could compete with other existing snack bars in the market. It contains only four wholesome ingredients that are nutritious and healthy. This bar is also free from common allergens such as gluten, soy, nut, and dairy. The developed energy bar is beneficial for consumers who are allergic to those ingredients.
2. The developed energy bar is plant-based and can be certified as "vegan." The ingredients used are Sukkari date fruit, rolled oats, brown rice protein powder, and pea powder. The developed energy bar is minimally processed which ensures the stability of the nutritional value of the ingredients.
3. The developed energy bar had higher concentrations of carbohydrate and moisture and lower percentages of protein and ash in comparison to the commercial bar. Fat content in the developed energy bar was much lower (0.35%) compared to the commercial bar (15.04%).

4. The commercial bar had a hard texture compared to the developed energy bar which had more of a soft texture. There was a difference in chewiness, stickiness, adhesiveness to teeth between the commercial and developed bars. Those differences are minimum and did not affect the overall acceptance of the two products.
5. The suggested HACCP plan for the developed energy bar indicated the following:
    a. The developed energy bar was a shelf stable product that had a water activity of 0.66. The developed bar did not pose microbial threat. In the HACCP plan of energy bar production process, only one CCP was established to prevent physical hazards of metal and date seeds. An X-ray unit detection system can be implemented as a control measure for this CCP.
    b. It is suggested to use tray packaging for the developed energy bar to maintain the bar's shape and texture from any damage during handling and distributing as the developed bar has a chewy and soft texture. Bite-sized portions are also suggested as consumers are more concerned about the quantity of food they consume.

RECOMMENDATIONS

1. Since date fruit flavor is dominate in the developed energy bar, other studies may increase the percentage of oats to an equal amount and/or add natural flavors in order to obtain new flavors that might also be accepted by consumers.
2. Studies about the total phenolic, fiber, and antioxidant activity of the developed energy bar are encouraged to be conducted. In addition, further studies about the physical property (e.g., color, size, total solids) of the developed bar are also recommended.
3. To minimize the undesirable stickiness in the developed energy bar, it could be covered with oat bran or rolled oats.
4. It is recommended to conduct studies regarding the marketing of the developed energy bar in order to determine product demand, preferred packaging, product shelf life, and optimum serving size.

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APPENDICES

Appendix A. IRB Approval Letter

Oklahoma State University Institutional Review Board

Date:	Wednesday, September 23, 2015 **Protocol Expires:** 9/13/2018
IRB Application No:	AG1542
Proposal Title:	Developing a Gluten, Nuts, Soy, and Dairy Free Energy Bar
Reviewed and Processed as:	Exempt **Modification**

Status Recommended by Reviewer(s) **Approved**

Principal Investigator(s):

Bayan Altoiami
2001 N Perkins Rd Apt B32
Stillwater, OK 74075

Tim Bowser
124 FAPC
Stillwater, OK 74078

The requested modification to this IRB protocol has been approved. Please note that the original expiration date of the protocol has not changed. The IRB office MUST be notified in writing when a project is complete. All approved projects are subject to monitoring by the IRB.

The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

The reviewer(s) had these comments:

Modification to add a second protein bar and complete the questionnaire about each protein bar.

Signature :

Hugh Crethar, Chair, Institutional Review Board

Wednesday, September 23, 2015
Date

Appendix B. Consent Form Signed by Panelists Prior to Taste Samples

CONSENT FORM

Project Title: Developing a Gluten, Nuts, Soy, and Dairy Free Energy Bar

Investigators:

Dr. Timothy Bowser, Department of Biosystems & Agricultural Engineering

(405)744-6688; bowser@okstate.edu

Bayan Altoaimi, Master candidate, Department of Food Science

(405)762-2227; altoaim@okstate.edu

Purpose:

The main purpose of the project is to develop a healthy energy bar that is plant-based and does not contain the common food allergies (e.g. milk, gluten, nuts, and soy).

Procedures:

If you agree to participate in this study, I will give you a sample of energy bar that contains a mixture of date fruit, pea protein, brown rice protein, and oats and another bar sample that contains date fruit, pea protein, brown rice flour, and PEANUTS. In addition, I will give you two short questionnaires for each sample in order to obtain your opinion on some of the characteristics (e.g., color, chewiness, etc.) of the two products. You will then taste the samples and complete the questionnaires.

Risks of Participation:

If you are **not** allergic to NUTS, there are no other known risks or embarrassment associated with this project which are greater than those ordinarily encountered in daily life.

Benefits:

You will learn about healthy energy bar and have the opportunity to taste it. Findings can be used to help people who have allergy towards gluten, soy, milk, and/or nuts to be able to eat energy bars without having concerns about their health.

Confidentiality:

The records of this study will be kept private. Any written results will discuss group findings and will not include information that will identify you. Research records will be stored in a locked office on a password-protected computer and only the main researcher responsible for research oversight will have access to the records. The data will be reported as numbers (percentages and mean) to answer research questions. Data will be destroyed three years after the study has been completed.

Compensation:

In return for your participation, you will receive NO compensation.

Contacts:

You may ask any questions about the research procedures, and these questions will be answered. If you have any question and/or if you want to obtain the results of the study, you can contact Dr. Timothy Bowser, Department of Biosystems & Agricultural Engineering

(405)744-6688; bowser@okstate.edu or Bayan Altoaimi (405)762-2227; altoaim@okstate.edu.

For additional information about the research and your rights as a research volunteer, you may contact Dr. Hugh Crethar, IRB Chair, 223 Scott Hall, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu.

Participant Rights:

Your participation is voluntary, that there is no penalty for refusal to participate, and you are free to withdraw your consent and participation in this project at any time, without penalty.

Signatures:

I have been fully informed about the procedures listed here. I am aware of what I will be asked to do and of the benefits of my participation. I also understand the following statements:

I affirm that I am 18 years of age or older.

I have read and fully understand this consent form. I sign it freely and voluntarily. A copy of this form will be given to me. I hereby give permission for my participation in this study.

_____ _____

Signature of Participant **Date**

I certify that I have personally explained this document before requesting that the prospective participant sign it.

_____ _____

Signature of Researcher **Date**

Appendix C. Flyer Used to Recruit Subjects

ENERGY BAR TASTERS WANTED

Purpose: To develop a healthy energy bar that is plant-based and does not contain the common food allergies (e.g. milk, gluten, nuts, and soy).
Method: Taste a new and healthy energy bar that has a mixture of date fruit, plant-based protein, and oats and another food bar that contains date fruit, plant-based protein, and peanuts.
Time required for completion: Approximately 20 minutes.
Benefits: Opportunity to taste a healthy energy bar.
Risks: Minimal (if you not allergic to nuts, there is no more risk than those ordinarily encountered in daily life).
Date & Time: Thursday, Oct 1st, from 8:30 am to 4:00 pm. **OR** Friday, Oct 2nd, from 8:30 am to 4:00 pm.
Place: Robert M. Kerr Food & Agricultural Products Center, Room 149.

Contact Information:

Bayan Altoaimi:
(405)762-2227; altoaim@okstate.edu
Dr. Tim Bowser:
(405)744-6688; bowser@okstate.edu

Appendix D. Sensory Evaluation Questionnaire

Developing a Gluten, Nuts, Dairy, and Soy Free Energy Bar

Date: _____ **Sample Code: _____**

Please taste the first sample and rate how much you like the following characteristics of the sample:

	Dislike extremely 1	**Dislike very much** 2	**Dislike moderately** 3	**Dislike slightly** 4	**Neither like nor dislike** 5	**Like slightly** 6	**Like moderately** 7	**Like very much** 8	**Like extremely** 9
Stickiness to touch									
Color									
Chewiness									
Flavor									
Sweetness									
Adhesiveness to teeth									
Texture									
Overall acceptance									

Developing a Gluten, Nuts, Dairy, and Soy Free Energy Bar

Date: _____ **Sample Code: _____**

Please eat a cracker. Then, taste the second sample and rate how much you like the following characteristics of the sample:

	Dislike extremely 1	**Dislike very much** 2	**Dislike moderately** 3	**Dislike slightly** 4	**Neither like nor dislike** 5	**Like slightly** 6	**Like moderately** 7	**Like very much** 8	**Like extremely** 9
Stickiness to touch									
Color									
Chewiness									
Flavor									
Sweetness									
Adhesiveness to teeth									
Texture									
Overall acceptance									

What is your gender?

☐ Male ☐ Female

What is your age group?

☐ 18-24 years old ☐ 25-34 years old ☐ 35-44 years old ☐ 45-54 years old ☐ 55-64 years old ☐ 65 or older

VITA

BAYAN ALTOAIMI

Candidate for the Degree of

Master of Science

Thesis: DEVELOPING A GLUTEN, SOY, DAIRY, AND NUT FREE ENERGY BAR WITH A SUGGESTED HACCP PLAN

Major Field: Food Science

Biographical:

Education:
Completed the requirements for the Master of Science in Food Science at Oklahoma State University, Stillwater, Oklahoma in December, 2015.
Completed the requirements for the Bachelor of Science in Food Science and Human Nutrition at King Saud University, Riyadh, Saudi Arabia in 2011.

Experience:
Vice president of the Saudi Student Association at Oklahoma State University, 2014.
Program coordinator, Gheeras Company, Riyadh, Saudi Arabia, May 2013 - July 2013.
Food service supervisor, King Abdulaziz University Hospital, Riyadh, Saudi Arabia, Oct 2010 - Jan 2011.
Dietitian, Al Yamamh Hospital, Riyadh, Saudi Arabia, Jul 2010 - Oct 2010.

Professional Memberships:
IFT student membership since 2015.