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EFFECTS OF DIFFERENT LOWBUSH BLUEBERRY PUREES ON LIPID OXIDATION IN PRE-COOKED GROUND TURKEY PATTIES

By

Kathleen Gabriel Buzzard

B.S. University of Maine, 2001

A THESIS

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Science

(in Food Science and Human Nutrition)

The Graduate School

The University of Maine

December, 2002

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By Kathleen Gabriel Buzzard

Thesis Advisor: Dr. Alfred A. Bushway

An Abstract of the Thesis Presented
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A growing trend in the food industry is the development of pre-cooked, ready-to-eat, meat products that only require reheating. However, reheating meats creates off-flavors that have been identified as warmed-over flavors (WOF). The off-flavors pose a problem to product development specialists during the development of cooked meat products.

Lipid oxidation has been determined to effect warmed-over flavor, texture, and the appearance of reheated meat products. Ground turkey undergoes lipid oxidation rapidly because of its high-unsaturated fat content. Blueberries contain antioxidants, including anthocyanins and phenolic acids, which could potentially retard the rate of lipid oxidation in precooked meats.

Blueberries are assorted according to grades by color and size. Grade A is the standard for selling fresh, but some blueberries do not meet the requirements for

Grade A. Therefore, the blueberries that do not meet grade A status are utilized in other blueberry products or discarded.

Two experiments were conducted to determine the effects of Grade A and Non-Grade A (Floater/Rejects) lowbush blueberry purees on oxidation in ground turkey patties held in refrigerated and frozen storage over time. In both studies, ground turkey patty treatments were prepared containing 3.5% w/w Grade A blueberry puree, 3.5% Non-Grade A blueberry puree, and a control with 0% puree. Patties were held in refrigerated storage at 4C and frozen storage at -18C. Gas chromatography using headspace analysis and thiobarbituric acid tests (TBARS) were performed to determine the extent of lipid oxidation.

Overall, in both studies there were significantly lower ($p \leq 0.05$) TBARS and hexanal concentrations for both purees compared to the control patties regardless of storage temperature. The blueberry purees retarded the rate of lipid oxidation in the turkey patties. The possible implications of these studies are incorporating blueberry purees into precooked meat systems to prevent lipid oxidation.

Warmed-over flavor (WOF) attributes were determined by a descriptive sensory panel. Results showed that panelists described WOF taste as rancid and metallic. Panelists also found blueberry treatments had a sweeter flavor than a control patty with no puree.

An acceptance panel determined that both purees were acceptable in pre-cooked ground turkey patties compared to a control with no puree and a fresh cooked turkey patty. However, panelists were less likely to purchase pre-cooked turkey patties containing either blueberry puree compared to a fresh cooked turkey patty.

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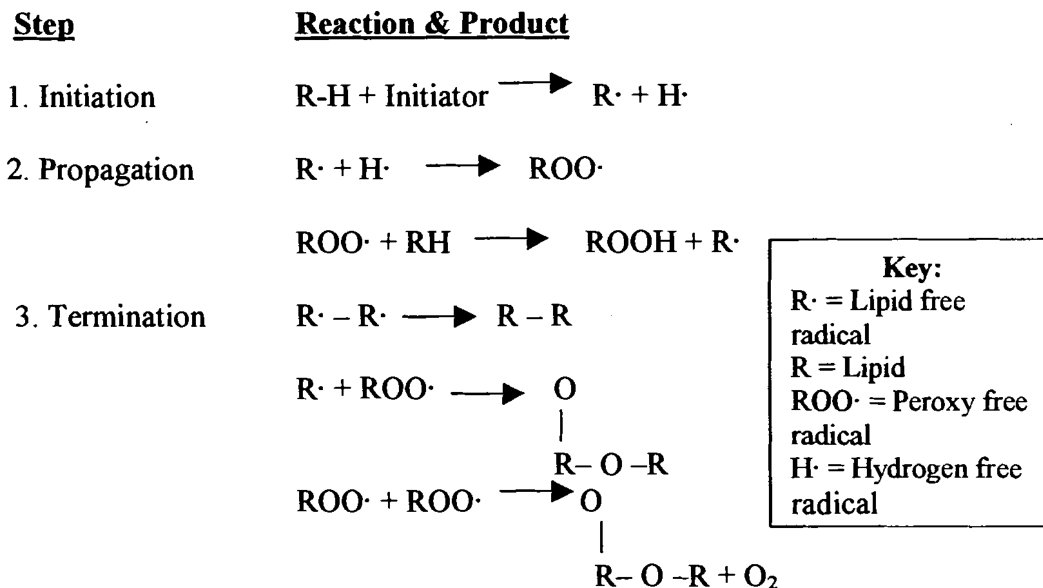
INTRODUCTION

Lipid Oxidation

Lipid oxidation of meat causes great concern for product development specialists in the food industry. In retail foods, there is an increasing demand for pre-cooked, reheated meat products. The results of lipid oxidation in meat-based systems are the creation of off-flavors, changes in texture, discoloration, and spoilage. Lipid oxidation occurs extensively during the refrigerated and frozen storage of comminuted turkey meat (Dawson and Gartner, 1983). There have been numerous research studies on the detection and the prevention of lipid oxidation in meat -based systems (Sheldon et al., 1997; Gatellier et al., 2000; McKibben et al., 2002).

Oxidative rancidity is caused by a series of chemical reactions. In order for oxidation to occur, a lipid compound must come into contact with oxygen or other reactive substances. The steps for lipid oxidation are initiation, propagation, and termination. Figure 1 shows the overall schematic representation of autoxidation. During the initiation step, an initiator forms a lipid free radical. The initiator can be a hydroxy free radical, superoxide, hydrogen peroxide, irradiation, oxygen, or other reactive substance (Schmidt, 2000). Once the free radical is formed, propagation begins. During propagation, lipid peroxy radicals are formed. This step is caused by the lipid free radical attacking free hydrogen atoms found at the double bonded carbon of an unsaturated fatty acid. Under optimum conditions, if more unsaturated fatty acids are present in a food system then the greater the oxidative rancidity. The newly formed lipid peroxy radicals can then remove hydrogen atoms from the unsaturated fatty acids.

Figure 1. Steps of Autoxidation (Adapted from Schmidt, 2000)



This cyclic reaction can continue until all of the unsaturated fatty acids have lost their double bonded carbons. The reaction ends when peroxide compounds are formed at the termination step.

Determination of Lipid Oxidation

Methods for determining lipid oxidation in meat products include hexanal and malondialdehyde (MDA) production. Malondialdehyde is a secondary product of lipid oxidation. Higher concentrations of hexanal and MDA are found in meat products that have undergone lipid oxidation. The volatile content of foods that undergo lipid oxidation increases with time. The end products of lipid oxidation can create secondary then tertiary products. One method for detecting MDA in a product is the thiobarbituric acid test (TBA) (Tarladgis et al., 1960 and Rhee et al., 1966). TBA tests measures for all aldehydes that are created, which react with TBA.

Therefore, TBA values can be expressed as thiobarbituric acid reactive substances (TBARS). TBA analysis has demonstrated that turkey meat is most susceptible to warmed-over flavor development (Wilson et al., 1976). Studies have shown that hexanal is a major volatile formed in cooked and oxidized meats and can correlate with off-flavor scores (Ahn et al., 1998). Hexanal can be detected using a gas chromatograph (GC) equipment with a headspace analyzer.

Lipid oxidation has negative effects on food products and human health. Research has shown that free radicals may promote a number of diseases, including cancer, heart, vascular, and neurodegenerative diseases (Halliwell, 1997). Oxidative rancidity alters food products by changing the color, texture, flavor, and other quality attributes of a product (Fukumoto and Mazza, 2000). The final step in lipid oxidation creates a complex mixture of aldehydes, ketones, hydrocarbons, esters, furans, and lactones, which are largely responsible for rancid flavors and sensory defects in meat products (Ladikos and Lougovois, 1990).

Blueberry Antioxidants

As a result of the negative effects of lipid oxidation in food systems and on the human body, new methods for lowering the rate of oxidation have been researched. One method for slowing lipid oxidation is to add antioxidants to the diet or food systems. Interest has been growing to finding naturally occurring antioxidants for use in foods to replace synthetic antioxidants (Fukumoto and Mazza, 2000). The protection provided against diseases by fruits and vegetables have been attributed to the various antioxidants contained in these foods (Ames et al., 1993). The FDA only recognizes beta-carotene, vitamin E, ascorbic acid, and selenium as

dietary antioxidants, which may not be labeled. By definition, antioxidants prevent oxidation by donating hydrogen atoms that can delay the initiation step, interrupt the propagation step, or hasten the termination step (Schmidt, 2000).

Fruits and vegetables have been identified as having varying antioxidant capacities (Prior et al., 1998). Flavonoids, which include flavones, isoflavones, flavonones, anthocyanins, and catechins, are components of fruits and vegetables that have strong antioxidant capacity (Cao et al., 1997). Vitamin C, E, and carotenoids also contribute to the total antioxidant capacities of fruits and vegetables (Prior et al., 1998).

Studies have been conducted to determine what types of fruits have high antioxidant capacities (AC). One study performed by Kalt et al. (1999a) determined the antioxidant capacity, vitamin C, phenolics, and anthocyanin contents of small fruits after fresh storage. It was found that the AC of the lowbush (*Vaccinium Angustifolium* Ait.) and the highbush (*V. corymbosum* L.) blueberries had a 3-fold higher AC than did strawberries and raspberries.

An important note is that there is a great debate over which fruits have the highest antioxidant capacity. There is not a standard agreement on methods to determine the antioxidant capacity of fruits. Oxygen radical absorbance capacity (ORAC) has been used by several research groups to quantify antioxidant capacities of fruits (Prior et al, 1998; Kayano et al., 2002). ORAC is based upon the principle that antioxidant compounds will delay the decrease in fluorescence produced by a peroxy radical generator. Results are reported as tocopherol equivalents (TE) per gram.

Kayano et al. (2002) researched the antioxidant activity of prune constituents. Prunes have shown higher ORAC values because the percent soluble solids in prunes is higher than in most fresh fruits due to the drying process. Prunes also contain different isomers of phenolic compounds such as caffeoylquinic acid isomers. The researchers determined that the antioxidant activity of the prunes was highly dependent on the phenolic compounds. The major isomers found in the prunes were neochlorogenic acid followed by crytochlorogenic acid, and chlorogenic acid. Caffeic acid showed one of the highest ORAC values in the prune components. They also concluded that unknown antioxidant compounds also played a role in the AC of prunes.

Donovan et al. (1998) determined the phenolic composition and antioxidant activities of prunes and prune juice using reverse-phase high performance liquid chromatography (HPLC). The results agreed with Kayano et al. (2002) that found neochlorogenic acid as the major phenolic compound in the prunes. The total phenolics found in pitted prunes were 1840 +/- 855 (mg/kg). The researchers noted that it is hard to compare the levels of phenolics in prunes to other commercial fruits because large representative samples were not used and the major prune phenolic is not the same for all fruits that show antioxidant activities.

A study performed by Prior et al. (1998) determined the antioxidant capacity of a variety of blueberries as influenced by the total phenolic and anthocyanin content. Prior compared the oxygen radical absorbance capacity (ORAC) of four different *Vaccinium* species. The results show that the Bilberry (*V. myrtillus* L) and the lowbush blueberry (*V. angustifolium*) have the highest ORAC values (44.6 ± 2.3

and 45.9±2.2 μmol TE/g), respectively. These two species also had higher total phenolic contents (525±5.0 and 495±3.5 mg/100g) respectively. It was determined that a linear relationship exists between the total anthocyanin or total phenolic content and the ORAC value of blueberries.

Variation in total anthocyanin content has been found within the *Vaccinium* species (Kalt et al., 1999b). Compared to the bilberry clones, commercial lowbush blueberry clonal mixtures had 40% of the level of anthocyanins. Specifically, the clones Blomidon, Cumberland, and Fundy were different in their anthocyanin content, ranging between 26 and 69% of the bilberry level. Kalt et al. (1995) found substantial interclonal variation in wild blueberries for sugar and acid content. The variation in wild blueberry sugar and acid content creates varying levels of anthocyanin content in clones.

Maturity and size contributes to the total phenolic and anthocyanin content of blueberries (Kalt et al., 1995). It was found that lower anthocyanin contents occurred in larger berries because the pigments are concentrated in the skins of the berries. The research also showed that maturity increases anthocyanin content. Unripe berries had an average anthocyanin content of 6 mg per g dry weight, while ripe berries had 11mg/g dry weight (Kalt et al., 1995).

The distribution of anthocyanins in blueberries has been quantified for ten cultivars of lowbush berries from Nova Scotia and one cultivar of highbush blueberries from British Columbia (Gao and Mazza, 1994). The results showed that the anthocyanin composition of lowbush blueberries is cultivar dependent. All of the cultivars contained nonacylated glucosides and galactosides of delphinidin, cyanidin,

petunidin, peonidin, and malvidin. These anthocyanins occurred in eight of the eleven cultivars in the acetylated form. It was also found that chlorogenic acid was the major colorless phenolic of both lowbush and highbush blueberries.

Blueberries are one of the richest sources of antioxidant phytonutrients of the fresh fruits and vegetables tested (Prior et al., 1998). Therefore, blueberries have the potential to be of great importance to the food industry in preventing or reducing lipid oxidation. When added to foods, antioxidants minimize rancidity, retard the formation of toxic oxidation products, maintain nutritional quality, and increase shelf life (Jadhav et al., 1996).

Processing can affect the anthocyanin, phenolics, and antioxidant capacity of lowbush blueberries (Kalt et al., 2000). Temperature, pH, and oxygenation were studied in lowbush blueberry puree extracts at 25 and 60°C. The authors found that anthocyanin, total phenolics, and antioxidant capacity were all affected by extraction temperature and time. After 60 minutes, the monomeric anthocyanin content had increased 2.6-fold in the blueberry purees extracted at 25°C. The 60°C extracts had a 15-fold increase in monomeric anthocyanins after 60 minutes. The total phenolic content was two times higher in the 60°C extract compared to the 25°C extract. The authors noted that these results maybe caused by the higher temperatures, which decreases the solubility of oxygen therefore reducing oxidative degradation of the anthocyanins. The AC of the 60°C extract was 1.8 times greater than the 25°C extract. However, greater losses were experienced in the 60°C extracts during storage at 20°C compared to the 25°C extracts. The anthocyanin content decreased by half and the total phenolics decreased by 30% in the 60°C treatment. The 25°C extracts

had a 1.7-fold increase in anthocyanin content and a 1.5-fold increase in total phenolics after two weeks of storage at 20°C. The researchers believed the increase in anthocyanin content was caused by the increased permeability of the membranes in the peel tissue at higher temperatures, which caused a greater release in anthocyanins during extraction. The authors concluded that both time and temperature of processing must be optimized in order to get the highest anthocyanin content and total phenolics in lowbush blueberry puree. High temperature short time processing was discussed as a possible option in creating processed blueberry products.

Connor et al. (2002) investigated the changes in fruit antioxidant activity among blueberry cultivars during cold-temperature storage. The authors correlated phenolic, anthocyanin, and antioxidant activity with titratable acidity and changes in fruit firmness for nine cultivars held for seven weeks at 5°C. The results showed that antioxidant activity correlated with total phenolic and anthocyanin content. Antioxidant activity, total phenolic, and anthocyanin content did not correlate with fruit firmness, weight loss, or bruising. One cultivar was found to have a 29% increase in antioxidant activity during the cold storage. The antioxidant activity was found to be cultivar dependent.

Wild Maine Blueberries

Commercial stands of lowbush blueberries are wild and are made up of many different clones that exhibit a great deal of phenotypic diversity (Kalt et al., 1995). The three most commonly found in Maine are the *Vaccinium angustifolium* Aiton, *Vaccinium nigrum*, and the *Vaccinium myrtilloides* (Yarborough, 1998). Once harvested, the berries are individually quick frozen (IQF) and held in frozen storage

for later use. When needed the berries are sorted in Grades according to USDA guidelines. Approximately 10-20% of the crop is not Grade A due to immaturity, color, or other defects (Chen and Camire, 1997). Blueberries are sorted by high fructose corn syrup density methods. Blueberries are then analyzed by spectrophotometric methods for color. These blueberries that cannot be sold as Grade A could be used by the food industry as potential antioxidants in food systems.

Lipid Oxidation in Meats

Oxygen, cooking, the addition of salt, and the amount of polyunsaturated fatty acids in meats all affect the deterioration of meat quality through lipid oxidation (Ahn et al., 1993b). Numerous studies have been conducted on the factors that affect oxidation in meat and how to retard the process. Ground meats are more prone to oxidation than whole cuts because of the much higher surface area. The chelation of metallic ions and the elimination of oxygen are important in prevention of lipid oxidation in cooked meats during storage (Ahn et al., 1993b). Phospholipids have been shown to be the primary lipid components that contribute to WOF during cooking (Hettiarachchy and Gnanasambandam, 2000).

Hot packaging and antioxidant combinations have been found to prevent lipid oxidation (Ahn et al., 1993a). Ahn (1993a) determined that packaging cooked meat immediately after cooking (hot packaging) was very effective in preventing lipid oxidation. Hot packaging with the addition of EDTA, BHA, and ascorbate lowered thiobarbituric acid reactive substances (TBARS) more than cold packaging. Other antioxidant combinations were tested and all demonstrated that hot packaging with

the addition of antioxidants lowers TBARS values significantly ($p<0.05$) compared to cold packaging with the same antioxidant combinations.

The same study by Ahn (1993a) also determined that salt acted as a prooxidant. When salt (NaCl) was added, the hot packaging and combination of antioxidants did not effectively reduce the amount of lipid oxidation in the turkey patties. The author concluded that NaCl could possibly cause cell damage that would disrupt membrane lipids. The lipids would then be exposed to more oxidation. Another possibility was the salt displaced ionic iron from binding macromolecules. Therefore, the iron would act as a catalyst in the lipid oxidation process.

The iron content of meat can influence the rate and the amount of oxidation a meat-based system undergoes. Nonheme iron is the major prooxidant in cooked meat (Love and Pearson, 1974). Nonheme iron content has been reported as a catalyst for the rapid development of oxidized flavors that have correlated with rancidity (Chen et al., 1984). These oxidized flavors have been called warmed-over flavor (WOF) (Tims and Watts, 1958). WOF is formed when meat is cooked, held in refrigeration, then reheated. These flavors have been described as rancid and stale (Graf and Panter, 1991).

Graf and Panter (1991) have determined that during the cooking and storage of chicken significant quantities of free iron are released. Iron bound to negatively charged phospholipids causes site-specific oxidation, which creates WOF. The researchers found that iron sequestration by chelation with phytic acid reduced the formation of WOF. It was also determined that competitive displacement of iron from phospholipids with polyvalent cations lowered WOF. In a phospholipid model

system, 25 mM Ca^{2+} caused 50% lower malondialdehyde values. In chicken breasts, a sensory panel evaluated WOF formation and concluded that calcium chloride decreased WOF.

Chen et al. (1984) have studied how different factors influence the nonheme iron content and its effects on oxidation. The authors analyzed the effects of heating and nitrite on the release of nonheme iron. The results show that slow heating meat resulted in higher concentrations of nonheme iron 2.25 μg/g compared to rapid-heating nonheme iron concentrations of 1.31 μg/g. The results also showed that nitrite inhibits WOF.

Another study performed by Schricker and Miller (1983) examined the effects of cooking and chemical treatments on heme and nonheme iron in meat. Oxidative cleavage of the iron-porphyrin ring in meat releases iron, which increases nonheme iron content. Six separate studies were carried out to determine the effects of different chemical treatments. The authors found that baking and microwave cooking increased the levels of nonheme iron. Ground beef samples were baked for 20 and 40-minutes at 176°C or microwaved for 0.5 and 3 minutes. There was a linear relationship between nonheme iron content and exposure time for both cooking methods. Both microwave and baked samples that contained ascorbic acid had a significant ($p<0.05$) increase in nonheme levels. Consistent exposure to hydrogen peroxide also increased nonheme iron. Braising, roasting, and microwave cooking at 68°C and 63°C were examined for nonheme iron content on the surface and center of meat samples. The authors concluded that surface samples of all cooking methods contained higher nonheme iron levels. This was caused by greater contact with

oxygen. Braising resulted in significantly higher ($p<0.05$) nonheme iron levels than roasting. Microwave cooking had the lowest levels of nonheme iron.

Antioxidants in Meat

Numerous studies have been performed to determine if natural and chemical antioxidants will affect lipid oxidation in meat systems. The effect of α-tocopherol, β-carotene, and sodium tripolyphosphate on lipid oxidation in refrigerated, cooked ground turkey and pork has been studied (Vara-Ubol and Bowers, 2001). Different treatments of these antioxidants were added to ground turkey and ground pork at 0.2% and 0.3% levels, plus combinations of these antioxidants. One percent sodium chloride was added to half of the treatments in order to determine the effects of the antioxidants with a prooxidant. Lipid oxidation was measured using gas chromatography methods. Hexanal was measured after cooking and storing the meat for six days. The authors concluded α-tocopherol alone reduced hexanal values in turkey but not pork. Sodium tripolyphosphate (STP) was more effective then α-tocopherol and combinations of antioxidants in both meat systems. STP protected against lipid oxidation but hexanal values still increased in the turkey after refrigeration. Salt at the 1% level had no significant effect ($p>0.05$) on lipid oxidation in either the pork or turkey. Since salt has been demonstrated as a prooxidant the researchers concluded that the NaCl used contained trace amounts of metal impurities ($Fe \leq 2ppm$). β-Carotene at 0.03% levels had no significant effect on hexanal values in the treated patties because the values were similar to the control samples.

Another study by Sheldon et al. (1997) looked at the effect of dietary vitamin E on the oxidative stability, flavor, color, and volatile profile of refrigerated and frozen turkey breast meat. Nicholas turkey toms were fed diets containing varying levels of vitamin E. Turkeys were processed and the breast meat removed for evaluation by TBA, descriptive flavor profiling, and GC. The results show that the TBA values for the refrigerated samples were not influenced by the days of refrigeration ($p>0.05$) therefore the TBA values were pooled across days. There was an inverse relationship between TBA scores and dietary tocopherol levels. Refrigerated turkeys that had been fed 25x the Nutritional Research Council (NRC) diet had significantly lower TBA values than those fed 10x and 5x the NRC diet. The frozen turkeys had no significant differences ($p>0.05$) between treatments after 150 days of storage. Sensory scores also showed that higher levels of dietary tocopherol had greater acceptable roasted turkey aromatic notes than treatments with lower levels of dietary tocopherol. Panelists detected oxidized aromatic notes after one day of storage with no difference between treatments. The volatile profile showed that hexanal was the most abundant of all the volatiles found in all treatments after day one of storage. As the days progressed the hexanal levels were higher. Turkeys fed higher dietary tocopherol levels had lower hexanal values throughout storage. Color scores increased with the amount of dietary tocopherol fed to the turkeys.

Other researchers have looked at α-tocopherol, β-carotene, and ascorbic acid as antioxidants in stored poultry muscle (King et al., 1995). Broilers were fed ethoxyquin as an antioxidant for the control treatment plus varying levels of α-tocopherol, β-carotene, and ascorbic acid. Oxidation was measured using TBA

analysis and a trained sensory panel. The results showed that alpha-tocopherol maintained the redness of unheated meat stored at freezer temperatures for eight weeks. Ethoxyquin in the control treatment decreased from 80mg/kg to 9.6 mg/kg over the eight weeks. L-ascorbic acid treatments had similar TBA results as the control samples for ground stored meat. Alpha-tocopherol at 13mg/kg in the microsomes or meat prevented lipid deterioration shown by the lower TBA values. Beta-carotene acted as a prooxidant in the samples compared to the control and other antioxidants tested.

Other researchers have studied how dietary fat and vitamin E supplementation effects free radical production and its effects on lipid and protein oxidation in turkey muscle extract (Gatellier et al., 2000). The dietary fat and lipid oxidation was determined by removing two types of turkey muscle extracts, *Pectoralis major* (glycolytic) and the *Sartorius* (oxidative muscle). The dietary fat added to the turkey diet was compromised of 6% soy or rapeseed or tallow oil at 30 and 200 ppm. Alpha-tocopherol acetate was added at 30 and 200 ppm. Free radical production was measured using Electron Spin Resonance (ESR) spectroscopy. Lipid oxidation was measured using TBARS and protein oxidation was measured by an estimation of carbonyl groups formed during incubation. The results showed that vitamin E content of muscle was significantly influenced ($p<0.05$) by supplementation in the diet. The *Sartorius* muscle had twice as much vitamin E content as the *Pectoralis major* muscle. The turkeys fed soy oil had lower vitamin E content than those fed tallow or rapeseed oil. The TBARS showed that vitamin E significantly ($p<0.05$) lowers the TBARS value no matter the muscle type. As reported in other research

(Chen et al., 1984 and Graf et al., 1981) after one hour of incubation time, TBARS levels were higher in the *Sartorius* muscle, which shows that lipid oxidation is dependent upon iron catalysts such as myoglobin and free iron. These results relate to the function of each muscle. The *Sartorius* muscle is found in the leg of the turkey and has more myoglobin in the muscle fibers. The *Sartorius* muscle is used more than the *Pectoralis* muscle, which is found in the breast of the turkey. As a result of the leg muscle receiving more blood for movement, the higher iron content influenced the extent of lipid oxidation of this muscle. The ESR spectroscopy results show that vitamin E strongly inhibited free radical formation. ESR signals were five to eight times higher in the control samples then the vitamin E supplemented samples. The carbonyl results for protein oxidation show that carbonyl formation was higher in *Sartorius* muscle than in *Pectoralis* muscle. In the *Sartorius* muscle it was found that carbonyl formation was significantly correlated with lipid oxidation ($r= 0.73$; $p < .001$). Overall, these results show that vitamin E is more pronounced toward lipid oxidation than protein oxidation because free radicals attack phospholipids first.

Processing methods such as irradiation can improve the microbial safety of foods but can act as a prooxidant during the lipid oxidation process. Packaging also plays a role on the extent of lipid oxidation in meats. Ahn et al. (1998) have researched the effects of dietary vitamin E supplementation on lipid oxidation and volatile content (secondary products of lipid oxidation) of irradiated, cooked turkey meat patties with different packaging. Turkeys were fed diets containing 25, 50, 75, and 100 IU of dl-α-tocopherol (TA)/kg of diet. Breast and leg meat patties were prepared by irradiating at 0 or 2.5 kGy doses, cooked, and then stored in either air or

vacuum packages. TBARS and volatile contents were used to determine the extent of lipid oxidation of the patties. The results of the research showed that vacuum packaged nonirradiated breast patties had lower TBA values as the TA content of the patties increased. High levels of TA were found to reduce TBARS in irradiated breast meat. However, irradiated patties had higher levels of TBA than nonirradiated patties. The TBARS of leg meat were higher than breast meat. This was due to the higher fat content of the dark leg meat. In the air-packaged treatments, lipid oxidation was significantly higher ($p<0.05$) than the vacuum packaged samples. Overall, irradiation was determined to act as a prooxidant in vacuum packaged and air packaged samples. However, the increase in TA content was found to reduce the volatiles and TBARS of all the treatments. Oxygen was found to act as the key factor on increasing lipid oxidation of both irradiated and nonirradiated patties regardless of meat type.

Natural antioxidants found in fruits and spices have been reported to reduce lipid oxidation in meat patties (Britt et al., 1998; McKibben and Engeseth, 2002; El-Alim et al., 1999). Britt et al. (1998) demonstrated that tart cherry tissue reduced lipid oxidation in ground beef patties. The addition of 11.5% (w/w) Montmorency and Balaton cherry tissue to raw and cooked ground beef patties significantly lowered TBA values ($p<0.05$) compared to control ground beef patties with no cherry tissue.

McKibben and Engeseth (2002) used different types of honey to slow down lipid oxidation in precooked ground turkey. Ninety-three percent lean ground turkey was combined with 1%, 5%, and 10% (w/w) soy honey. These treatments were compared to 0.02% butylated hydroxy toluene (BHT) and alpha-tocopherol.

Another experiment was designed to compare the effectiveness of 5% (w/w) buckwheat, 5% acacia, and 5% clover honey in the ground turkey. Finally, the antioxidant contents (AC) of the honeys were determined using a spectrophotometric assay. Loss of absorbance at 517 nm was measured when a free radical, 1,1,-diphenyl-2-picrylhydrazyl, reacted with the antioxidants found in the honey. The water-soluble antioxidant content was measured using another spectrophotometric assay with ascorbic acid as the standard. The results of their research show that 5% soy honey was the most effective at reducing lipid oxidation compared to the 1% and 10% soy honey treatments. By day 3, all soy honey treatments had statistically lower ($p<0.05$) TBARS values than the control with no honey. Five percent soy honey was also more effective at lowering TBARS values than both BHT and alpha-tocopherol. In the second experiment, 5% buckwheat honey reduced TBARS by 70% compared to the control treatment. Acacia honey only had a 30% reduction in TBARS. Both the 5% soy honey and 5% clover honey treatments were equally effective at slowing down lipid oxidation. The authors concluded that different floral sources contain varying levels of antioxidant capacities. The darker honey, especially buckwheat, was found to have higher antioxidant content than the lighter honey. Overall, honey was found to be a source of antioxidants for retarding the rate of lipid oxidation in precooked ground turkey patties.

El-Alim et al. (1999) used culinary spices and the ethanol extracts of those spices to control lipid oxidation in raw and cooked chicken and pork patties. Patties contained sodium chloride, which acted as a prooxidant. Samples were held in refrigerated storage for four days and frozen storage for six months. Lipid oxidation

was measured using TBA analysis and peroxide values (POV). Marjoram, wild marjoram, and caraway were the most effective dry spices at retarding lipid oxidation. The ethanolic extracts of these spices were more effective at retarding lipid oxidation and TBARS values to 20-27% compared to the dry spices. The ethanolic extracts of sage, basil, thyme, and ginger significantly reduced ($p<0.05$) POV and TBA values in cooked pork patties. Marjoram, clove, and nutmeg showed a significant difference ($p<0.05$) in refrigerated raw ground chicken stored for seven days compared to a control. Dry marjoram and wild marjoram showed the most significance in cooked chicken meat held for six months. The researchers concluded that dry spices could retard the rate of lipid oxidation. However, the ethanolic extracts of spices were more effective at retarding lipid oxidation.

Another study done by Ahn et al. (2002), studied the antioxidant properties of natural plant extracts containing polyphenolic compounds in cooked ground beef. TBARS, hexanal, and sensory scores for WOF were used to evaluate the effectiveness of grape seed extract (ActiVin™) and pine bark extract (Pycnogenol®) on the extent of lipid oxidation in 80 % lean cooked ground beef. Results showed that both ActiVin™ and Pycnogenol® at 0.05% and 0.10% significantly reduced ($p<0.05$) TBARS, hexanal, and WOF. ActiVin™ reduced TBARS and hexanal concentrations more than Pycnogenol®. Significant correlations were seen between TBARS and hexanal ($r=0.96$; $p<0.01$), WOF and TBARS ($r=0.90$; $p<0.01$), and WOF and hexanal ($r=0.87$; $p<0.01$).

Water-soluble rosemary extracts were evaluated as inhibitors of lipid oxidation and color change in cooked turkey products during refrigerated storage (Yu

et al., 2002). TBARS, hexanal production, and color of the cooked turkey samples were evaluated for two weeks in refrigerated storage. Turkey breast was ground through a meat grinder and rosemary extracts were added at 0, 100, 250, and 500 ppm on a wet/weight basis. Results showed that 500 ppm treatments reduced TBA, hexanal, and color change more than the 100 and 250 ppm treatments over all days tested. Hunter lab color scores showed that higher levels of rosemary extracts created darker color in the turkey samples. The authors noted that the dark color could be attributed to the darkness and the reducing power of the extract. Antioxidants can inhibit metmyoglobin formation, which prevents color change. The researchers concluded that higher rosemary extract concentrations had a more significant reduction in TBA and hexanal concentrations than any other treatment while maintaining color.

Warmed-Over Flavor (WOF)

As seen in previous studies, warmed-over flavor can occur in pre-cooked meats that are reheated (Ahn, 1998, Sheldon, 1997, Graf and Panter, 1991, Chen, 1984, Tims and Watts, 1958). These off-flavors are detrimental to the growing demand for frozen meat products. Bailey et al. (1997) found that WOF was inhibited using high cooking temperatures. The preventative effect of the high heat was attributed to the end products of the Maillard reaction, which occurs at high temperatures.

Research has shown that the addition of chemical antioxidants can reduce lipid oxidation and warmed-over flavor, but can impart chemical flavors in meats (Craig et al., 1991). The study performed by Craig (1991) demonstrated that the

addition of sodium tripolyphosphate (STP) and sodium ascorbate monophosphate (SAMP) inhibited off-flavor development in cooked, vacuum-packaged frozen turkey. Tims and Watts (1958) suggested that phosphate salts prevented autoxidation by chelating heavy metal ions. Treatments of 0.3% and 0.5% STP and SAMP in water solutions were added to ground turkey, then cooked and vacuum packaged, and finally held in frozen storage for five months. Non-heme iron contents and hexanal levels were used to determine lipid oxidation. The results showed that non-heme iron levels and hexanal levels were lowered with the addition of the phosphate salts. A five member trained panel was used to evaluate the reheated turkey patties. The results indicated that turkey flavor and aroma was significantly ($p<0.05$) more intense in samples containing the 0.3% SAMP than 0.5% SAMP. The 0.3% and 0.5% STP levels were not significantly different ($p>0.05$) but showed similar effects as the SAMP treatment on turkey flavor and aroma. Both the STP and SAMP samples had lower intensity scores for turkey flavor and aroma compared to control patties without the phosphates. The authors noted that there was a loss of meaty character in the patties containing phosphates. The stale aroma and flavor attributes were not affected by the SAMP and STP treatments. Both phosphate salts at the 0.5% level had significantly higher ($p<0.05$) soapy flavors than samples with the 0.3% STP or SAMP and control treatments. The rancid flavor was significantly different ($p<0.05$) in the patties containing the phosphate salts than the control samples. Since the patties were vacuum packaged, all of the scores for all treatments were low (<1) for the attributes pertaining to WOF. Even though the ascorbate phosphates lowered rancid off-flavor attributes, the government has not approved the use of these antioxidants in foods.

As seen with the previous study performed by Craig (1991), sodium tripolyphosphate can reduce lipid oxidation but can leave soapy notes in precooked meats. Chambers et al. (1992) used two trained sensory panels with different phosphate sensitivities to determine the flavor of cooked ground turkey patties treated with STP. As of 1991, the USDA allows 0.5% STP in poultry products (USDA, 1991). The study divided an eight-member panel into two groups according to a low and high sensitivity (threshold<0.2%) to STP. The results showed that turkey patties without STP had more intense protein, serumy, brothy, and metallic notes and less intense turkey and soapy notes than patties treated with 0.4% STP. Both panels agreed the STP patties had higher soapy characteristics. However, the high sensitivity panel found the soapy notes to be more intense and linger longer than the less sensitive panelists. Differences were found for metallic aftertaste and slick mouthfeel for patties containing STP. The STP treatments increased these attributes, which might lead panelists to describe the STP patties as having more off-flavors. In conclusion, this study verified that STP treated turkey patties have a different flavor profile than control patties. Even panelists with lower sensitivities to STP determined a difference in both treatments.

Another study performed by Hwang et al. (1990) determined the effects of vacuum packaging, modified atmospheric packaging (MAP), and air packaging on lipid oxidation in cooked beef loin slices. The MAP treatment was a packaging procedure that flushed 80% N_2 and 20% CO_2 into the sealed beef slices. A five member trained panel determined that MAP improved flavor and odor. The MAP also had higher meaty and lower WOF and cardboard attributes than the air packaged

treatments. Vacuum packaged samples also had lower TBA, hexanal, and pentanal concentrations compared to the air packaged samples. There was no change in the textural properties of the loin slices in any of the treatments. The vacuum packaged beef slices also had higher Hunter Lab a-values than either the MAP and treatments packed without the removal of air.

Kerler and Grosch (1996) determined that WOF was the result of a loss of desirable odorants in cooked beef patties. Eleven odorants were quantified using stable isotope dilution assays. After the quantification of 1-octen-3-one, (E-E)-2, 4-nonadienal, trans-4, 5, -epoxy-(E)-2 decanal, and hexanal, it was found that hexanal and epoxydecanal contributed the most to warmed-over flavor. The results of the eleven odorants tested determined that there was a loss in desirable odorants such as 4, hydroxy-2,5,-dimethyl-3(2H)-furanone and 3-hydroxy-4,5-dimethyl-2(5H)-furanone. The intensity of the roasty and meaty notes was high in the freshly cooked patties. Once reheated, the intensities of these attributes decreased. Reheated samples smelled musty, cardboard-like, and metallic in both oxygen packed and nitrogen flushed packages.

Lai et al. (1995) studied the hexanal contents of restructured chicken nuggets treated with antioxidant combinations. The objective of the study was to determine antioxidant effects on lipid oxidation and to correlate hexanal results with TBA and sensory scores. Combinations of oleoresin rosemary, sodium tripolyphosphate (STPP), and tertiary butylhydroquinone (TBHQ) were added to chicken nuggets. A ten member trained sensory panel determined the degree of WOF in the nuggets with a zero score meaning no WOF and five score meaning very strong WOF. However,

the authors noted that the panel was not a descriptive panel that determined a flavor profile for WOF. The results showed that STPP was the most effective at reducing oxidation. However, the 0.5g kg^{-1} and 1g kg^{-1} levels of oleoresin rosemary were also effective at reducing hexanal values by 13% and 47%, respectively. The greatest decrease in hexanal (95%) was seen in the patties containing both TBHQ and STPP. A higher correlation coefficient ($r=0.68$ pooled within treatments) was found between hexanal concentrations and sensory scores. A correlation coefficient ($r=0.14$ pooled within treatments) was found between TBA and hexanal scores, which showed that TBA scores did not correlate with hexanal results. A statistically significant ($p<0.05$) correlation coefficient was found ($r=0.56$ pooled within treatments and storage time) between TBA scores and sensory scores. The authors noted that the TBA test might be less meaningful when correlating WOF overtime in stored meats because malondialdehyde is unstable and very reactive.

However, a study by Wilson et al. (1976) determined the effects of total lipids and phospholipids on WOF in red and white muscle from several species as measured by TBA. Chicken, turkey, pork, and mutton were analyzed for TBA after cutting, after cooking, and after storage for 48 hours at 4°C.

The results of the research showed that TBA values were highest for turkey, then chicken, pork, beef, and finally mutton. The authors concluded that turkey was the most susceptible to WOF development. Red muscle in cooked and raw turkey consistently had higher TBA values than the white muscle. This trend was not seen in the other types of meat tested. However, after two days all the meats tested had higher TBA values in the red muscle than the white muscle. The total lipid levels in

red muscle of mutton and pork, chicken, beef, and turkey were 4.74%, 5.58%, 14.79%, and 1.86%, respectively. The white muscle from turkey contained less than half as much total lipid as red muscle. However, white muscle contains higher unsaturated fatty acids than red muscle. White muscle in pork averaged 8.88% total lipid, which was one and half times higher than the red muscle. In the pork, there was significance ($p<0.10$) between TBA values and total lipid levels in both red and white muscles. Therefore, as lipid levels increase in pork there is an increase in the amount of oxidation. However, this was not seen in any of the other treatments tested. There was a negative relationship between TBA values and phospholipid as a percentage of total lipid for both red and white muscle of pork. Therefore, it was concluded that high phospholipid content does not have a negative effect on WOF in pork. Overall, the results show that phospholipids are not important in the development of WOF in pork, but total lipid levels are important in the development of WOF in pork.

Sensory Development

Warmed-over flavor has been detected within the first 48 hours of refrigerated storage of cooked meats (Tims and Watts, 1958). The ability to discriminate and describe WOF has been demonstrated with the use of a descriptive panel (Byrne et al, 2001; Johnson and Civille, 1986; Sheldon et al., 1997; Craig et al., 1991). Descriptive analysis methods involve the detection and description of the qualitative and quantitative attributes of a product by a trained panel (Meilgaard et al., 1999). Descriptive panels can be used to determine the changes in products overtime.

Training a panel to understand the complex attributes of warmed-over flavor in meat can be tedious. However, the panelists if properly trained can be an effective

tool in describing the effects of antioxidants on lipid oxidation and WOF. Byrne et al. (2001) demonstrated the need for panel consistency when training a descriptive panel. Their research determined necessary steps to train panelists to detect WOF in pre-cooked pork patties. In their research, they created a vocabulary that could be used to describe WOF by all panelists. A gradual increase in agreement on flavor and odor terms was seen as sessions increased. However, it was noted that in session five of training there was a large disagreement in terms. This was attributed to the references being introduced in session five. The authors concluded that references for terms should be introduced to panelists as early as session one. Overall, the study results showed that as oxidation progresses a sweet, fresh pork or chicken meat-like and rancid-like flavor developed.

Another panel was trained for a study on determining the sensory characteristics of broiled and grilled patties from grain-fed bison (McClenahan et al., 2001). Thirteen panelists were trained to detect the differences and effects of cooking methods on surface color, interior color, juiciness, tenderness, flavor and aroma intensities. Panelists found that broiled patties were grayer in color, not brown on the surface, but had more red color than gray on the interior. Broiled patties were more juicy and tender than the grilled patties. Significant differences ($p<0.05$) were seen for all attributes tested between the grilled and broiled patties. An important conclusion in the study was that no off-flavors were found in the patties. This was due to the patties being tested directly after cooking with no reheating.

Heterocyclic Aromatic Amines (HAA)

According to Chen (1997), polycyclic aromatic hydrocarbons (PAHs) formed through the incomplete combustion of wood or gasoline, can be harmful to humans if consumed in significant quantities. Processed meats were found to contain high levels of PAHs. Benzo [a] pyrene (BaP) and dibenz [ah] anthracene have been used as an indicator of the possible presence of other PAH compounds. BaP has been used as a quantitative index of chemical carcinogens in foods (Larsson et al., 1983).

Grilling foods can lead to the production and consumption of PAH compounds, which can be potent carcinogens. Larsson et al. (1983) determined the levels of 22 PAH compounds in 63 samples of grilled meat. The objective of the study was to discover if cooking method and type of heat source were significant factors in the formation of PAH's. Frankfurters, pork chops, chicken halves, and T-bone steaks were charcoal grilled. Frankfurters were also subjected to either of the following heat sources: log fire, log fire embers, cone fire, electric oven, frying pan, or charcoal. Gas chromatography equipped with mass spectrophotometer was used to determine PAH levels in the samples.

The results show that the PAH levels in fried or electrically broiled frankfurters did not significantly differ from the original trace levels in the uncooked sample. BaP mean levels (μg/kg) in frankfurters cooked by log fire, log fire embers, cone fire, charcoal fire, electric oven, and frying pan were 54.2, 7.7, 17.6, 0.3, 0.2, and 0.1, respectively. It was concluded that heat source plays a significant role in the formation of BaP. The amount of individual PAH compounds was also effected by the heat source. The distance the sample was from the heat source was a factor in the

uptake of PAH in flame grilled frankfurters. The closer to the flame the sample was cooked the higher the levels of BaP detected. In the charcoal grilled meats, the average BaP levels (μg/kg) of the pork, T-bone steak, and chicken were 3.6, 4.2, and 3.6, respectively. These results were significantly higher than the 0.3 μg/kg BaP found in the frankfurters. It was reasoned that the pyrolysis of the fat that drips into the coals during cooking produces PAH. The authors concluded that PAH formation is dependent on cooking method and heat source. Electrical broiling and frying do not produce PAH. Grilling over charcoal leads to a slight increase in PAH, but not as much as using pine or spruce cones.

Three methods have been extensively used to determine BaP in grilled meats, which include thin layer chromatography (TLC), gas chromatography equipped with a flame ionization detector, and high performance liquid chromatography equipped with a UV or fluorescence detector. Grimmer and Jacob (1987) determined a thin-layer chromatographic screening method for the quantification of BaP in smoked food. The method was used for the detection of BaP up to 0.5 ng. Samples contained more than 0.6 μg BaP/kg of meat.

Doremire et al., (1979) used TLC to detect 3,4-benzopyrene (BP) in charcoal grilled meats. The objective of the study was to determine the effects of fat concentration on BP. The first part of the study focused on detecting BP in grilled beef, pork, lamb, and turkey. The second part of the study focused on the effects of varying levels of beef fat added to turkey and beef. Control samples were made by broiling in an electric oven.

The results of the research showed that in grilled turkey with no added fat there were undetectable levels of BP. The thin layer chromatograms showed a blue fluorescence in all of the beef samples with added fat. Pork, which had the highest percent fat 22.5%, was found to have the highest average concentration of BP of 29.3 ppb. No fluorescent spots were seen in the control samples. Beef had a 14.3% fat content and an average BP content of 21.5 ppb. As the percentage of beef fat was increased than the BP levels also increased. The authors concluded that the results show BP concentrations are proportional to fat concentration in the meat.

Objectives

The objective of the project was to determine the effects of two different lowbush blueberry purees on lipid oxidation in precooked ground turkey patties. Wild Maine lowbush blueberries were used in the research in order to develop a new product that utilizes the floater rejects not sold as grade A. Two studies were performed to detect the extent of lipid oxidation in precooked ground turkey patties using puree manufactured from grade A wild Maine blueberries and non-grade A wild Maine blueberries (floater rejects).

Study #1:

The objective of study #1 was to determine the extent of lipid oxidation in precooked ground turkey patties held at 4°C for two weeks and -18°C for six months. A trained descriptive panel was used to describe and determine the amount of WOF in the precooked turkey patties containing lowbush blueberry puree, in order to

determine if non-grade A blueberry puree was different in reducing WOF compared to the grade A lowbush blueberry puree.

Study #2

The objective of study #2 was to determine the extent of lipid oxidation in precooked ground turkey patties held at 4°C for two weeks and at -18°C for three months. An untrained acceptance panel was used to determine the acceptance of reheated turkey patties containing blueberry puree. Another objective of the panel was to determine if there is a possible market for precooked turkey patties containing blueberry puree.

A pre-trial was performed in order to determine if differences existed between highbush and lowbush blueberry purees and their ability to retard lipid oxidation in precooked turkey patties (Appendix A).

EXPERIMENT 1: MATERIALS & METHODS

Materials

Two blueberry purees (one from Grade A blueberries and the other from floater rejects) were obtained from Cherryfield Foods (Cherryfield, ME) in June 2001. The purees were held in frozen storage at -18°C until ready to use. Purees were thawed at room temperature for 48 hours before incorporating into the turkey. Ninety-three percent lean fresh ground turkey (120 lbs.) was purchased from Sam's Club (Bangor, ME).

Sample Preparation

Treatments were prepared on the same day that the ground turkey was purchased. Sample preparation and cooking took place at Stodder Commons, located on the University of Maine, Orono campus. Formulations were prepared on a wet weight basis. The three treatments were: 0% puree (control), 3.5% grade-A blueberry puree, and 3.5% non-grade A blueberry puree. 3.5% puree was chosen because pre-trials using 5.0% puree showed similar results as the 3.5% for retarding lipid oxidation. The 5.0% level also had a gray color change that could potentially inhibit the marketability of the product. Therefore, 3.5% puree was chosen for use in this research. The ground turkey was divided into three batches each weighing 40 pounds using a Fisher Model XL-500 scale (Fisher Scientific, Denver, CO). Three and a half percent grade-A blueberry puree was added by hand to one of the 40 lb. batches of ground turkey and mixed for approximately two minutes. Following hand mixing, the turkey meat was ground once through a Hobart meat grinder (Troy, OH). After grinding, turkey patties weighing 115.00 +/- 0.10 grams were made by pressing in a

plastic patty press in order to assure similar thickness. The same weighing and grinding procedure was used to make 3.5% non-grade A and 0% control treatments. The patties were broiled in a electric oven until the internal temperature reached 74°C. The internal temperature of the patty was measured with a Fluke 52K/J thermocouple (Paramus, NJ). Patties were cooled until they reached a temperature of 21°C. Individual patties were sealed in a Tetra Laval Foods plastic bag (Holdbrook, MA). Bags were heat sealed with a NY Clave Heat Sealer (St. Louis, MO) removing as much air as possible. Enough patties to perform chemical and sensory evaluation for two weeks were stored at 4°C and the rest were stored at -18°C for six months.

The refrigerated turkey treatments were tested on Day 1, 3, 7, and 14. The frozen turkey treatments were tested on Day 1, 30, 60, 90, 120, 150, and 180 of storage.

Chemical Analyses

Thiobarbituric Acid Test (TBA)

Thiobarbituric acid tests were performed according to the method of Tardladgis et al. (1960) and Rhee and Watts (1966). Each treatment was performed in triplicate. All chemicals for the TBA analysis were from Sigma Chemical Company (St. Louis, MO). The following solutions were prepared: 1L of buffer (50M PO_4, 0.1% EDTA, 0.1% n-propyl gallate), 250 mL of 30% trichloracetic acid (TCA), 100 ml of 8:2 buffer:TCA, 500 ml of 20mM TBA, and 10^{-5} M 1,1,3,3,-tetraethoxypropane (TEP). All chemicals and treatments were stored on ice during analysis.

Four grams of each treatment were weighed into a 50 ml Falcon tube (St. Louis, MO). The weight was recorded for each sample. Sixteen ml of cold buffer was added and the sample was vortexed on a Vortex Genie-2 (VWR Scientific, U.K.) The samples were then homogenized with a Polytron Model CH-6010 (Kinematica, Switzerland) for two minutes. The homogenizer was washed with 10% hydrochloric acid solution then washed with distilled water between each sample. Four ml of 30% TCA were added to each sample then vortexed for 15 seconds. The slurry was filtered through a 15.0 cm crepe fluted Whatman filter (VWR Scientific Products, U.K.). Four ml of the filtrate were added to a clean test tube. Four ml of 20mM TBA was added to the test tube. A standard curve was made by pipetting 0, 0.5, 1.0, 1.5, 2.0, and 2.5 ml of TEP into separate tubes. Each tube was brought up to a volume of 4 ml with TCA:buffer 8:2 solution. Finally, four ml of TBA was added to each tube containing TEP standard and the blank. All of the test tubes were put into a boiling water bath for twenty minutes. The samples were cooled for five minutes. Samples were read at an absorbance of 530nm using distilled water for a blank on the Beckman Model DU-64 spectrophotometer (Beckman Instruments, Fullerton, CA).

Gas Chromatography Headspace Analysis (GC)

Sample preparation and method were taken from Frankel et al. (1989), Frankel et al. (1991), and Snyder et al. (1985). One-gram samples from each treatment were weighed into a GC headspace vial and capped with teflon septa from Tekmar-Dorhman (Cincinnati, OH). Each treatment was run in triplicate. A standard curve was prepared at each analysis time from 50 μM, 25 μM, 12.5 μM, 6.25 μM, 3.125 μM, 1.56 μM, 0.781 μM, and 0 μM stock solution of hexanal (98% 11.560-6,

Aldrich Chemical Co., Milwaukee, WI). Five ml of each dilution of hexanal were pipetted into the GC headspace vials. All of the samples and standards were analyzed by a Hewlett Packard HP 6890 Series GC system equipped with a headspace analyzer model Tekmar 7000 Headspace Autosampler (Cincinnati, OH) (Table 1.).

The software used for headspace analysis was the ChemStation revision A.08.03 (Agilent, Burlington, MA) and Teklink 7000 version 2.00 (Tekmar-Dorhman, Cincinnati, OH). Table 2. contains the hexanal parameters set in the Teklink 7000 software.

Hexanal Evaluation

Hexanal concentrations were determined by preparing a standard curve and a linear regression equation then using the following calculation to determine hexanal concentrations in the treatments.

Calculation:

(Area of sample)*(Area of curve) + constant = sample hexanal concentration (μM)

Statistical Analysis for TBARS and Hexanal

Both TBARS and hexanal concentrations were statistically analyzed in Systat Version 9 (SPSS Inc., Chicago, IL). A one-way ANOVA was performed followed by a Tukeys post hoc test for differences between treatments during each day. A multiway ANOVA was performed to determine overall differences. Hexanal concentrations that were found to be undetectable were substituted with the lower detection limit value of 0.78 μM because the value was either equal or lower than the detection limit. Correlation coefficients were determined for correlations between hexanal and TBA concentrations.

Table 1. Gas Chromatography Method for Hexanal Detection

Oven: Initial temp: 50°C Initial time: 2.00 min Ramps: Rate 5.00 Final temp 65°C Final time 10.00 Post temp: 50°C Post time: 0.00 min Run time: 15.00 min Maximum temp: 275°C Equilibration time: 3.00 min	**Front Inlet (Split/Splitless)** Off **Back Inlet (Split/Splitless)** Mode: Split Initial temp: 225°C on Pressure: 11.91 psi on Split ratio: 100:1 Split flow: 259.8 ml/min Total flow: 265.6 ml/min Gas saver: off Gas type: Helium
Column 1 Capillary column Model Number: Restek stabilwax capillary (Restek Bellefonte, PA) Max temp: 250°C Nominal length: 30.0m Nominal diameter: 320.00 cm Nominal film thickness: 1.00 cm Mode: constant flow Initial flow: 2.6 ml/min Nominal initial pressure: 11.91 psi Average velocity: 41 cm/sec Inlet: Back inlet Outlet: Back detector Outlet Pressure: ambient **Column 2** Not installed	**Front Detector (NPD): OFF** **Back Detector (FID):** Temperature: 180.0°C on Hydrogen flow: 40.0 ml/min on Mode: constant column+makeup flow Combined flow: 45.0 ml/min Makeup flow: on Makeup Gas Type: helium Flame: on Electrometer: on Lit offset: 2.0

Table 2. Teklink 7000 Version 2.00 Hexanal Method

Parameter	Value
Platen Temperature	100°C
Platen Equilibrate Time	5 minutes
Sample Equilibrate Time	10 minutes
Vial Size	22 ml vial
Mixer (OFF/ON)	ON
Mix Time	1 minute
Mix Power	1
Stabilize Time	1 minute
Vial Pressurization Time	0.25 minutes
Pressure Equilibrate Time	0.25 minutes
Loop Fill Time	0.25 minutes
Loop Equilibrate Time	0.20 minutes
Inject Time	1.00 minutes
Sample Loop Temperature	65°C
Line Temperature	65°C
Injections Per Vial	1
GC Cycle Time	15
Loop Injection	1 ml

Anthocyanin Analysis

Total anthocyanin content of the blueberry purees was determined following the procedure of Chaovanalikit (1999). The procedure was based on the pH differential method taken from Wrolstad (1976) and modified for calculations according to wavelength, molar absorptivity, and molecular weight of the major anthocyanins found in blueberries.

All sample treatments were run in triplicate. Twenty grams of product were taken and blended in an Osterizer blender at low speed with two hundred ml of 0.1% hydrochloric acid in methanol solution. The entire sample was taken and placed into 250 ml plastic centrifuge bottles (Nalgene Labware, Nalge Company, Rochester, New York) with a magnetic stir bar. Each bottle was nitrogen flushed to remove oxygen

before capping. The bottles were covered with aluminum foil to prevent degradation of anthocyanins by light. The solutions were stirred overnight at room temperature on stir plates (Fisher Scientific, USA).

The next day, the centrifuge bottles were placed in a Sorvall RC-5B Refrigerated Superspeed Centrifuge (DuPont Company, Wilmington, Delaware) with a GSA Head at 8,000 rpm. The samples were centrifuged for ten minutes. The supernatant was collected by using a vacuum pump and filtering through a Whatman No. 1 filter paper.

A second washing step was performed on the remaining pellet by adding another 50 mL of 0.1% hydrochloric acid in methanol solution to the centrifuge bottle. The pellet was then centrifuged with the previous settings. The second supernatant was collected by using the vacuum pump and filter. Both supernatants were combined and the total weight of the all of the supernatant was recorded for each sample.

Measuring Total Anthocyanin Content

The total monomeric anthocyanin content was calculated according to the pH differential procedure by Wrolstad (1976). The samples were measured at 510 nm and at 700 nm to correct for haze in the samples. The total monomeric anthocyanin content was reported as mg/100g fresh weight of malvidin-3-glucoside. According to Wrolstad (1976), the molar absorbance of delphinidin-3-glucoside is very low and can interfere with results. Therefore, malvidin-3-glucoside was the chosen anthocyanin reference. The molecular weight was 493.5 g/L and the extinction

coeffecient (ε) was 28,000 L cm^{-1} mg^{-1} (Wrolstad, 1976). The absorbencies were measured with a Spectronic 20D+ (Spectronic Instrument, Rochester, New York). The following calculation was used to determine the absorbance of the sample.

Calculation:

Absorbance of sample= ($Absorbance_{\lambda vis\text{-}max}$ – $Absorbance_{700}$) pH 1.0 – ($Absorbance_{\lambda vis\text{-}max}$-$Absorbance_{700}$) pH 4.5

The next calculation is used to determine the monomeric anthocyanin concentration in the sample.

Calculation:

Monomeric anthocyanin concentration (mg/liter)= (Absorbance of sample x molecular weight of predominant anthocyanin x dilution factor x 1000)/ (ε x 1)

The results were reported as mg/100g fresh blueberry puree.

Total Phenolic Analysis

Total phenolics were determined according to the method by Velioglu et al. (1998) using Folin-Ciocalteu reagent. Absorbencies were read at 725nm. Results were reported as ferulic acid concentration (µg/g dry weight). A standard regression curve was made using ferulic acid and 85% methanol to bring standards up to volume. The standard curve concentrations were 100 µg/ml, 10 µg/ml, 1.0 µg/ml, and 0.1 µg/ml. Before extracting the phenolics, the percent moisture content of the purees was determined in triplicate. The percent moisture content was needed in order to calculate the total phenolics using the following calculation:

Calculation:

1. Concentration μg/ml= constant + ((Absorbance$_{725nm}$)(coefficient))
2. (Concentration μg/ml) x (extraction volume)= concentration μg
3. Concentration μg/((sample weight) x (1-%moisture)) = μg/g dry weight

Sensory Evaluation

Seven panelists from the University of Maine community were recruited by fliers and First Class e-mail to participate in a trained quantitative descriptive panel to quantify and describe warmed-over flavor in precooked turkey patties held for six months in frozen storage. Permission for recruitment was granted through the University of Maine College of Natural Sciences, Forestry, and Agriculture Human Subjects Protection Committee. Eleven people responded to the ad but due to scheduling conflicts only seven were able to participate the full length of the study. Panelists were trained over a six-week period using methods described by Byrne et al. (2001), Meilgaard et al. (1999), and the American Meat Science Association Research Guidelines (1995). The panel was comprised of four men and three women age 26-45. Each panelist signed an informed consent regarding the risks involved with the study and they were given a prescreening questionnaire (Appendix B).

Panel Training

In the initial training session, panelists were given reheated turkey patties held for three days at 4°C along with a list of 42 descriptors chosen by Byrne et al. (2001) (Appendix C). Panelists were asked to smell and taste the turkey patty and decide which descriptors they perceived were in the turkey patty. The first training session reduced the number of descriptors to 23, which were used throughout the remainder

of the study. Due to a lack ofvolunteers, time, and participation, no other panelists were removed from the panel.

During the second training session, panelists were given reference samples to describe each descriptor previously chosen. Panelists were asked to rate the intensity of each descriptor on a 15-point scale (1- no intensity to 15- very high intensity) (Appendix D). Mean values for each reference were taken and recorded next to each descriptor (Table 3). This sheet along with the reference sample was given to the panelists at every tasting session. Over the next four training sessions panelists were taught to compare fresh turkey patties to each reference sample. Turkey patties with no puree were also prepared and held for three days in refrigerated storage and given to panelists to compare them to each reference. The training sessions were run in the Consumer Testing Facility Sensory Suite at the University of Maine, Orono campus located in Holmes Hall. Samples were given to panelists in a controlled temperature room under fluorescent light. Each panelist evaluated samples in a private workstation equipped with a Pentium computer. The ballot questions used during the study after training are located in appendix E.

Descriptive Analysis

Turkey patties were tested on the same days as the chemical analyses (day 1 and 3 of refrigerated storage and day 30, 90, 120, 150, & 180 of frozen storage). Due to a lack of panelist participation because of holiday schedules, on day 60 the patties were only tested for TBA and hexanal not warmed-over flavor.

Panelists were given a practice session the day before the patties were tested. The re-training was necessary because of the length of time in between taste sessions.

During these re-evaluation periods, panelists were told their previous scores for each attribute. Panelists also were told how far their previous scores deviated from the mean scores for each attribute. Panel members were told their scores so that they could adjust their scores closer to the overall mean values for each attribute. Panelists were also informed of evaluation procedures for descriptive panel tasting, which helped reduce confusion among panelists.

On each day of testing, turkey patties were reheated according to the method published by the American Meat Science Association Research Guidelines, (1995). Turkey patties were wrapped in aluminum foil in order to prevent further browning, and baked in a preheated oven at 350° until the internal temperature reached 74°C as measured with a Fluke 52K/J thermocouple (Paramus, NJ). Panelists were each given a half of a patty for each treatment. Samples were randomly assigned to panelists. References were provided at each station. The computerized ballot provided tasting procedure instructions.

Sensory Statistics

Sensory analysis was performed using SIMS Software 2000 program for windows, which included SAS statistical software. Differences each day were run in SAS followed by a Tukey's post hoc test. Overall significant differences overtime were analyzed using Systat Version 9 statistical software followed by a Fischer post hoc test.

Table 3. Descriptors and References for Descriptive Panel

Descriptor	Reference	Mean Score
Poultry Odor	Fresh cooked turkey patty	12
Bouillon Odor	2 bouillon cubes/1 L water	3.5
Sulfur Odor	Hardboiled egg	11
Non-poultry Odor	Fresh cooked beef patty	11
Bitter Taste	1 g caffeine/1 L water	10
Sweet Taste	20 g sucrose/1 L water	7
Salt Taste	2 g salt/1 L water	6.75
Sour Taste	0.5 g citric acid/1 L water	7.75
Metallic Taste	1 iron pill supplement	6
Caramel Taste	Hard caramel candy	12.75
Non-poultry Taste	Fresh cooked beef patty	10.5
Rubber Taste	Balloon	8
Paper Taste	Paper napkin	10
Bread Taste	Slice of white bread	12.25
Bouillon Taste	2 bouillon cubes/1 L water	11
Rancid Taste	Oxidized vegetable oil	13.5
Poultry Taste	Fresh cooked turkey patty	13.5
Sour Aftertaste	0.5 g citric acid/1 L water	7.75
Fatty/Oily Mouthcoating	Oxidized vegetable oil	13.5
Metallic Aftertaste	1 iron pill supplement	6
Sweet Aftertaste	20 g sucrose/ 1 L water	7
Poultry Aftertaste	Fresh cooked turkey patty	13.5
Rancid Aftertaste	Oxidized vegetable oil	13.5

*Mean score was the average of seven panelists based on a 15-point hedonic intensity scale.

EXPERIMENT 2: MATERIALS & METHODS

Materials

The blueberry purees used were the same as in experiment one. One hundred and forty pounds of 93% lean ground turkey were purchased from a local supermarket (Lincoln, ME).

Sample Preparation

Sample preparation was the same as in experiment one. However, turkey patties were prepared in the Sensory Suite located in Holmes Hall, University of Maine, Orono campus. Turkey was ground through a Hobart meat grinder Model H-600D equipped with a 3/16" plate (Troy, OH). Patties were broiled in an electric broiling oven following the same protocol found in experiment one.

Broiled turkey patties were stored in refrigerated storage at 4°C for two weeks and frozen storage at -18°C for three months. Refrigerated patties were analyzed for TBARS and hexanal on day 1, 3, 7, & 14 and the frozen patties were tested on day 30, 60, & 90.

Chemical Analysis

Chemical analysis for TBA and hexanal followed the same protocol as found in experiment one.

Sensory Evaluation

Twenty-eight panelists from the University of Maine community responded to a flier or e-mail announcing recruitment for a three-month sensory panel. Permission to perform the study was granted through the Human Subjects Protection Committee

in the College of Natural Sciences, Forestry, and Agriculture at the University of Maine.

Panelists signed an informed consent prior to each sensory panel session (Appendix F). Panelists were required to complete three tasting sessions that were held on day 3 of refrigerated storage and day 30 & 90 of frozen storage. As a result of time constraints only twenty-one of the panelists remained on the panel for all three tasting sessions.

Affective Test: Acceptance Analysis

On each day of testing, 93% lean ground turkey was purchased from a local supermarket (Old Town, ME). The fresh ground turkey was ground through a Hobart Meat Grinder Model H-600D equipped with a 3/16" plate (Troy, OH). Approximately 115 +/- 0.05 grams of ground turkey were pressed into patties using a plastic patty press to insure uniform thickness. Patties were broiled before each panelist came in for testing in an electric broiling oven. Patties were cooked until the internal temperature reached 74°C. These patties were labeled as fresh control patties. The other treatments were the same as in experiment one and were reheated according to the same protocol.

Four treatments, each a half patty, were presented randomly by code to panelists. Panelists were asked questions on age and gender. The computerized ballot instructed them on tasting procedures. A 9-point hedonic scale (1-dislike extremely to 9-like extremely) was used to determine acceptance. A five point purchase intent scale (1- definitely would not buy to 5- definitely would buy) was

also used. Appendix G. is the ballot used for determining acceptance and purchase intent. Appendix H. is the questionnaire provided for comments.

Sensory Statistics

Sensory analysis was performed using SIMS Software 2000 program for windows, which included SAS statistical software. Overall significant differences overtime were analyzed using Systat Version 9 statistical software followed by a Fischer post hoc test.

EXPERIMENT 1: RESULTS

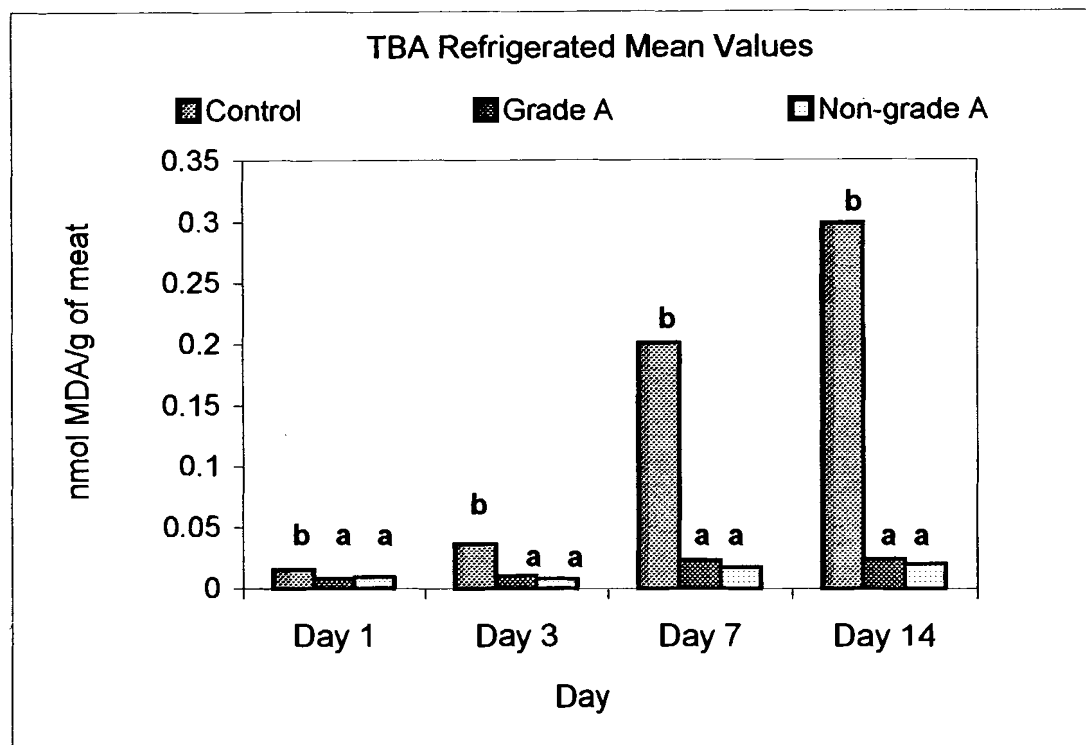
Chemical Analyses

Thiobarbituric Acid Test (TBA)

Both blueberry purees significantly decreased ($p \leq 0.05$) TBA values in the refrigerated turkey patties (Figure 2). The effects of the purees were more pronounced in the refrigerated turkey patties than the frozen turkey patties. On day 1 of refrigerated storage, the control patties had a mean value of 0.015 nmol malondialdehyde (MDA)/g of meat, grade A had a mean value of 0.008 nmol MDA/g of meat, and the floater rejects had a mean value of 0.009 nmol MDA/g of meat. By day 14 of refrigerated storage the control, grade A, and floater rejects had mean values of 0.299, 0.024, and 0.020 nmol MDA/g of meat, respectively. The control patties over the fourteen days of refrigerated storage consistently had higher TBA values than patties containing both blueberry purees. A multi-way ANOVA on the refrigerated patties showed day, treatment, and day crossed with treatment had significant effects ($p \leq 0.05$) on the TBA concentrations.

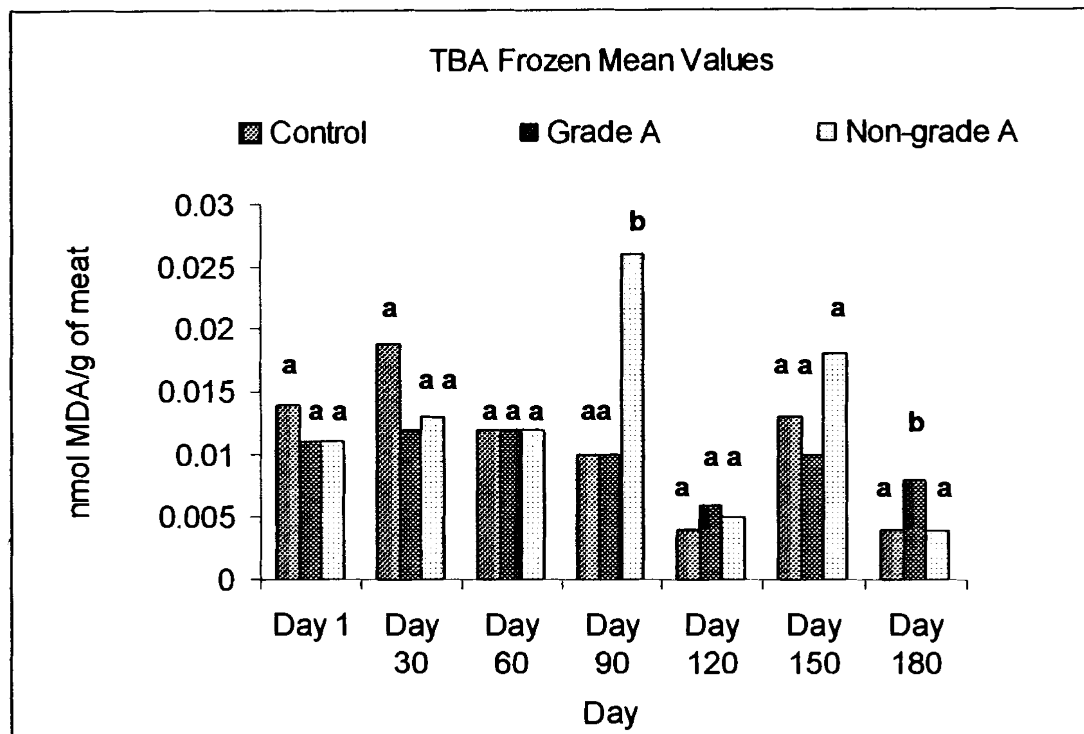
The frozen TBA results showed on day 1 of storage the control, grade A, and floater rejects had mean concentrations of 0.014, 0.011, and 0.011 nmol MDA/g of meat, respectively. By day 180 of frozen storage the control, grade A, and floater rejects had mean concentrations of 0.004, 0.008, and 0.004 nmol MDA/g of meat, respectively. There was not a consistent increase in malondialdehyde detected in any of the treatments as seen in the refrigerated storage (Figure 3). On day 90 and 180 of frozen storage, significant differences ($p \leq 0.05$) were found between the control patties and both puree treatments.

Figure 2. TBA Concentrations in Refrigerated Turkey Patties



*Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Tukey's post hoc test for significant differences. Mean values were determined by triplicate replications.

Figure 3. TBA Concentrations in Frozen Turkey Patties



*Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Tukey's post hoc test for significant differences. Mean values were determined by triplicate replications.

Overall, a multi-way ANOVA showed time, treatment, and time*treatment had significant effects on the frozen turkey patties ($p \leq 0.05$). As the days increased, TBA value increased until day 120 when values decreased. Table 4 and Table 5 show the standard deviations for TBA in experiment one.

Table 4. Experiment One Standard Deviations for Refrigerated Samples

	TBA Day 1	TBA Day 3	TBA Day 7	TBA Day 14
Mean	0.010	0.018	0.080	0.114
Std. Dev.	0.004	0.014	0.091	0.141

*TBA values expressed as nmolMDA/g of meat

Table 5. Experiment One Standard Deviations for Frozen Samples

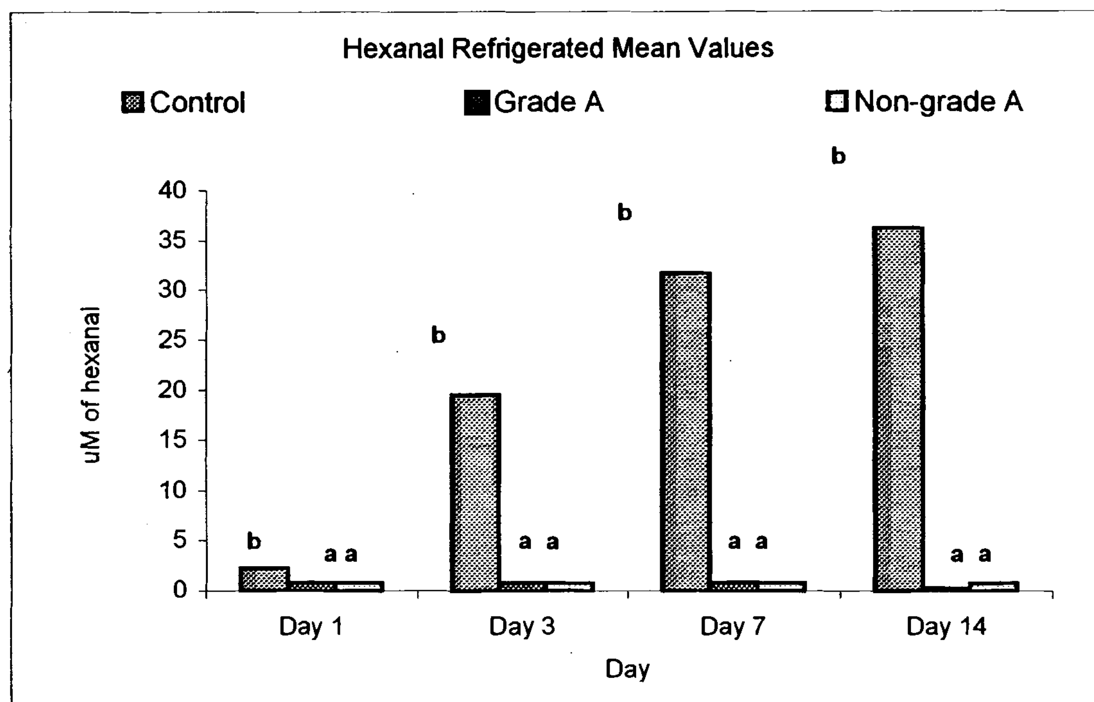
	TBA Day 1	TBA Day 30	TBA Day 60	TBA Day 90	TBA Day 120	TBA Day 150	TBA Day 180
Mean	0.012	0.015	0.012	0.015	0.005	0.014	0.014
Std. Dev.	0.004	0.006	0.003	0.009	0.002	0.005	0.004

*TBA values expressed as nmolMDA/g of meat

Gas Chromatography

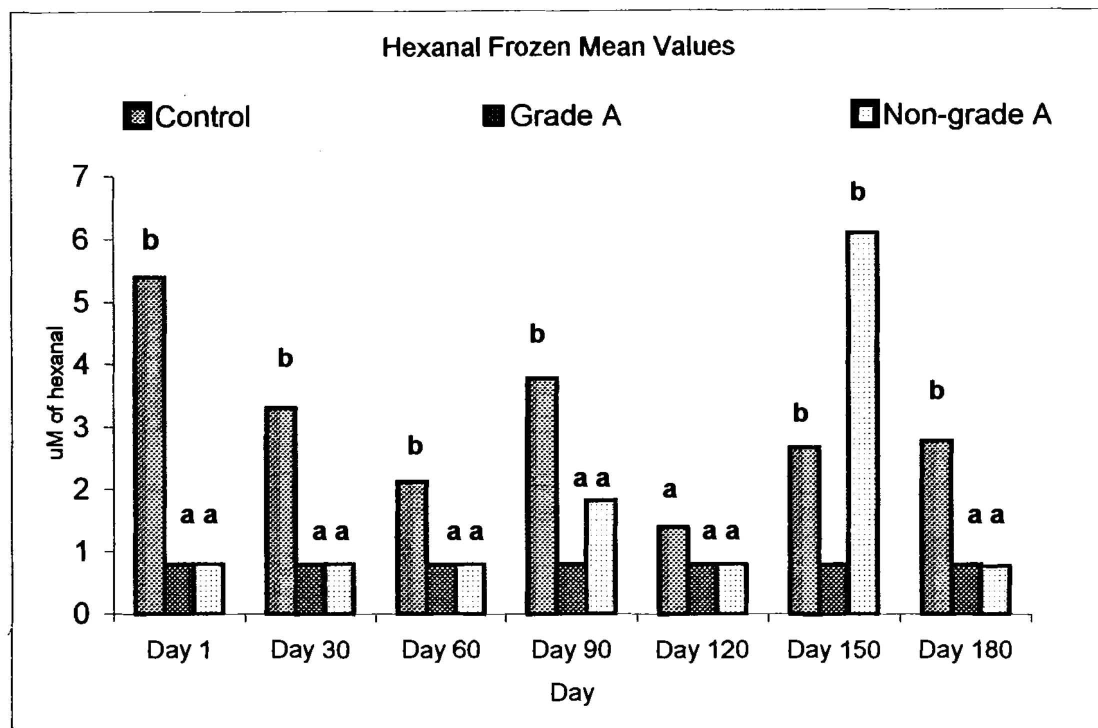
Gas chromatography results showed that both blueberry purees significantly lowered ($p \leq 0.05$) hexanal production in the turkey patties during refrigerated storage (Figure 4). A lower detection limit 0.78 μM of hexanal was determined by producing a standard curve. On day 1 and 3 of refrigerated storage, the grade A and floater reject treatments had undetectable levels of hexanal, which was determined to be a level of 0.78 μM of hexanal or lower (lower detection limit). Therefore, 0.78 μM was substituted for all days with undetectable levels in order to determine significant differences. On day 1 of refrigerated storage, the control had a mean hexanal

Figure 4. Gas Chromatography Refrigerated Mean Concentrations



*Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Tukey's post hoc test for significant differences. Mean scores were determined by triplicate replications.

Figure 5. Gas Chromatography Frozen Mean Concentrations



*Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Tukey's post hoc test for significant differences. Mean scores were determined by triplicate replications.

Table 6. Experiment One Standard Deviations for Refrigerated Samples

	Hexanal Day 1	Hexanal Day 3	Hexanal Day 7	Hexanal Day 14
Mean	1.27	6.99	11.43	12.57
Std. Dev.	3.16	9.47	15.66	17.80

*Hexanal values expressed as µM hexanal

Table 7. Experiment One Standard Deviations for Frozen Samples

	Hexanal Day 1	Hexanal Day 30	Hexanal Day 60	Hexanal Day 90	Hexanal Day 120	Hexanal Day 150	Hexanal Day 180
Mean	2.32	1.62	1.22	2.21	0.98	2.59	1.44
Std. Dev.	3.16	1.52	1.01	1.77	0.42	3.51	1.50

*Hexanal values expressed as µM hexanal

Total Anthocyanins

Results from the total anthocyanin analysis showed the grade-A puree contained an average monomeric anthocyanin content of 92.95 mg /100g fresh weight. Floater reject blueberry puree had an average monomeric anthocyanin content of 73.88 mg /100g fresh weight.

Total Phenolics

Results from the total phenolic analysis showed that the grade A blueberry puree contained an average 6961.41 µg/g ferulic acid equivalents. Floater reject puree had an average of 6873.77 µg/g ferulic acid equivalents.

Sensory Analysis

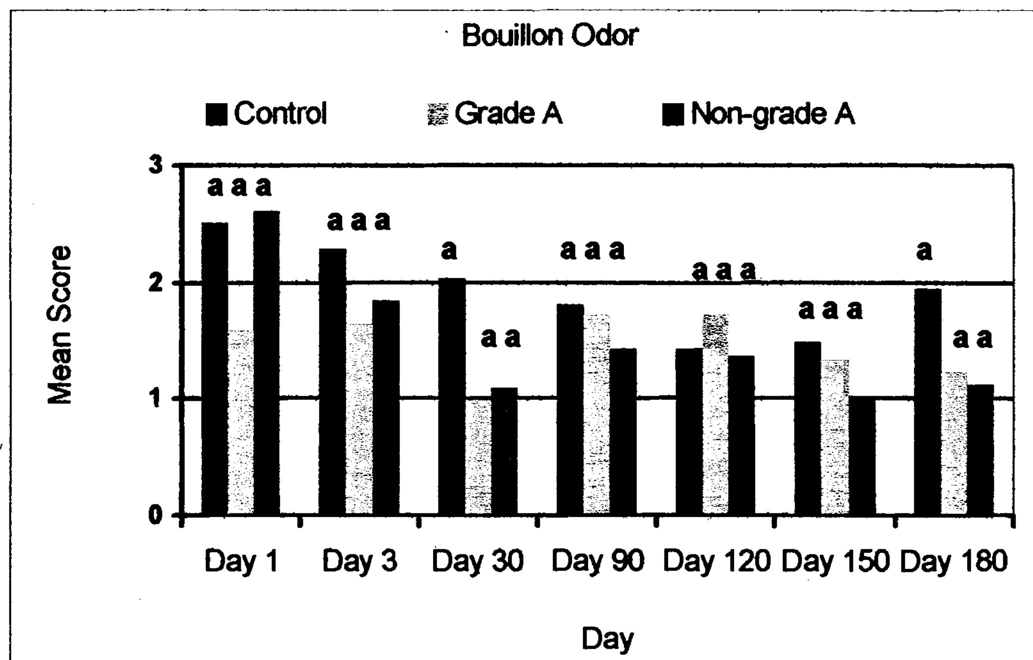
Bouillon odor showed significant differences ($p \leq 0.05$) between the control on day 1 and the non-grade A on day 150, grade A on day 30 and the non-grade A on day 1, non-grade A on day 1 and the non-grade A on day 30, and finally the non-

grade A on day 1 and the non-grade A on day 150. Overtime, the other treatments were not significantly different. Bouillon odor showed a decrease in intensity overtime for all samples. No significant differences were found between treatments on each day tested (Figure 6).

The poultry odor scores showed the control on day 1 was significantly higher ($p \leq 0.05$) than grade-A and non-grade A on day 30 and 150 (Figure 7). The control on day 3 was significantly higher than grade-A day 30 and 150 and the non-grade on day 30. The control on day 90 was significantly higher than grade-A day 30, 150, and 180 and the non-grade A on day 30 and 150. The control on day 120 was significantly higher than the grade-A on day 30. Control on day 150 and 180 was significantly higher than the grade A day 30 and 150 and the non-grade A on day 30. The grade-A on day 30 was significantly higher than the grade-A on day 90 and the non-grade A on day 90. Overall, the control samples had higher poultry odor scores compared to the puree treatments.

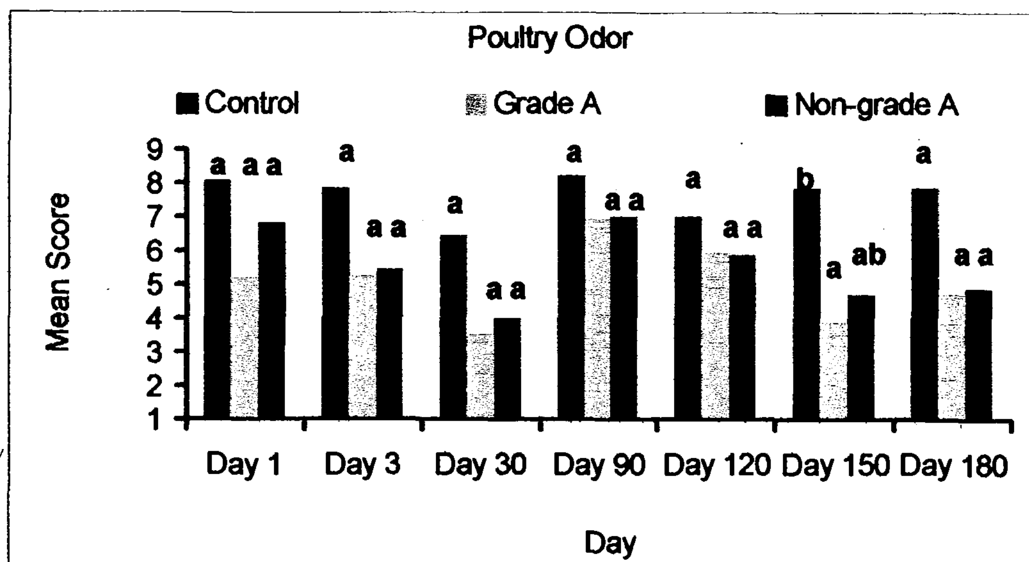
Odor scores for bouillon and poultry attributes tended to decrease with time. This trend was attributed to the refrigerated samples on day 1 having higher odor scores than the refrigerated on day 3. The odor scores for the frozen treatments increased at day 90 then decreased overtime. Panelists on day 30 of frozen storage were re-trained but may have experience confusion because of the one-month period between tasting sessions. By day 90 the odor scores appeared to be closer in values for all panelists.

Figure 6. Mean Scores for Bouillon Odor Descriptor



*Mean scores are the average of seven trained panelists. Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) followed by a Fisher's post hoc test. Score 0-no intensity, 15-high intensity. Day one and three were refrigerated storage, day 30 through 180 were frozen storage.

Figure 7. Mean Scores for Poultry Odor Descriptor



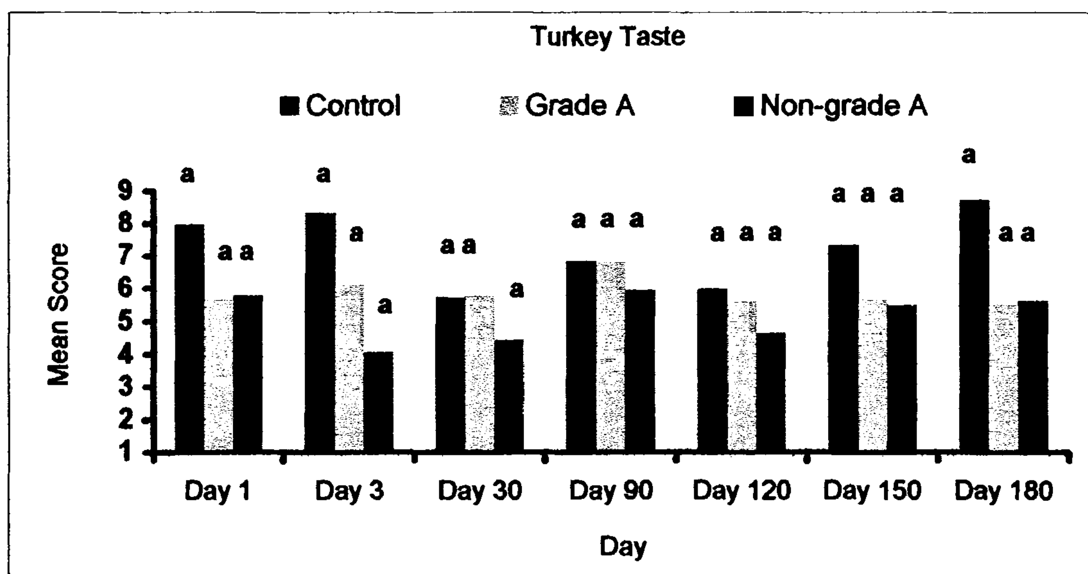
*Mean scores are the averages of seven trained panelists. Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) followed by a Fisher's post hoc test. Score 0-no intensity, 15-high intensity. Day one and three were refrigerated storage, day 30 through 180 were frozen storage.

Turkey taste descriptors showed significant differences ($p \leq 0.05$) between control day 3 and non-grade A day 30 and 120. Significant differences were also found between control day 180 and non-grade A on day 3, 30, and 120.

Rancid descriptors showed the control day 3 was significantly higher ($p \leq 0.05$) than the control day 30, 120, 150, grade-A day 1 through 180, and the non-grade A day 1, 3, 90, and 120 (Figure 9). The non-grade A day 180 was significantly higher ($p \leq 0.05$) than the control day 1, 30, 90, 120, 180, and the grade-A treatment on day 1 through 180, and the non-grade treatment on day 1 through 150. Overtime, both blueberry purees had lower rancidity scores than the control patty. On day 1 the control had similar rancidity scores as the puree but on day 3 of refrigerated storage the control had significantly higher rancid notes than both puree treatments. Therefore, in the refrigerated storage the blueberry purees were found to significantly decrease rancid taste. The frozen treatments were not significantly different because lipid oxidation reaction rates are slowed during frozen storage.

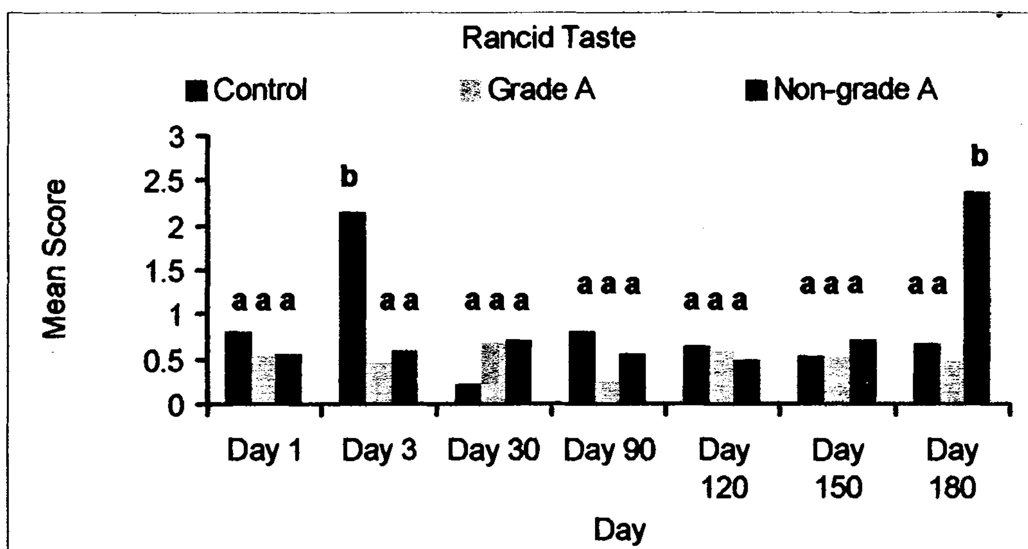
Metallic taste descriptors showed the control day 120 was significantly higher ($p \leq 0.05$) from the control day1, 3, and 150, grade A day 1 through 180, and the non-grade A day 1, 3, 30, 120, and 150 (Figure 10).

Figure 8. Mean Scores for Turkey Taste Descriptor



*Mean scores were the averages of seven trained panelists. Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) followed by a Fisher's post hoc test. Score 0-no intensity, 15-high intensity. Day one and three were refrigerated storage, day 30 through 180 were frozen storage.

Figure 9. Mean Scores for Rancid Taste Descriptor

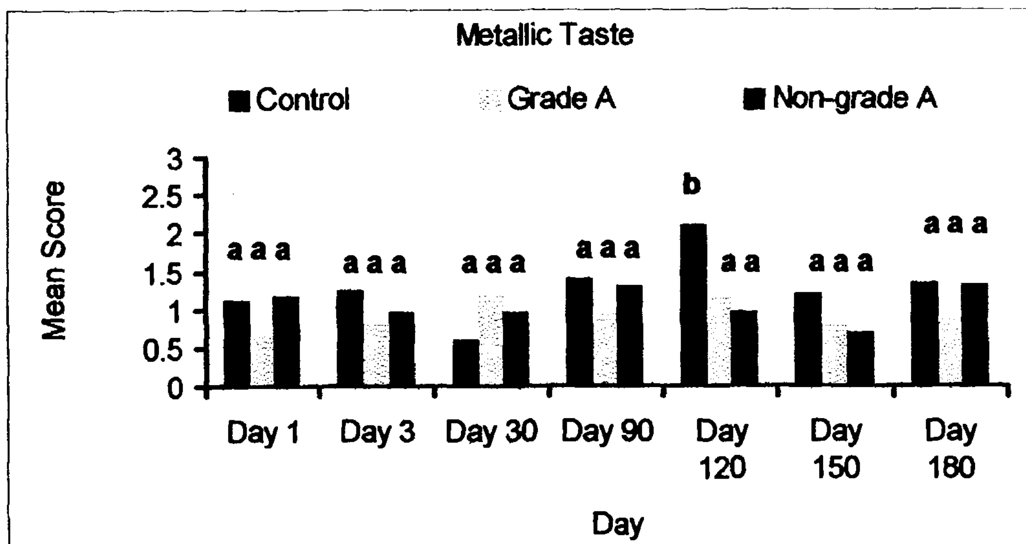


*Mean scores were the averages of seven panelists. Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) followed by a Fisher's post hoc test. Score 0-no intensity, 15-high intensity. Day one and three were refrigerated storage, day 30 through 180 were frozen storage.

Metallic aftertaste descriptors showed that the control on day 3 was significantly different ($p \leq 0.05$) than the grade A day 1 puree and the reject day 1 puree. Control on day 90 was significantly higher ($p \leq 0.05$) than the grade A day 1, grade A day 150, floater reject day 1, and the floater rejects day 150. The control day 120 was significantly higher ($p \leq 0.05$) than the grade A day 1 and rejects day 1. The grade A day 1 was significantly lower ($p \leq 0.05$) than the grade A day 120 and rejects day 30.

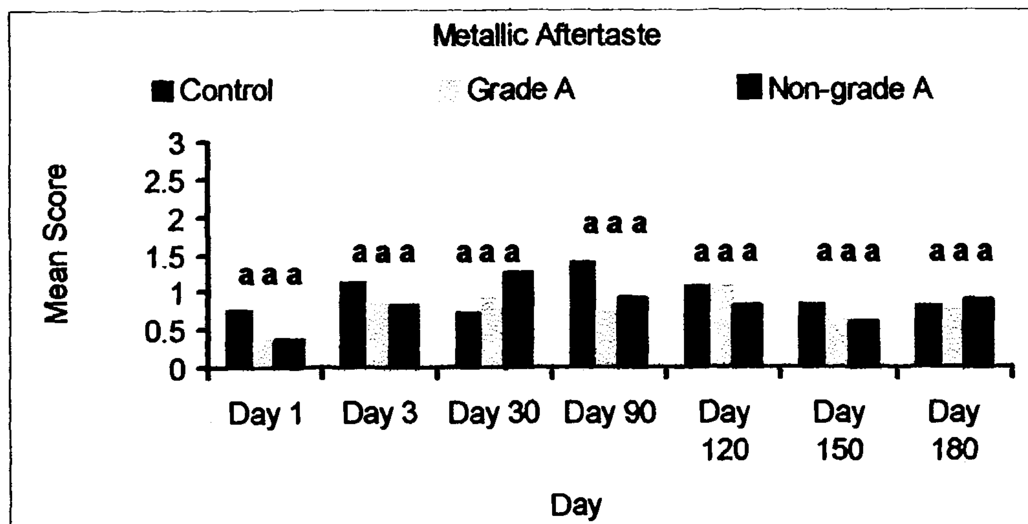
Panelists described the patties containing either blueberry puree sweeter than the control. Overtime, the blueberry patties consistently had significantly higher ($p \leq 0.05$) sweet scores than the control patties (Figure 12). However, overtime there were no significant differences found between the sweet scores from day one through 180.

Figure 10. Mean Scores for Metallic Taste Descriptor



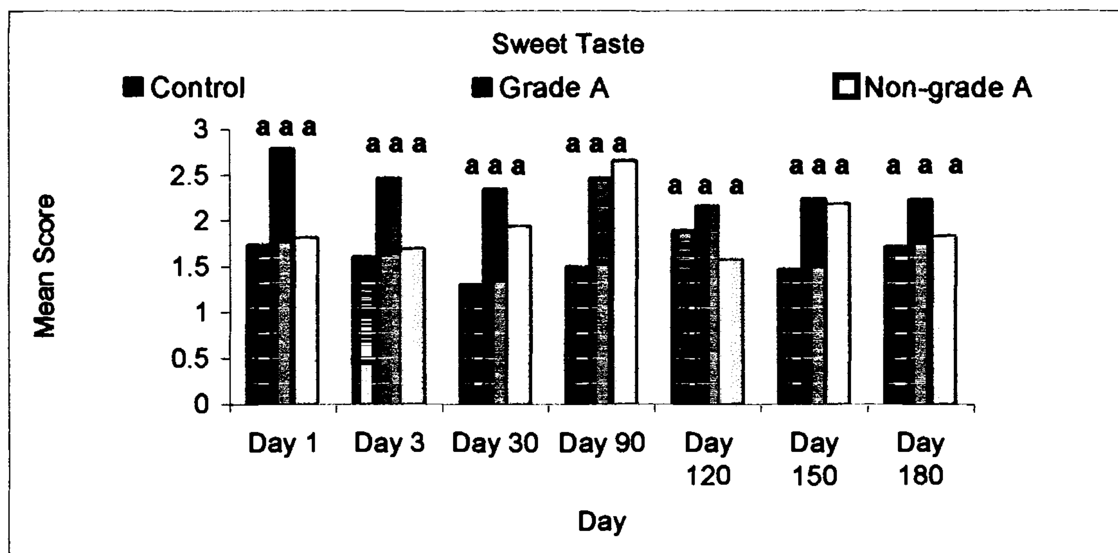
*Mean scores were the averages of seven panelists. Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) followed by a Fisher's post hoc test. Score 0-no intensity, 15-high intensity. Day one and three were refrigerated storage, day 30 through 180 were frozen storage.

Figure 11. Mean Scores for Metallic Aftertaste Descriptor



*Mean scores were the averages of seven trained panelists. Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) followed by a Fisher's post hoc test. Score 0-no intensity, 15-high intensity. Day one and three were refrigerated storage, day 30 through 180 were frozen storage.

Figure 12. Mean Scores for Sweet Taste Descriptor



* Mean scores were the averages of seven trained panelists. Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) followed by a Fisher's post hoc test. Score 0-no intensity, 15-high intensity. Day one and three were refrigerated storage, day 30 through 180 were frozen storage.

Correlations

A Pearson correlation matrix (McClenahan et al., 2001) showed that only a few attributes were closely correlated with TBA and hexanal data (Table 8). Hexanal had closer correlation coefficients with rancid taste and poultry taste descriptors than TBA concentrations. Metallic taste and TBA showed a negative correlation coefficient r = -0.126. A correlation coefficient r = 0.720 was found between poultry odor and poultry taste. A correlation coefficient r = 0.526 was found between metallic taste and metallic aftertaste. However, TBA and hexanal had the highest correlation coefficient of r=0.775. Poultry taste and poultry aftertaste had a correlation coefficient of r=0.505. Poultry odor and bouillon odor had a correlation coefficient of r=0.696.

Table 8. Pearson Correlation Coefficients for Descriptive Panel vs. TBA & Hexanal Concentrations

Descriptor	TBA	Hexanal
Bouillon Odor	r = 0.228	r = 0.314
Poultry Odor	r = 0.242	r = 0.374
Poultry Taste	r = 0.311	r = 0.502
Poultry Aftertaste	r = 0.036	r = 0.048
Rancid Taste	r = 0.278	r = 0.561
Metallic Taste	r = -0.126	r = 0.084
Metallic Aftertaste	r = 0.143	r = 0.256
Sweet Taste	r = -0.027	r = -0.147
Sweet Aftertaste	r = -0.248	r = -0.233
Bitter Taste	r = 0.016	r = 0.047
Non-poultry Taste	r = -0.277	r = -0.284

*Correlation coefficients were determined using a Pearson correlation matrix. Coefficients were determined by using the means for each descriptor, TBA, and hexanal data.

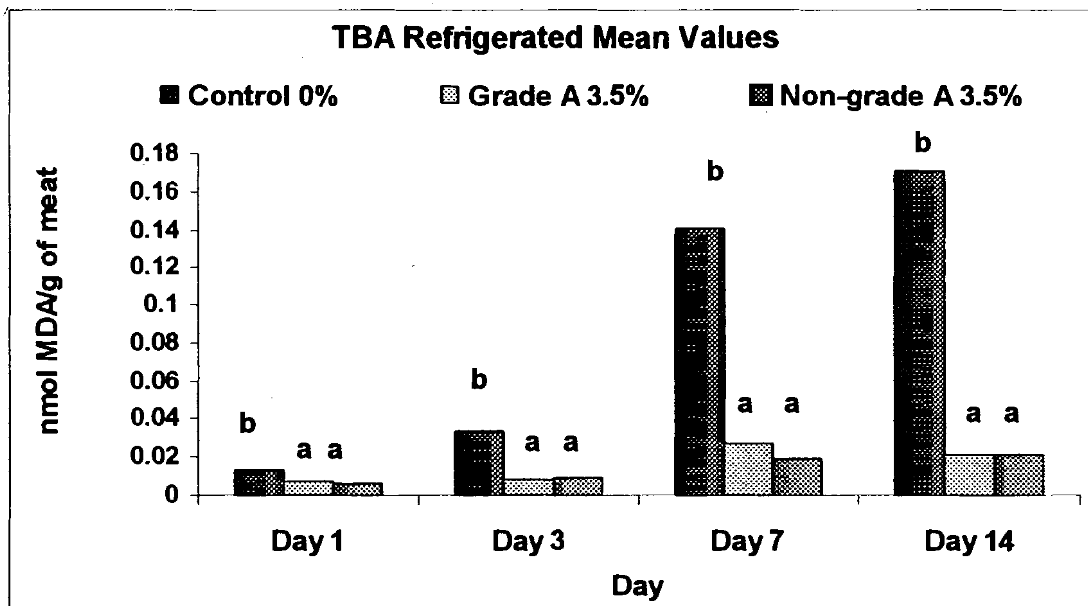
EXPERIMENT 2: RESULTS

Chemical Analyses

Thiobarbituric Acid Test (TBA)

Both blueberry purees had significantly lowered ($p \leq 0.05$) the MDA content of refrigerated turkey patties (Figure 13). As seen in study #1, the effects of the blueberry purees were more pronounced in the refrigerated turkey patties than the frozen turkey patties. On day 1 of refrigerated storage, the control patties, grade A, and floater rejects had mean values of 0.013, 0.007, and 0.006 nmol MDA/g of meat, respectively. By day 14, the control, grade A, and floater rejects had mean values of 0.171, 0.021, 0.021 nmol MDA/g of meat, respectively.

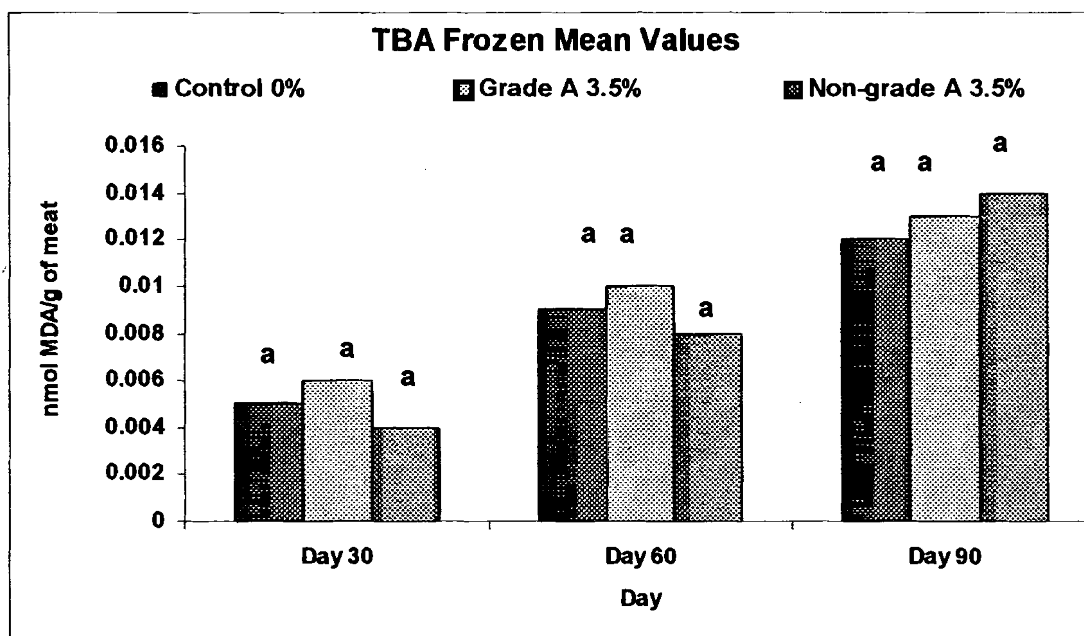
Figure 13. TBA Concentrations in Refrigerated Turkey Patties



*Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Tukey's post hoc test for significant differences. Mean values were determined by triplicate replications.

Frozen treatments showed that the blueberry purees did not significantly reduce malondialdehyde concentrations on day 30, 60, and 90 of storage (Figure 14). On day 30 and 60, grade A frozen treatments had higher concentrations of malondialdehyde than the control patties and the floater rejects had less. However, on day 90 of storage the grade A and floater reject treatments had higher levels of malondialdehyde than the control but were not significantly different.

Figure 14. TBA Concentrations in Frozen Turkey Patties



*Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Tukey's post hoc test for significant differences. Mean values were determined by triplicate replications.

Overall, a multi-way ANOVA showed treatment, day, and treatment*day had significant effects on the refrigerated turkey patties ($p \leq 0.05$). A multi-way ANOVA on the frozen patties showed that as days passed TBA values significantly increased ($p \leq 0.05$). However, blueberry treatments did not have a significant effect ($p \geq 0.05$) on the turkey patties. Treatment crossed with day also did not have a significant effect

($p \geq 0.05$) on the turkey patties. Table 9 and Table 10 show the standard deviations for TBA results in experiment two.

Table 9. Experiment Two Standard Deviations for Refrigerated Samples

	TBA Day 1	TBA Day 3	TBA Day 7	TBA Day 14
Mean	0.009	0.017	0.060	0.071
Std. Dev.	0.004	0.013	0.062	0.075

* TBA values were expressed as nmolMDA/g of meat

Table 10. Experiment Two Standard Deviations for Frozen Samples

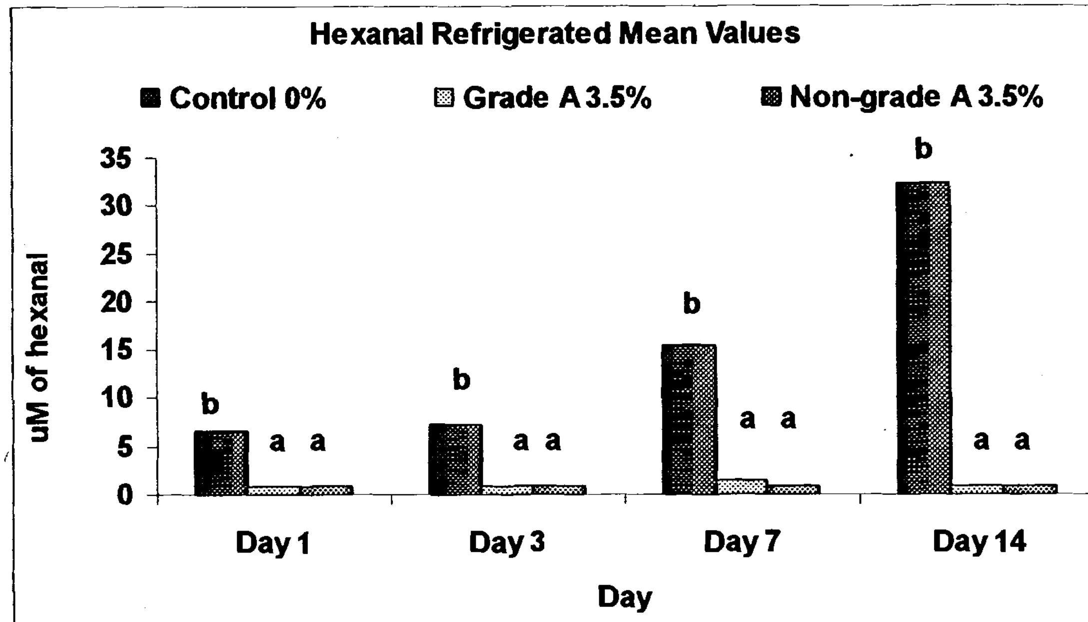
	TBA Day 30	TBA Day 60	TBA Day 90
Mean	0.005	0.009	0.013
Std. Dev.	0.003	0.002	0.004

*TBA values were expressed as nmolMDA/g of meat

Gas Chromatography

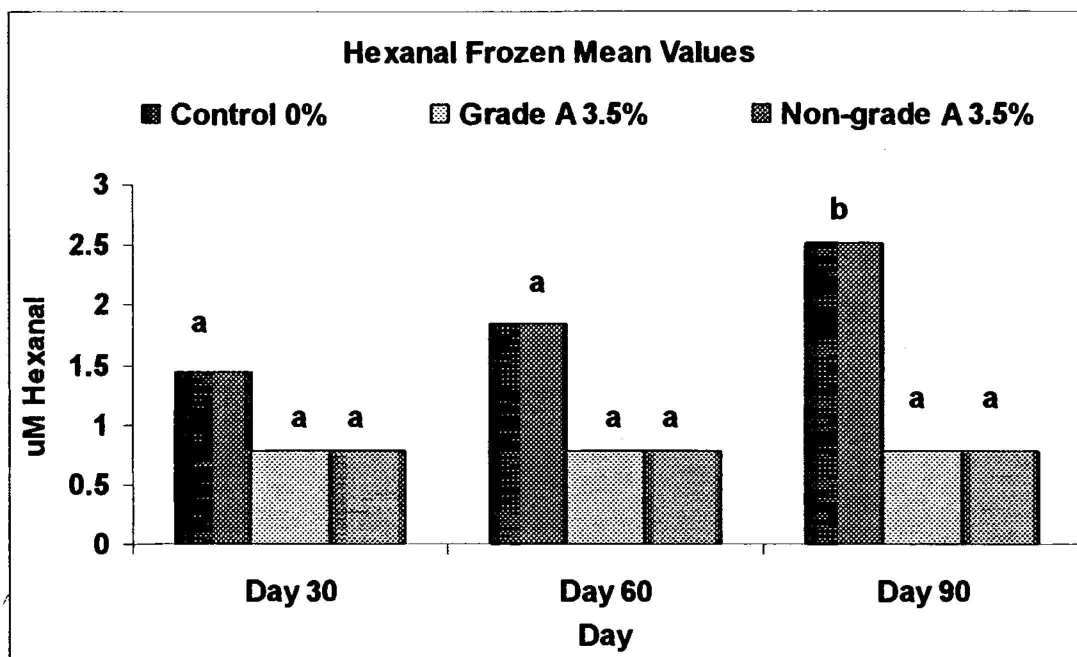
Gas chromatography results showed in the refrigerated turkey patties hexanal constantly increased with storage in the control patties. On day 1, the control had a mean hexanal concentration of 6.611 μM that increased to 32.348 μM by day 14. Both puree treatments had undetectable concentrations of hexanal over the refrigerated period except for the grade A treatment on day 7 had a mean concentration of 1.493 μM. Significant differences ($p \leq 0.05$) in the refrigerated treatments were seen on all days tested between the control patties and the grade A and floater rejects. However, there were no significant differences found between the grade A and floater rejects overtime (Figure 15).

Figure 15. Hexanal Concentrations in Refrigerated Turkey Patties



*Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Tukey's post hoc test for significant differences. Mean values were determined by triplicate replications.

Figure 16. Hexanal Concentrations of Frozen Turkey Patties



*Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Tukey's post hoc test for significant differences. Mean values were determined by triplicate replications.

Table 11. Experiment Two Standard Deviations for Refrigerated Samples

	Hexanal Day 1	Hexanal Day 3	Hexanal Day 7	Hexanal Day 14
Mean	2.72	2.92	5.88	11.30
Std. Dev.	3.37	3.70	8.22	18.23

*Hexanal was expressed as μM of hexanal

Table 12. Experiment Two Standard Deviations for Frozen Samples

	Hexanal Day 30	Hexanal Day 60	Hexanal Day 90
Mean	1.00	1.14	1.36
Std. Dev.	0.38	0.62	1.01

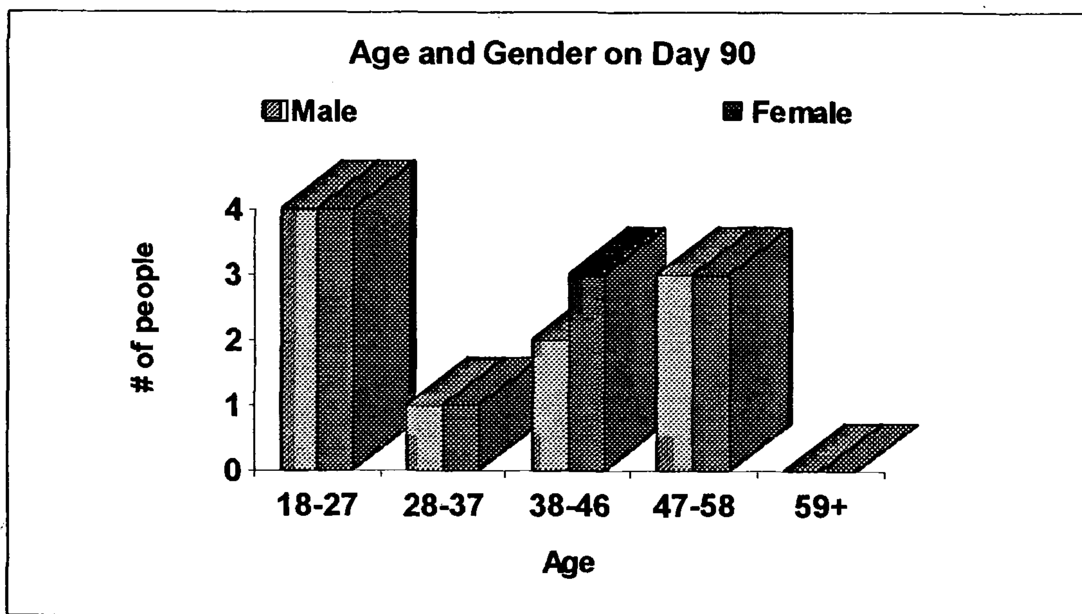
*Hexanal was expressed as μM of hexanal

Sensory Analysis

A nine-point hedonic scale was used to determine the acceptability of the blueberry puree treatments compared to the control with no puree. The twenty-one panelists who remained on day 90 of testing consisted of eleven females and ten males (Figure 17) with an age range of 18-58.

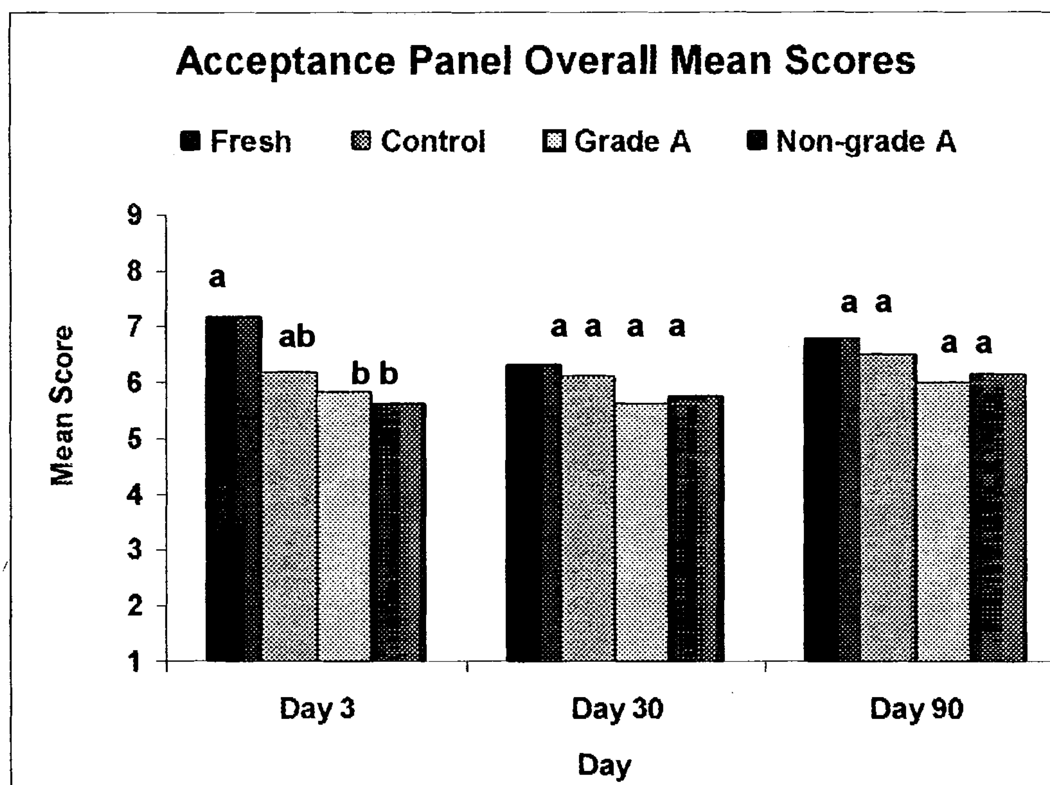
Overall acceptability showed each treatment as being neither like nor dislike on each day tested with a mean score of at least 5-neither like, nor dislike (Figure 18). Fresh patties made the day of the sensory testing had consistently higher mean scores than the other treatments. On day 30 and 90, the non-grade A treatment had higher mean acceptability scores than the grade A treatment. A Fisher's Least-Significant Difference pairwise comparison of probabilities overtime showed the fresh turkey patty with no puree on day 3 had significantly higher acceptability scores ($p \leq 0.05$) than the control day 3 and 30, grade A day 3, 30, and 90, and the non-grade A on day 3, 30, and 90. The fresh turkey patty on day 90 was significantly higher ($p \leq 0.05$) than the grade A on day 30 and the non-grade A day 3.

Figure 17. Acceptance Test: Age and Gender of Panelists on Day 90



*N=21 panelists

Figure 18. Overall Acceptability Mean Scores

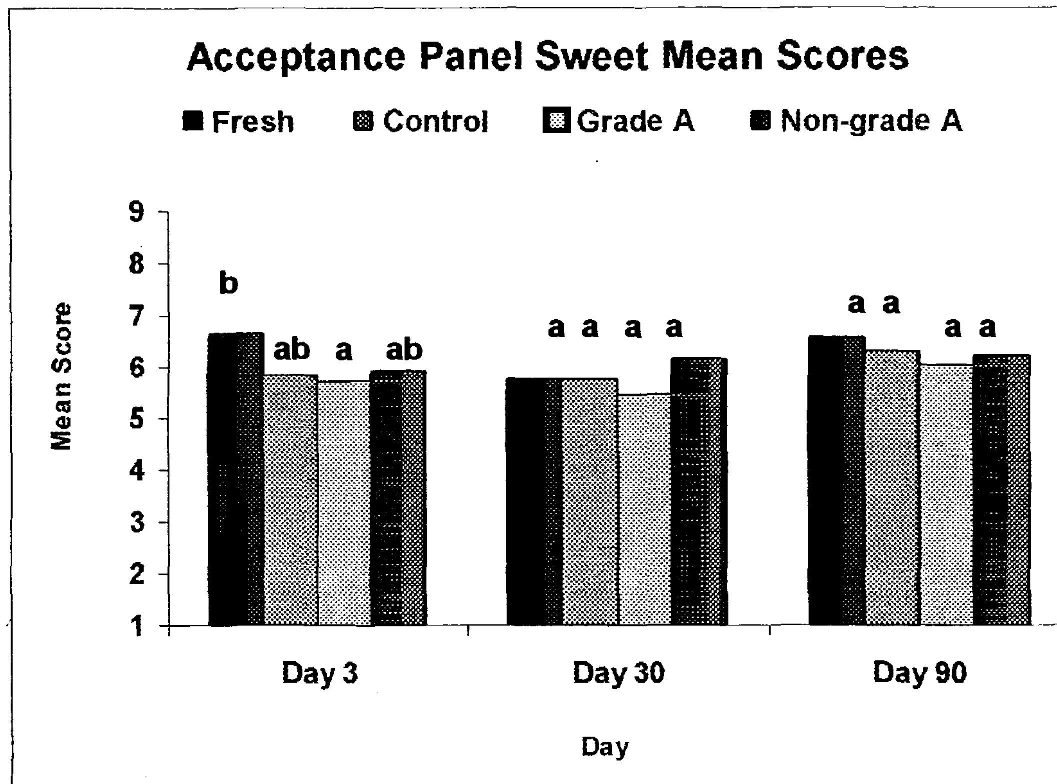


*Mean scores were the averages of 28 panelists on day 3, 25 panelists on day 30, and 21 panelists on day 90. Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Fisher's post hoc test for significant differences. Based on 9-point hedonic scale, 1-dislike extremely, 5-neither like nor dislikes, 9-like extremely. Day 3 was refrigerated storage, day 30 and 90 were frozen storage.

Sweetness acceptability scores showed that on day 3, the fresh patties were significantly different from the grade A day 3 ($p \leq 0.05$) (Figure 19). All treatments had acceptable levels of sweetness with a mean sweetness score of at least 5 or more. Day 30 was the only day where the non-grade A treatment had a higher mean score than all other treatments. Panelists scored the fresh patties as having the highest sweetness. A Fisher's Least-Significant Difference comparison of probabilities overtime showed that the grade A on day 30 was significantly different ($p \leq 0.05$) from the fresh on day 3 and 90. No other significant differences across treatments and days were detected for sweetness.

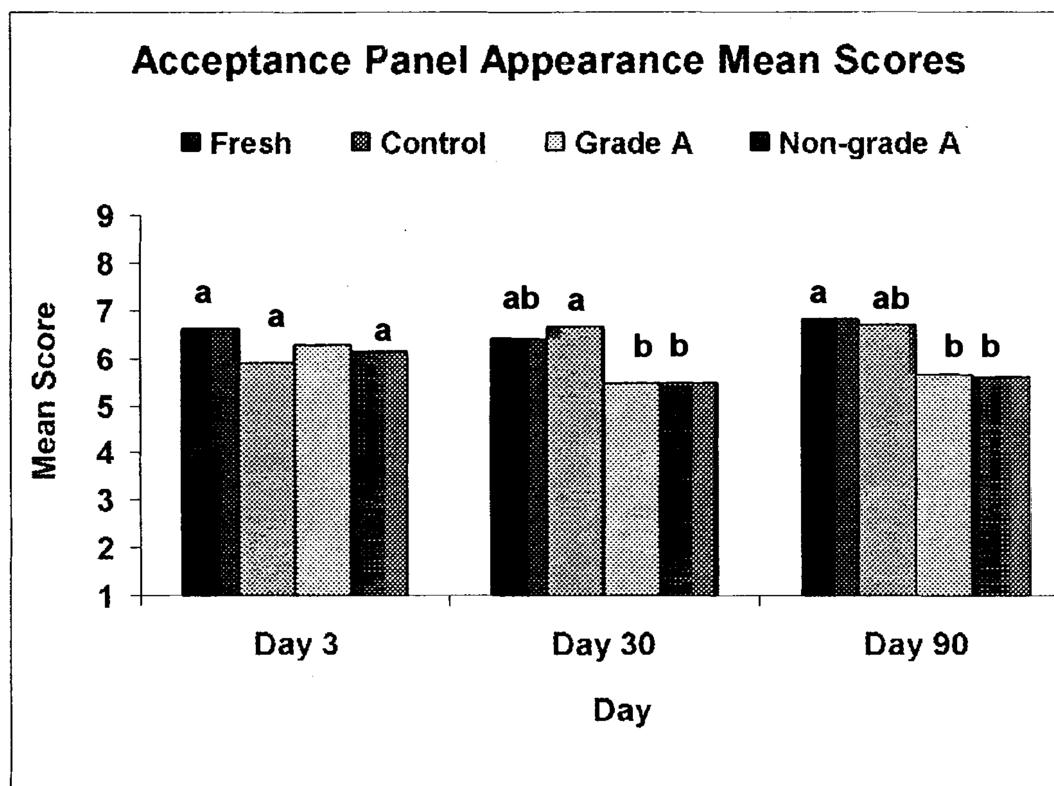
Figure 20. shows significant differences among days. A Fisher's Least-Significant-Difference pairwise comparison of probabilities showed that the control day 30 was significantly higher ($p \leq 0.05$) from the grade A day 30 and the non-grade A day 30. The control day 90 was significantly higher ($p \leq 0.05$) from the grade A day 30 and the non-grade A day 30. The fresh patties day 3 were significantly higher ($p \leq 0.05$) than the grade A day 30 and the non-grade A day 30. The fresh patties on day 90 were significantly higher than the grade A day 30 and 90, and the non-grade A day 30 and 90.

Figure 19. Sweetness Acceptance Mean Scores



*Mean scores were the averages of 28 panelists on day 3, 25 panelists on day 30, and 21 panelists on day 90. Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Fisher's post hoc test for significant differences. Based on 9-point hedonic scale, 1-dislike extremely, 5-neither like nor dislikes, 9-like extremely. Day 3 was refrigerated storage, day 30 and 90 were frozen storage.

Figure 20. Appearance Acceptance Mean Scores



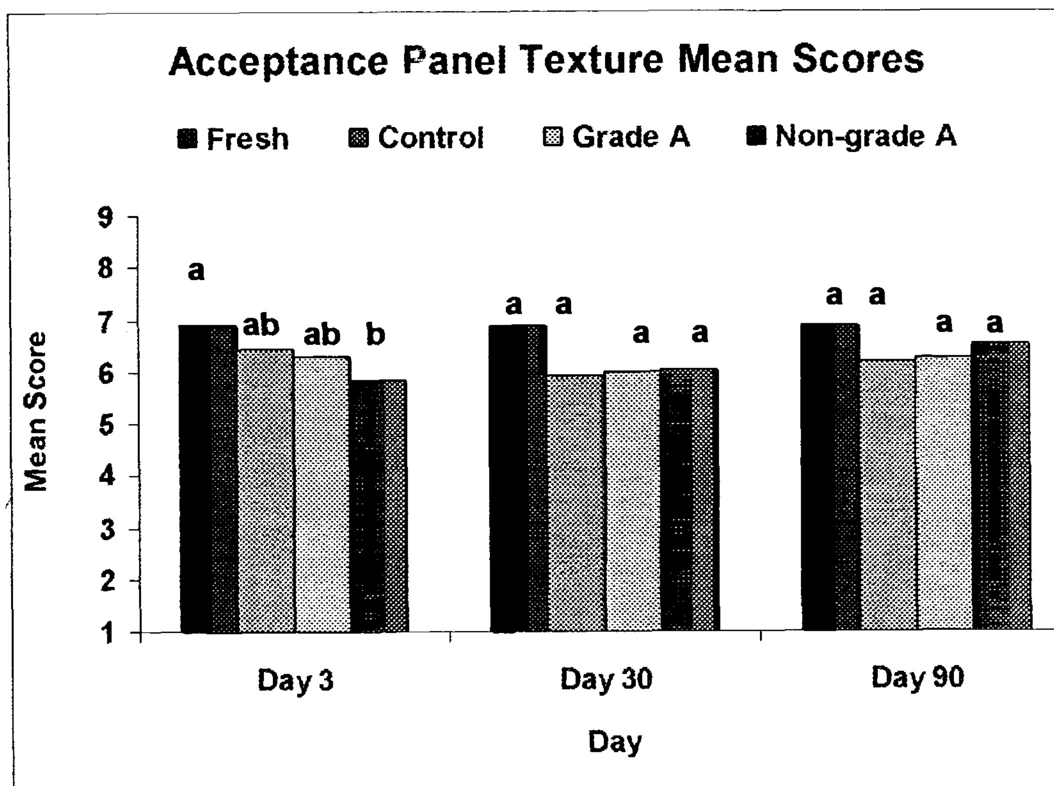
*Mean scores were the averages of 28 panelists on day 3, 25 panelists on day 30, and 21 panelists on day 90. Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Fisher's post hoc test for significant differences. Based on 9-point hedonic scale, 1-dislike extremely, 5-neither like nor dislikes, 9-like extremely.
Day 3 was refrigerated storage, day 30 and 90 were frozen storage.

A Fisher's Least-Significant Difference pair wise comparison of probabilities showed that on day 3 the rejects had texture scores that were significantly lower ($p \leq 0.05$) than the fresh day 3, 30, and 90. No other significant differences were detected across treatments and days. The only significant difference ($p \leq 0.05$) found among each day was on day 3 between the fresh and non-grade A (Figure 21). No other significant differences were found across days and treatments.

Turkey taste significant differences among days are found in Figure 22. On day 3, the fresh patty was significantly higher ($p \leq 0.05$) than all other treatments on day 3. No other significant differences were found among days. However, the Fisher's Least Significant Difference pair wise comparison did show that the fresh on day 3 was also significantly higher ($p \leq 0.05$) than the grade A day 30 and 90, and the non-grade A day 30 and 90. The fresh on day 90 was also significantly higher ($p \leq 0.05$) from the grade A day 3 and 30, and the non-grade A day 3. The control on day 90 was significantly higher ($p < 0.05$) than the non-grade A on day 3.

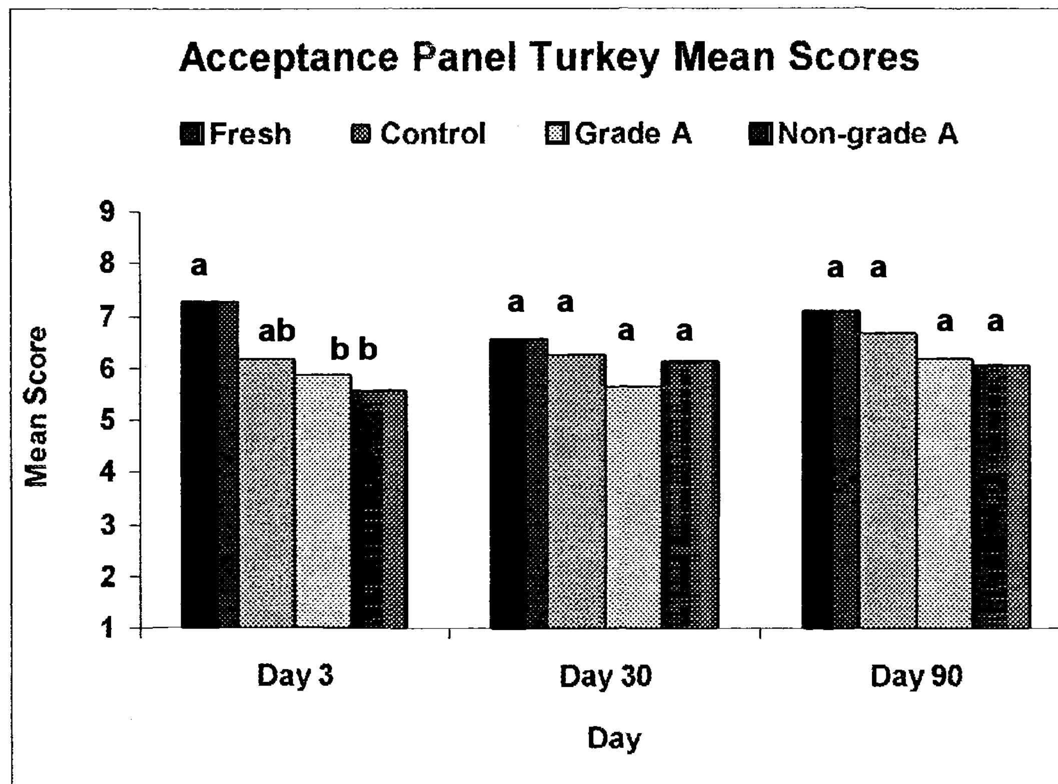
Purchase intent scores showed significant differences on day 3 and 90 (Figure 23). A Fisher's Least Significant Different Pairwise Comparison of probabilities showed that across treatments and days there were many significant differences. The fresh on day 3 was significantly different ($p \leq 0.05$) from the control day 3 and 30, the grade A day 3-90, and the non-grade A day 3 and 30. The fresh on day 90 was significantly higher ($p \leq 0.05$) from the control day 3 and the grade A day 3-90. No other significant differences were found across days and treatments.

Figure 21. Texture Acceptance Mean Scores



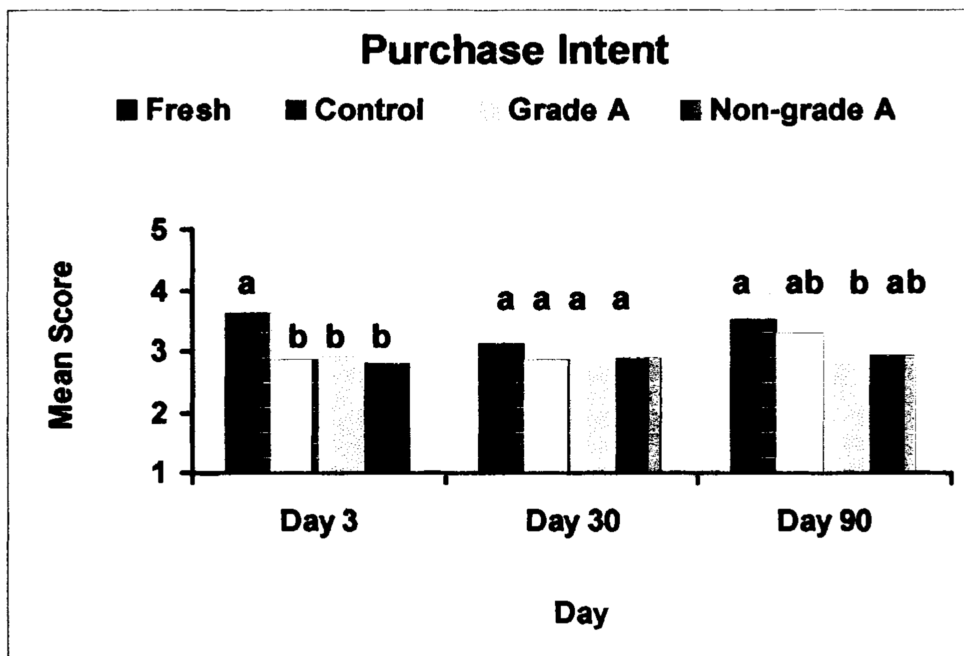
*Mean scores were the averages of 28 panelists on day 3, 25 panelists on day 30, and 21 panelists on day 90. Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Fisher's post hoc test for significant differences. Based on 9-point hedonic scale, 1-dislike extremely, 5-neither like nor dislikes, 9-like extremely. Day 3 was refrigerated storage, day 30 and 90 were frozen storage.

Figure 22. Turkey Taste Acceptance Mean Scores



*Mean scores were the averages of 28 panelists on day 3, 25 panelists on day 30, and 21 panelists on day 90. Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Fisher's post hoc test for significant differences. Based on 9-point hedonic scale, 1-dislike extremely, 5-neither like nor dislikes, 9-like extremely. Day 3 was refrigerated storage, day 30 and 90 were frozen storage.

Figure 23. Purchase Intent Mean Scores



*Mean scores were the averages of 28 panelists on day 3, 25 panelists on day 30, and 21 panelists on day 90. Different letters within each day represent a significant difference between treatments ($p \leq 0.05$) using a one-way ANOVA followed by a Fisher's post hoc test for significant differences. Based on 5-point hedonic scale, 1-would not purchase, 3-maybe would purchase, 5-would purchase.

Correlations

A Pearsons' correlation matrix (McClenahan et al., 2001) (Table 13) showed that overall mean scores were strongly correlated to turkey taste mean scores ($r=0.916$). Turkey mean scores were also strongly correlated with purchase intent ($r=0.754$). Purchase intent was also correlated with overall mean scores ($r=0.762$). TBA and hexanal were also strongly correlated ($r=0.899$). Turkey taste and sweet taste had a correlation coefficient $r=0.611$.

Table 13. Pearson's Correlation Coefficient Matrix

	Hexanal	**TBA**
Overall	r=0.463	r=0.429
Texture	r=0.369	r=0.569
Turkey Taste	r=0.343	r=0.230
Appearance	r=0.126	r=-0.068
Sweet Taste	r=-0.014	r=0.107
Purchase Intent	r=0.121	r=0.025

*Correlation coefficients were determined using a Pearson correlation matrix. Coefficients were determined by using the means for each descriptor, TBA, and hexanal data.

DISCUSSION

Turkey Patty Preparation

One of the first drawbacks of incorporating blueberry puree into ground turkey was to assure homogeneous mixing. This was difficult when working with large volumes of meat. Therefore, as stated in the Materials & Methods, the blueberry puree was added and mixed by hand for two minutes. The 93% lean ground turkey meat could only be ground through the Hobart Meat Grinder once because the more times the meat was passed through the grinder than the more fat was lost. Pieces of fat that remained in the screw of the grinder were added back to the batches of meat. It was also found in grinding trials that when the meat was ground in the grinder that it was more difficult to form turkey patties that stayed together once pressed. This might have been caused by the lack of fat and the breakdown of the protein that holds the meat together.

As a result of the process of incorporating the purees into the meat, there could be a possibility that puree did not come into contact with all of the ground meat. Therefore, it would be necessary in future studies to incorporate the percentage of blueberry puree into smaller batches. Then, the smaller batches could be combined to form the forty pounds of meat needed for each treatment. This would not be feasible on a commercial scale. Therefore, a process or new piece of equipment for effective incorporation of the puree is necessary. Puree could be incorporated into the patties during the grinding process, which could help to disperse the puree evenly throughout the meat.

Another drawback in preparation was the use of two ovens for broiling. Even though the ovens were the same model and temperature, it is difficult to measure and maintain the temperature of the ovens, which could potentially effect the length of time the patties were cooked. Samples in oven one could only take five minutes to reach an internal temperature of 74°C while oven two could take ten minutes for the same internal temperature to be reached. Therefore, varying levels of browning occurred on the turkey patties. This browning could produce end products that would interfere with chemical and sensory analysis. If the study were performed again, it would still be difficult to maintain uniform cooking times, however, it would be ideal to use only one oven.

Another problem noted with the sample preparation were the seeds in the blueberry purees. Filtering of the purees or a finer puree would be necessary because grittiness in the patties containing blueberry puree was detected during the sensory studies, which was attributed to the seeds.

Chemical Analyses

Thiobarbituric Acid Test Analyses

Refrigerated TBA results for both experiment one and two showed significant increases ($p \leq 0.05$) in malondialdehyde overtime in the turkey patties regardless of treatment. However, the control patties consistently had significantly higher levels of TBA ($p \leq 0.05$) on all days tested than either the grade A or the floater reject treatments. There was not a significant difference found between either blueberry puree treatments. Britt et al. (1998) found that the addition of Montmorency cherry tissue and Balaton cherry tissue significantly reduced TBARS in precooked

refrigerated beef patties held for four days of storage at 4°C. The researchers incorporated Britt et al. did not find a significant difference between cherry tissue varieties. This might have been attributed to the phenolic and anthocyanin contents of the cherry tissue because the types of individual flavonoids vary with maturity. TBARS for the blueberry puree treatments might not have been different from each other because the phenolic and anthocyanin contents of the purees were not significantly different.

Frozen TBA results for experiment one showed that on day 90 and 180 of storage, there were significant differences ($p<0.05$) between the control and both puree treatments. The control had higher TBA values than both puree treatments. On all of the other days tested there were no significant differences found between treatments. There were no significant differences between the types of blueberry purees on any of the days tested. There was not a consistent increase in TBARS overtime. El-Alim et al. (1999) found that culinary herbs decreased the levels of TBARS in precooked pork patties held for 6 months in frozen storage at -18°C. However, there was not a consistent increase in TBARS overtime in the pork patties treated with different spices. After one month, the patties treated with thyme had a decrease in malondialdehyde. However, MDA levels increased at month six.
In experiment two, from day 30 through 90 there were no significant differences detected among treatments. There were no significant differences found between either blueberry purees.

The steady increase in TBARS in the refrigerated patties was expected. Refrigeration temperatures are not cold enough to retard lipid oxidation. Because of

microbial and oxidative damage, meat products are not kept at refrigerated temperatures for long periods of time.

However, the frozen temperatures were capable of retarding lipid oxidation and the end products of such oxidation. Sheldon et al. (1991) noted that previous studies showed a decrease in TBA values across treatments held after 90 and 150 days of frozen storage compared to the same samples held for 30 days of frozen storage. The fluctuation in TBA values held overtime in frozen storage is attributed to the change in aldehyde composition generated during lipid oxidation. Overtime, the lipid oxidation process creates further reactions producing different compounds that are not detectable with the TBA method.

As a result of the changes in mean TBA scores held in frozen storage, researchers have questioned the validity of the TBA test for frozen products. Jardine et al. (2002) investigated the different colored species that react with TBARS, which could cause an over estimation of the extent of lipid oxidation. The author discovered that a yellow product exhibited strong absorption at 455nm but was not able to be eluted for further investigation. It was assumed to be a barbituric acid impurity found in the thiobarbituric acid. The yellow impurity caused a 1:1:1 molar ratio of TBA:barbituric acid:malondialdehyde. This ratio is different from the normally assumed molar ratio of 2:1 TBA:malondialdehyde. Further investigations of the pink and yellow compounds were performed using tandem mass spectrophotometry. The results showed that both compounds were similar in structure. The authors concluded that TBA testing should be used as an estimate of lipid oxidation.

Gas Chromatography Analysis

Gas chromatography results of refrigerated samples from both experiment one and two showed that hexanal content increased overtime in all patties. Control patties had statistically different ($p \leq 0.05$) hexanal concentrations compared to the patties containing either blueberry purees. There was not a significant difference ($p > 0.05$) between puree treatments in the refrigerated patties for either study. However, the control patties continuously had higher concentrations of hexanal overtime. On day 1 and 3 in study one and two there were undetectable levels of hexanal found in patties containing grade A or floater reject purees.

Ahn et al. (2002) found hexanal content increased in pre-cooked beef patties containing natural plant extracts with polyphenolics. However, the natural plant extracts significantly decreased hexanal concentrations compared to a control containing no plant extracts.

Gas chromatography results of frozen samples from study one showed that on day 1 and 30 of storage, both blueberry puree treatments significantly reduced ($p \leq 0.05$) hexanal compared to the control. However, from day 60 through 180 there were no significant differences found between treatments. Sixty days could be a possible limit for detecting hexanal and further volatile compounds could be formed from the breakdown of hexanal. On day 1 through 180, undetectable levels of hexanal were found in the grade A treatments. Floater reject treatments had detectable levels of hexanal only on day 90 and 150.

Gas chromatography results of frozen samples from study two showed that only on day 90 were hexanal concentrations significantly lower ($p \leq 0.05$) in both puree treatments compared to the control.

Overall, the blueberry purees were not significantly different from each other but were capable of retarding hexanal formation in the turkey patties. However, other volatiles could have been present that are secondary products of lipid oxidation such as pentanal, propenal, and heptanal. Snyder et al. (1985) identified thirty headspace volatiles from vegetable oils using capillary gas chromatography. Vara-Ubol and Bowers (2001) used gas chromatography methods to detect hexanal in cooked ground turkey and pork held in storage for six days. Further research would need to be done in order to determine if the blueberry purees contain different volatiles than the control.

Total Anthocyanin and Total Phenolics

It is not known which specific anthocyanins and phenolics are responsible for retarding lipid oxidation or if these compounds are the reason for a reduction in lipid oxidation. Under similar assumptions that these compounds work as antioxidants from researchers who conducted studies on phenolics as antioxidants in meats (Var-Ubol, 2001; King et al., 1995; Sheldon et al., 1997; Britt et al., 1998, McKibben et al., 2001) TBA and hexanal results for both purees were not significantly different possibly because there was not a significant difference between their total phenolic and anthocyanin contents.

The anthocyanin content of the grade A puree was found to be higher than the floater rejects. This was expected because the grade A contained lowbush blueberries

that were riper and not green. The floater rejects contained smaller and greener blueberries. Therefore, as seen in studies done by Kalt et al. (1995) maturity and size contributes to the total phenolic and anthocyanin content of blueberries. Maturity increases total phenolic and anthocyanin content. Similarly, the total phenolics found in the grade A puree was higher than the floater rejects.

Storage also effects the anthocyanin and phenolic content of blueberries. Sapers et al. (1985) determined that thawing blueberries caused pigments to leak from the skin. The purees in the study were frozen, thawed, and then analyzed for phenolics and anthocyanins. This could have had an effect on the structure and anthocyanin content of the purees.

Further research needs to be conducted in order to determine a method for analyzing anthocyanin and phenolics in meat patties. Possible changes or a breakdown of these compounds could be responsible for the fluctuation in hexanal and TBA concentrations in the frozen patties.

Sensory Analysis

Descriptive Panel

The trained descriptive panel on day 1 and day 3 showed that the purees were able to reduce warmed-over characteristics compared to the control patty. Since these patties on day 1 and 3 were refrigerated a greater significant difference was seen between these two days. However, on day 30 until 180 the patties were frozen and this temperature was able to retard WOF. Poultry odor was the highest overtime in the control patty because the blueberry puree was masking the poultry odor and added a sweet note to the turkey patties.

Bouillon odor decreased overtime in all treatments. Poultry odor also decreased overtime up to day 30. On day 90, poultry odor scores were as high in all treatments as day 1. This trend could have been attributed to the panelists having a clearer understanding of scoring the patties by day 90. On day 90, turkey taste scores also increased in all treatments. Another possible reason for this occurrence could have been the long period between tasting sessions. However, a re-training session was held one day prior to tasting on day 90. Another possible reason that bouillon odor decreased over time was due to the low levels of hexanal detected in the patties overtime. Kerler and Grosch (1996) determined that at 5 ppm hexanal, rancid and meaty-like odors formed. Levels that fell below 5 ppm did not have these attributes.

An important finding in this experiment was that both purees added a sweet flavor to the patties. Panelists continuously scored both puree treatments higher for sweet taste than the control. Panelists did not appear to report that the sweetness had an effect on rancid or turkey taste. This was apparent in the low correlation coefficients between sweet taste and rancid taste ($r=-0.140$) and sweet taste and turkey taste ($r=-0.322$).

Byrne et al. (1999) found that a sweet, meat-like flavor, decreased as oxidation proceeded in pork and chicken. In this study, rancid taste decreased throughout the study. This might have been caused by the patties being frozen on day 30-180 of testing. Kerler and Grosch (1996) determined that rancid flavors attributed to hexanal content did not occur until hexanal levels reached 5 ppm. In this study, hexanal levels of the frozen patties did not reach 5 ppm. Therefore, the rancid flavors may have decreased in the frozen patties overtime because of the lower levels of

hexanal detected. Kerler and Grosch (1996) also found that metallic odors increased in reheated cooked beef patties. Metallic scores in this study remained consistent throughout the testing. In this study hexanal was more highly correlated with rancid taste (r=0.561) than TBA (r=0.278) which is a low correlation.

It is recommended that future sensory descriptive panels should have a broad source of panelists that could be trained. Working with a small number of panelists made it difficult to remove any from the study. In an ideal situation, panelists would have been removed and replaced when their scores were consistently different from other panelists. However, in this study, all panelists were not consistent overtime with their scores. This was caused by the short time for training panelists. Panelists in other studies on WOF development have had extensive training or had sensory backgrounds (Byrne et al., 2001; McClenahan et al, 2001). Byrne et al. (2001) also determined that confusion and inaccurate scoring procedures did occur until session five of training. Reinforcement of concepts and what was expected from the panelists was presented at each tasting session. However, some confusion on scoring patties compared to the references existed among panelists.

Acceptance Panel

The acceptance panel showed that overall the patties had approximately a score of six on a nine-point scale. Therefore, it can be concluded that all of the patties were acceptable. However, the fresh patty consistently had higher scores. These results were expected since the patty was fresh and had not been held in storage. However, the control patty that was held in storage overtime had similar results as the treatments with either blueberry puree. It was noted that by day 90, the

acceptance panel had increased their overall scores for the blueberry puree treatments. Therefore, the acceptance of these patties improved overtime.

Purchase intent was highest in the fresh cooked patty over all days tested. Purchase intent was highly correlated with overall scores (r=0.762) and turkey taste scores (r=0.754). Two panelists reported that reasons for their purchase intent scores were attributed to the fact that they did not purchase ground turkey but rather ate ground beef.

Other panelists noted that the color of the fresh patty was not liked and the blueberry that added color to the patties was liked. However, color attributes were not asked in this study because blueberry puree will change the color of ground turkey. In the future, it is recommended that red lights be used in the sensory testing facility to mask the color of the patties. However, even if the color is masked the general public might not like the color, which could inhibit the marketability of the product. Therefore, another study to identify the acceptability of the color is recommended.

Sweetness also was higher in the patties containing either puree. Panelists said they liked the sweetness in both of the treatments containing puree. Panelists did note that the fresh patty had the most turkey flavor.

It was determined that there is a potential market for turkey patties containing blueberry puree based on these acceptability scores. A purchase intent score of six is not highly acceptable. However, a plain ground turkey patties are a novelty food item. Some panelists did note that they purchased ground beef for burgers not turkey. Advertising the potential benefits of the blueberry purees might help to sell

these turkey patties. There is also potential to add blueberry puree to other meat products, such as hamburger meat, based on the responses of these panelists who purchase other meats instead of ground turkey. Fresh ground hamburger is darker in color when cooked. Therefore, blueberry puree might not affect the color change in a hamburger patty and could possibly be marketed. Foodservice opportunities also could be a potential marketing approach. School lunch programs, catering services, and fast-food suppliers could utilize turkey patties with blueberries because they could hold them for longer periods of time.

CONCLUSIONS

This study determined that lipid oxidation was reduced with the addition of both blueberry purees. Hexanal and TBAR concentrations were significantly ($p \leq 0.05$) reduced in refrigerated storage treatments containing either blueberry puree compared to a control in both studies. Significant differences ($p > 0.05$) between blueberry purees was not detected in hexanal and TBAR concentrations. Frozen storage retarded lipid oxidation and attributed to less significant differences in both studies for TBA and hexanal.

The descriptive panel identified warmed-over flavor as rancid, metallic, and sweet. The sweet taste was attributed to the blueberry purees. Turkey taste was higher in the control patty with no puree. However, rancid flavor was also higher in the control patty on day 3 of refrigerated storage. Rancid flavors were lower in frozen patties held for 180 days.

The acceptance panel showed an average score of six for acceptability of all treatments. The response of panelists to the turkey patties containing puree was positive for sweetness, taste, and overall acceptability. However, purchase intent scores were lower in patties containing puree compared to a fresh or a control patty with no puree. Purchase intent was lower for some panelists because of the types of meat products they consumed.

It is recommended that in future studies the assumption that anthocyanins and phenolics are the attributing factors that retard lipid oxidation is accurate. Future research to detect the changes in anthocyanins and phenolics within the turkey patties held in storage overtime should also be conducted. Further analysis of the possible

reduction in heterocyclic aromatic amines by the addition of blueberry purees also needs to be determined. Further sensory analysis for the marketability of a blueberry puree turkey patty should be conducted based on the color and taste attributes.

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APPENDICES

APPENDIX A

Effects of Highbush and Lowbush Blueberry Purees Lipid Oxidation in Precooked Turkey Patties

Abstract

Variation in anthocyanin content within and among blueberry species has made it necessary to determine which type of blueberry puree would work best as a natural antioxidant in a meat system. This study investigated if differences in highbush and lowbush anthocyanin content affected their ability to retard lipid oxidation in precooked turkey patties held at 4°C for 14 days. Lowbush and highbush blueberry purees were incorporated at 0%, 0.875%, 1.75%, 3.5%, and 5.0% (wet/weight) into 93% lean ground turkey. Patties were broiled to an internal temperature of 74°C and then held in refrigeration for fourteen days. Gas chromatography methods for detecting hexanal and thiobarbituric acid test (TBA) were used to determine the extent of lipid oxidation on day 0, 3, 7, 10, and 14 of storage. Results showed that as the concentration of blueberry puree was increased, hexanal and TBA concentrations decreased. The 3.5% and 5.0% puree treatments were most effective at reducing TBARS and hexanal. Both purees at these levels were not significantly different ($p>0.05$) from each other. Neither the highbush or lowbush blueberry purees were significantly different from each other. Both were capable of significantly reducing TBARS and hexanal in precooked turkey patties.

Introduction

This investigation was conducted to determine the differences in lowbush and highbush blueberry purees as natural antioxidants in precooked turkey patties.

Blueberries have been found to be one of the richest sources of antioxidants of the fresh fruits and vegetables (Prior et al., 1998). Jadhav et al. (1996) stated that antioxidants when added to foods could minimize rancidity and increase shelf life. However, blueberries have differing antioxidant capacities among cultivars. Kalt et al. (1999) found variation in the total anthocyanin content within the *Vaccinium* species. Gao and Mazza (1994) determined lowbush blueberries have higher total anthocyanin contents than highbush blueberries. Therefore, it was necessary to determine if lowbush blueberries were significantly different at retarding lipid oxidation in precooked turkey patties from highbush blueberries.

Materials & Methods

Materials

Lowbush wild Maine blueberries were obtained from Blueberry Hill Farm (Jonesboro, ME). Highbush blueberries from Bleuets Brady Farm (West Olive, MI) and 93% Lean Ground Turkey was purchased at a local supermarket (Old Town, ME).

Sample Preparation

Purees were made by grinding each type of blueberry in an Osterizer blender until smooth. Blueberry puree was incorporated by hand on a wet weight basis and the following treatments were prepared: 0% (control), 0.875%, 1.75%, 3.5%, and 5.0%. Following hand mixing for approximately two minutes, the turkey meat was ground once through a Hobart Meat Grinder Model 600D equipped with a 3/16" plate (Troy, OH). Approximately 17.5 (+/- 0.05) grams of turkey meat was weighed and formed into a patty using a plastic patty press in order to assure uniform thickness.

Patties were broiled in an electric broiling oven until they reached an internal temperature of 74°C measured with a Fluke Thermocouple 52K/J (Paramus, NJ). Patties were cooled in a room temperature oven until they reached 21°C. Patties were sealed in a Tetra Laval Foods plastic bag (Holdbrook, MA). Bags were heat sealed with a NY Clave Heat Sealer (St. Louis, MO) removing as much air as possible. Bags were stored in refrigerated temperatures of 4°C until needed for testing. Patties were tested on day 0, 3, 7, 10, and 14 of storage for hexanal and TBA.

Methods

Thiobarbituric acid tests and gas chromatography methods followed the same protocol found in experiment one.

Statistical Analyses

Statistical analysis was done using Systat Version 9 Statistical software program (SPSS, Chicago, IL). A one-way ANOVA was performed followed by a Tukeys post hoc test for differences between treatments during each day. A multiway ANOVA was performed to determine overall differences. Correlation coefficients were determined for correlations between hexanal and TBA concentrations.

Results

Table A1. TBARS Mean Values: Highbush vs. Lowbush Blueberry Purees

	Day				
Treatment & Blueberry Type	**0**	**3**	**7**	**10**	**14**
Control 0%	0.063 **ab**	0.115 **a**	0.175 **a**	0.302 **a**	0.556 **a**
0.875% Highbush	0.058 **abc**	0.041 **d**	0.141 **b**	0.240 **bc**	0.556 **a**
0.875% Lowbush	0.049 **cde**	0.068 **b**	0.141 **b**	0.213 **c**	0.430 **b**
1.75% Highbush	0.071 **a**	0.060 **bc**	0.109 **b**	0.246 **b**	0.512 **ab**
1.75% Lowbush	0.040 **de**	0.045 **cd**	0.126 **b**	0.146 **d**	0.448 **b**
3.5% Highbush	0.035 **e**	0.020 **e**	0.033 **cd**	0.124 **de**	0.294 **c**
3.5% Lowbush	0.054 **bcd**	0.024 **e**	0.052 **c**	0.110 **e**	0.243 **c**
5.0% Highbush	0.045 **abc**	0.035 **de**	0.029 **d**	0.111 **e**	0.252 **c**
5.0% Lowbush	0.036 **e**	0.000 **f**	0.021 **d**	0.074 **f**	0.099 **d**

*Different letters within each column represent a significant difference of ($p \leq 0.05$) using a one-way ANOVA followed by a Tukey's post hoc test. Means values were the average of triplicate replications. TBARS measured in nmol MDA/g of meat.

Table A2. Gas Chromatography Hexanal Mean Values: Highbush vs. Lowbush Blueberry Purees

	Day				
Treatment & Blueberry Type	**0**	**3**	**7**	**10**	**14**
Control 0%	21.99**ab**	29.41**a**	63.30**a**	23.99**a**	17.40**cde**
0.875% Highbush	11.34**abc**	18.23**b**	39.83**b**	24.35**a**	45.61**a**
0.875% Lowbush	20.41**ab**	29.06**a**	78.39**a**	17.40**a**	36.85**ab**
1.75% Highbush	24.00**a**	19.27**b**	30.25**bcd**	13.93**ab**	25.08**bc**
1.75% Lowbush	9.65**bc**	8.10**cd**	13.22**ef**	15.91**a**	23.45**bcd**
3.5% Highbush	5.20**c**	13.65**bc**	35.73**bc**	8.35**ab**	17.53**cde**
3.5% Lowbush	3.43**c**	6.44**de**	18.29**def**	8.57**ab**	15.27**cde**
5.0% Highbush	6.09**c**	12.27**c**	26.21**cde**	7.78**ab**	11.18**de**
5.0% Lowbush	2.27**c**	0.781**e**	5.44 **f**	0.781**b**	4.71**e**

*Different letters within each column represent a significant difference of ($p \leq 0.05$) using a one-way ANOVA followed by a Tukey's post hoc test. Mean values were the average of triplicate replications. Hexanal measured as µM of hexanal.

A multi-way ANOVA showed that treatment ($p \leq 0.05$), day ($p \leq 0.05$), and treatment*day ($p \leq 0.05$) had significant effects on hexanal and TBA results. A Pearson correlation matrix showed that a correlation did not exist between TBA and hexanal values ($r = 0.312$).

Discussion

TBA results showed that as time increased the TBA concentrations also increased in all of the treatments. However, a linear relationship existed between puree percentages and TBA values. As the puree increased, TBA values decreased. The control treatment on every day tested was significantly higher ($p > 0.05$) than the 1.75%, 3.5%, and 5.0% highbush and lowbush treatments. The 0.875% highbush on day 0 and 14 were not significantly different from the control. The 0.875% lowbush were significantly different from the control on all days tested. There were days when some of the other treatments were not significantly different from the control. However, a general trend was found that as puree increased the lower the TBA values became compared to the control.

Possible reasons for finding varying levels of TBA during the study could have come from sample preparation errors. When preparing samples blueberry puree might not have come into contact with all of the meat, especially at the 0.875% level. Meat portions taken during random sampling that were used for analysis might have higher or lower amounts of puree dispersed throughout that patty. In future studies, smaller batches could be prepared in order to evenly distribute puree.

Another possible problem in the TBA results was the interference of puree with the TBA, which could cause a darker color change. The possible interference of

the blueberry composition with TBA could cause an overestimation of malondialdehyde detected in samples. Because of possible interferences of other compounds, Jardine et al. (2002) determined that the TBA test should be used as an estimate of lipid oxidation to determine differences between treatments.

Hexanal results showed that on day 0, 3, and 7 the 3.5% and 5.0% lowbush and highbush puree significantly reduced hexanal content compared to the control. The 0.875% lowbush and highbush purees were not significantly different from the control on day 1, 3, 7, and 10. It was found that hexanal content in all samples increased until day 7 then began to decrease at day 10 and 14. Since hexanal is a volatile compound that changes as lipid oxidation progresses, it was theorized that hexanal was broken down into further volatiles by day 10 and 14. Significant differences were not found between the 3.5% purees and the 5.0% purees. Significant differences ($p<0.05$) in the purees were found. On day 3 and 7 at the 0.875%, 1.75%, 3.5%, and 5.0% level the purees were significantly different. However, there was no trend that showed the lowbush having continuously lower hexanal values over the highbush purees.

It is recommended that the anthocyanin and phenolic content of the purees be determined in future studies in order to identify if differences existed. Color changes in turkey due to the puree levels would also need to be determined for consumer acceptance.

Conclusion

Both 3.5% and 5.0% lowbush and highbush blueberry purees significantly reduced hexanal and TBARS. No trend was discovered that showed that one puree

worked more efficiently at retarding lipid oxidation in precooked turkey patties. However, a level of puree that would not affect sensory attributes such as color and taste would need to be determined for acceptance of blueberry puree in meat systems. From this study, the 3.5% puree was not significantly different from the 5.0%. It is recommended that 3.5% puree be used because of the color change noted in the 5.0% treatments. This research demonstrated the possible use of incorporating blueberry puree into precooked meat products as a method to retard lipid oxidation and extend the shelf life of the product.

Appendix B

Informed Consent

Product being tested: Ground Turkey Patties

Trained panel: Sucrose, 1g/L in solution of water
Citric acid monohydrate, 0.3g/L in solution of water
Sodium chloride, 0.5g/L in solution of water
Caffeine, 0.05g/L in solution of water
Bouillon cube, to be added to 1L of water
Whites of boiled eggs
Iron Supplement Pill, to taste on the tongue then spit out of mouth
White Bread
Vegetable Oil
Caramel toffees

If you have any known allergies to ground turkey, blueberries, eggs, bread, or iron you may not participate in this study.

This study is being conducted for the purpose of writing a thesis for the completion of the requirements of a Master's degree at the University of Maine, Orono, Maine. This section of research involves consumption of ground turkey with and without added blueberries while looking for distinctive flavors that can affect consumer acceptability of the ground turkey. This study will take approximately 6 months from beginning to end. Each panelist will be asked to commit a total of 3-5 days over the time of the study. Individual sessions will be limited to no more than 1 hour. It is hoped that those who start the panel will be able to remain until it is completed.

For those that do not have any allergies to these products, every care has been taken to properly handle and prepare the samples so as to prevent, minimize and/or eliminate any food related safety hazards. Poultry patties will be cooked to an internal temperature of 165°F/74°C. This represents the internal temperature recommended by the USDA.

I understand the study described above may involve the following risks and/or discomforts: risks to subjects no more than that occurring in the course of everyday living.

I understand I have the right to refuse to participate in, or withdraw from, this research at any time without penalty or loss of benefits to which I am entitled.

I understand that my name will not be associated with data.

I understand circumstances may arise which might cause the investigator to terminate my participation before the completion of the study.

I understand that if I have further questions, comments, or concerns about the study or the informed consent process, I may contact the Project Investigator, Kathleen Buzzard at 58101635, Dr. Alfred A. Bushway, Professor of Food Science at 581-1629, or Dr. Mary Ellen Camire, Professor of Food Science and Sensory Testing Center Coordinator at 581-1627.

Subject's Signature: ____________________
Date: ______________________________
Witness: ___________________________

Prescreening Questionnaire

Please answer all questions to your best knowledge. All answers are confidential and will be viewed only by the panel coordinator, Kathleen Buzzard. If you have any questions please contact Kathleen at 581-1635 or buzz@umit.maine.edu.

History:

Name:

____

Address:

____

Phone # (Home and Workday):

____

How did you hear about this sensory panel? (Poster, Advertisement, Friend etc.):

______

Time:

1. Are there any weekdays (M-F) which you are not available on a regular basis to participate in the sensory panel?

____

2. Is there a particular time weekdays, which you are available on a regular basis? (Mornings, Afternoons, Evenings (5pm-6pm)

____

Health:

1. Do you have the following? (Yes/No)

   Dentures _______
   Diabetes _______
   Oral or gum disease _______
   Hypoglycemia ________
   Food allergies ________ If yes, what are they?
   Hypertension _________

2. Do you take any medications that would affect your senses, especially taste and smell?

____

Food Habits:

1. Are you currently on a restricted diet? If yes, explain.

____

2. How often do you eat fast foods in one month?

____

3. Do you eat frozen meals?

____

4. What are your favorite foods?

____

5. What are your least favorite foods?

____

6. How often do you eat poultry in one month?

____

7. What foods can you not eat?

____

8. Is there a particular way you like to prepare your poultry?

____

9. Is your ability to distinguish smell and tastes

	SMELL	TASTE
Better than average	______	______
Average	______	______
Worse than average	______	______

Appendix C

Table C1. Initial 42 Descriptors to Describe Warmed-Over Flavor

Odor	Taste	Flavor	Aftertaste	Other
Roasted	Sweet	Metallic	Sour	
Toasted	Salt	Nut	Fatty/oily	
Caramel	Sour	Caramel	Astringent	
Nut	Bitter	Roasted	Metallic	
Chicken meat	MSG/umami	Toasted	Slick	
Non-poultry		Meat		
Fresh turkey		Poultry		
Organ Meat		Bouillon		
Bouillon		Piggy		
Linseed Oil		Rubber		
Cardboard		Rancid		
Rubber		Paper		
Egg/sulfur		Cardboard		
Paint		Paint		
		Linseed oil		
		Lactic acid/sour		
		Vegetable oil		
		Bread		

*Adapted from Byrne et al., 2001

Appendix D

Training Session: Turkey Patty Evaluation

Please take a sip of water before tasting the patty. Taste the turkey patty. Please rank the intensity of each descriptor on the intensity line by placing a slash at the mark where you feel the intensity is appropriate. Use the references as guidelines for comparing the intensity of each descriptor.

1. Bitter

1_____________________5_____________________10_____________________15
No intensity Slight intensity High intensity Very high intensity

2. Sweet

1_____________________5_____________________10_____________________15
No intensity Slight intensity High intensity Very high intensity

3. Salt

1_____________________5_____________________10_____________________15
No intensity Slight intensity High intensity Very high intensity

4. Sour

1_____________________5_____________________10_____________________15
No intensity Slight intensity High intensity Very high intensity

5. Metallic

1________________5__________________10_________________15
No intensity Slight intensity High intensity Very high intensity

6. Caramel

1________________5__________________10_________________15
No intensity Slight intensity High intensity Very high intensity

7. Non-Poultry Meat

1________________5__________________10_________________15
No intensity Slight intensity High intensity Very high intensity

8. Rubber

1________________5__________________10_________________15
No intensity Slight intensity High intensity Very high intensity

9. Paper

1________________5__________________10_________________15
No intensity Slight intensity High intensity Very high intensity

10. Bread

1________________5__________________10_________________15
No intensity Slight intensity High intensity Very high intensity

11. <u>Bouillon</u>

1__________________5____________________10____________________15

No intensity	Slight intensity	High intensity	Very high intensity

12. <u>Vegetable Oil</u>

1__________________5____________________10____________________15

No intensity	Slight intensity	High intensity	Very high intensity

13. <u>Poultry</u>

1__________________5____________________10____________________15

No intensity	Slight intensity	High intensity	Very high intensity

Odor Evaluation

1. <u>Poultry</u>

1__________________5____________________10____________________15

No intensity	Slight intensity	High intensity	Very high intensity

2. <u>Bouillon</u>

1__________________5____________________10____________________15

No intensity	Slight intensity	High intensity	Very high intensity

3. <u>Egg/Sulfur</u>

1__________________5____________________10____________________15

No intensity	Slight intensity	High intensity	Very high intensity

4. <u>Non-Poultry Meat</u>

1________________5____________________10__________________15

No intensity	Slight intensity	High intensity	Very high intensity

5. <u>Cardboard</u>

1________________5____________________10__________________15

No intensity	Slight intensity	High intensity	Very high intensity

Appendix E

Ballot for Descriptive Panel

Please slide the black bar to indicate how strong
the odor intensity is for each attribute.

Please rate the intensity of the poultry odor.
Move the bar all the way to the left if the odor
is not present.

+---+
0 15
None Very high intensity

Please rate the intensity of the bouillon odor.
Move the bar all the way to the left if the odor
is not present.

+---+
0 15
None Very high intensity

Please rate the intensity of the egg/sulfur odor.
Move the bar all the way to the left if the odor
is not present.

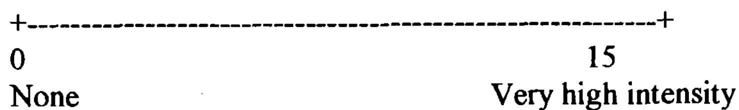
+---+
0 15
None Very high intensity

Please rate the intensity of the non-poultry odor.
Move the bar all the way to the left if the odor
is not present.

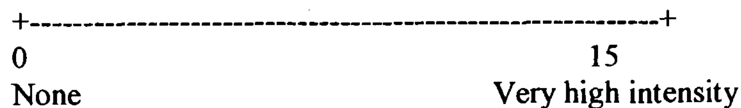
+---+
0 15
None Very high intensity

Please take a drink of water before tasting the burger. Using your mouse, click on each bar to slide it to the value you think corresponds to the intensity of each descriptor.

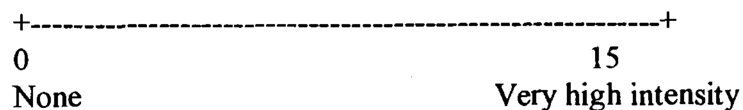
Please rate the intensity of the bitter taste. Move the bar all the way to the left if the taste is not present.



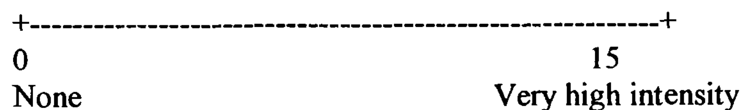
Please rate the intensity of the sweet taste. Move the bar all the way to the left if the taste is not present.



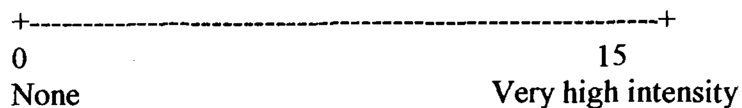
Please rate the intensity of the salt taste. Move the bar all the way to the left if the taste is not present.



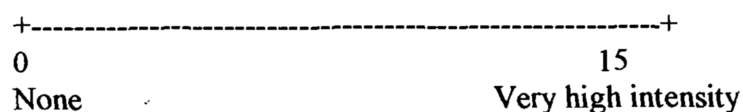
Please rate the intensity of the sour taste. Move the bar all the way to the left if the taste is not present.



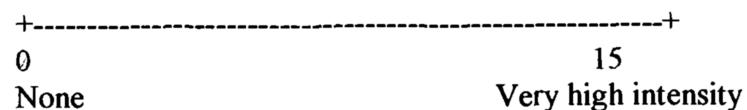
Please rate the intensity of the metallic taste.
Move the bar all the way to the left if the taste
is not present.



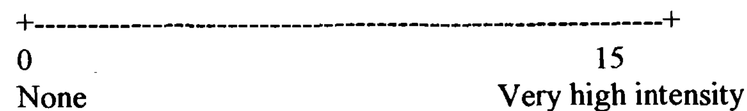
Please rate the intensity of the caramel taste.
Move the bar all the way to the left if the taste
is not present.



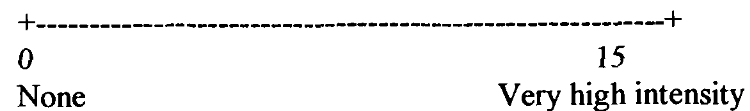
Please rate the intensity of the non-poultry
taste. Move the bar all the way to the left if
the taste is not present.



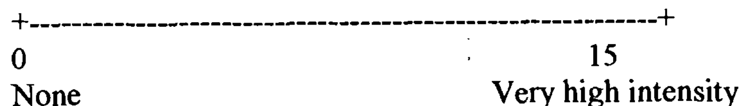
Please rate the intensity of the rubber taste.
Move the bar all the way to the left if the taste
is not present.



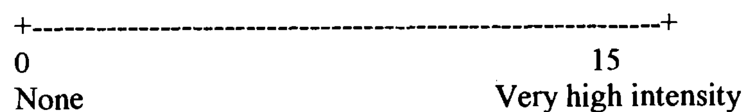
Please rate the intensity of the paper taste.
Move the bar all the way to the left if the taste
is not present.



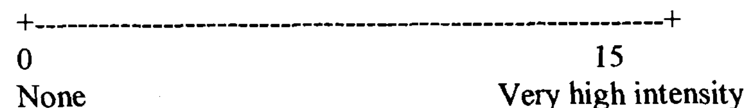
Please rate the intensity of the bread taste.
Move the bar all the way to the left if the taste
is not present.



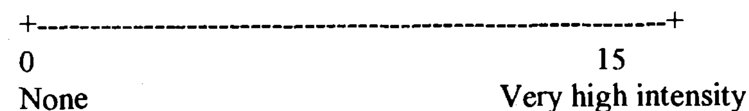
Please rate the intensity of the bouillon taste.
Move the bar all the way to the left if the taste
is not present.



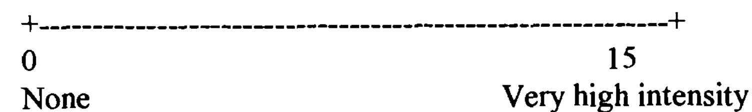
Please rate the intensity of the rancid vegetable
oil taste. Move the bar all the way to the left
if the taste is not present.



Please rate the intensity of the poultry taste.
Move the bar all the way to the left if the taste
is not present.



Please rate the intensity of the sour aftertaste.
Move the bar all the way to the left if the taste
is not present.



Please rate the intensity of the fatty/oily mouthcoating aftertaste. Move the bar all the way to the left if the taste is not present.

+---+
0 15
None Very high intensity

Please rate the intensity of the metallic aftertaste. Move the bar all the way to the left if the taste is not present.

+---+
0 15
None Very high intensity

Please rate the intensity of the rancid vegetable oil aftertaste. Move the bar all the way to the left if the taste is not present.

+---+
0 15
None Very high intensity

Please rate the intensity of the sweet aftertaste. Move the bar all the way to the left if the taste is not present.

+---+
0 15
None Very high intensity

Please rate the intensity of the poultry aftertaste. Move the bar all the way to the left if the taste is not present.

+---+
0 15
None Very high intensity

Appendix F

Informed Consent Acceptance Panel

Product being tested: Ground Turkey Patties with Blueberry Puree

If you have any known allergies to ground turkey or blueberries you may not participate in this study.

This study is being conducted for the purpose of writing a thesis for the completion of the requirements of a Master's degree at the University of Maine, Orono, Maine. This section of research involves consumption of ground turkey with and without added blueberries while looking for acceptance. This study will take approximately three months from beginning to end. Each panelist will be asked to commit a total of approximately ten minutes at each time interval tested. It is hoped that those who start the panel will be able to remain until it is completed.

For those that do not have any allergies to these products, every care has been taken to properly handle and prepare the samples so as to prevent, minimize, and/or eliminate any food related safety hazards. Poultry patties will be cooked to an internal temperature of 165F/74C. This represents the internal temperature recommended by the USDA.

I understand the study described above may involve the following risks and/or discomforts: risks to subjects no more than that occurring in the course of everyday living.

I understand I have the right to refuse to participate in, or withdraw from this research at any time without penalty or loss of benefits to which I am entitled. Gift certificated will be rewarded to those who complete ALL three panels.

I understand that my name will not be associated with data.

I understand the circumstances my arise which might cause the investigator to terminate my participation before the completion of the study.

I understand that if I have further questions, comments, or concerns about the study or the informed consent process, I may contact the Project Investigator, Kathleen Buzzard at 581-1635, Dr. Alfred Bushway, Professor of Food Science at 581-1629, or Dr. Mary Ellen Camire, Professor of Food Science and Sensory Testing Center Coordinator at 581-1627.

Subject's Signature: ________________
Date: ___________________________
Witness: ________________________

Appendix G

Ballot Acceptance Panel

Please answer the following questions. When finished please click on the hand at the bottom of the screen to begin testing samples.

Please mark the box that best describes your age.

[] 18-27
[] 28-37
[] 38-46
[] 47-58
[] 59+

Please mark the box that best describes your gender.

[] Male
[] Female

Please take a sip of water before tasting the sample. Make sure the sample code on the plate matches the code on the screen.

How do you like the appearance of this turkey patty?

[] Like extremely
[] Like very much
[] Like moderately
[] Like slightly
[] Neither like nor dislike
[] Dislike slightly
[] Dislike moderately
[] Dislike very much
[] Dislike extremely

How do you like the sweetness of this turkey patty?

[] Like extremely
[] Like very much
[] Like moderately
[] Like slightly
[] Neither like nor dislike
[] Dislike slightly
[] Dislike moderately
[] Dislike very much
[] Dislike extremely

How do you like the turkey taste of this turkey patty?

[] Like extremely
[] Like very much
[] Like moderately
[] Like slightly
[] Neither like nor dislike
[] Dislike slightly
[] Dislike moderately
[] Dislike very much
[] Dislike extremely

How do you like the texture of this turkey patty?

[] Like extremely
[] Like very much
[] Like moderately
[] Like slightly
[] Neither like nor dislike
[] Dislike slightly
[] Dislike moderately
[] Dislike very much
[] Dislike extremely

What is your overall opinion of this turkey patty?

[] Like extremely
[] Like very much
[] Like moderately
[] Like slightly
[] Neither like nor dislike
[] Dislike slightly
[] Dislike moderately
[] Dislike very much
[] Dislike extremely

Would you buy this pre-cooked turkey patty?

[] Definitely would buy
[] Probably would buy
[] Maybe/maybe not buy
[] Probably would not buy
[] Definitely would not buy

Appendix H

Comment Sheet

Please feel free to write any comments about any of the samples. Your opinions are very important to the study. Below is a list of the sample numbers. Make sure your comments are written next to the correct sample number so that we can verify the product. Thank you.

Sample # | Comments

#1

#2

#3

#4

BIOGRAPHY OF THE AUTHOR

Kathleen Gabriel Buzzard was born in Bangor, Maine on January 29, 1979. She was raised in Landing, New Jersey and graduated from Roxbury High School in 1997. She attended The University of Maine and graduated in May 2001 with a Bachelor's degree in Food Science and Human Nutrition. In the summer of 2001 she entered the graduate program in the Department of Food Science and Human Nutrition at The University of Maine.

While at The University of Maine, Kathleen has become a member of Phi Tau Sigma and Kappa Omicron Nu honorary societies, the Institute of Food Technologists, and the Northeast section of the Institute of Food Technologists. Kathleen is a candidate for the Master of Science degree in Food Science and Human Nutrition from The University of Maine in December, 2002.