EFFECT OF SORGHUM BRAN ADDITION ON LIPID OXIDATION AND SENSORY PROPERTIES OF GROUND BEEF PATTIES DIFFERING IN FAT LEVELS

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Introduction

The meat industry is faced with the challenge of supplying higher-quality meat products that have extended shelf-life. One of the major sources of changes that occurs during processing and storage of meat products is lipid oxidation. Oxidation of lipids influences the color and sensory qualities of meat products. Meat with a high fat content, such as ground meat, is susceptible to lipid oxidation that leads to the development of negative flavor and color changes. Antioxidants are used to control the effects of lipid oxidation. Common antioxidants, such as butylated hydroxanisole (BHA) and butylated hydroxytolune (BHT) and extracts of rosemary, are used in meat products. Sources of antioxidants of plant origin that are naturally occurring recently have been examined. Awika (2000, 2003) found that sorghum bran is rich is phytochemicals that have high antioxidant properties. Jenschke et al. (2004) reported lower TBARS values in ground beef patties containing high levels of sorghum bran stored for up to fourteen days in a high oxygen environment at 4°C. We hypothesize that sorghum bran addition to ground beef patties will reduce lipid oxidation and stabilize color without affecting sensory characteristics during aerobic storage for up to 5 days in a retail display case at 4°C.

Objectives

The objective of this study was to evaluate ground beef patties that have been prepared with different treatments of synthetic and natural antioxidants. This study evaluated the effectiveness of sorghum bran antioxidant activity with varying levels of lipids. Comparative determinations were made by measuring oxidative rancidity, pH, color stability, and sensory characteristics of the ground beef patties. Knowledge from this study will enable future commercial application of sorghum bran varieties as targeted food ingredients to improve food quality and human health.

Methodology

Beef trimmings containing either 50% or 90% lean at 2 days post-fabrication were purchased on one of three processing days from two commercial beef processors. The beef trimmings were formulated into three meat blocks containing either 10, 20 or 30% chemical lipid (verified using the CEM Autoanalyzer). Within a processing day and fat content, ground beef was equally divided into one of six treatments: 1) negative control-no added ingredients; 2) BHA and BHT at .01% of the weight of the meat; 3) rosemary at 0.2% of the meat weight; 4) high level of sorghum at 1.0% of the meat weight; 5) medium level of sorghum at 0.5% of the meat weight; 6) and a low level of sorghum at .25% of the meat weight. Patties, 200 gm, were hand-formed and two patties were placed in a Styrofoam tray that was over-wrapped with PVC film. Six packages within a treatment and fat level were made. Four packages were randomly assigned to a storage day (0, 1, 3, and 5) and displayed at 4° C in a retail coffin display case under standard fluorescent lighting for chemical and color analysis of pH, TBARS, sensory color, and Minolta color space values. Two packages were randomly assigned to either 1 or 5 storage days for trained meat descriptive sensory evaluation.

A Minolta Colorimeter (CR-300, Minolta Co., Ramsey, NJ) was calibrated each day using a white tile and PVC over-wrap and three random locations were evaluated on the exterior surface of one patty per package for CIE L*, a* and b* color space values. The average of the three readings was reported. A six-member selected and trained descriptive color sensory panel evaluated each package for lean color (1=very dark red ;8=light, grayish red), percentage discoloration (1=0%; 7=100%), and discoloration color (1=very dark red; 8=light, grayish red) as defined by AMSA (1991, 1995). pH was determined using a pH meter (HI 98240, Hanna Instruments, Italy). Three readings were obtained randomly. The pH meter was calibrated using 4.0 and 7.0 buffers. Two 60g samples were removed from a patty and ground. The amount of mg malonaldehyde/ 1000 g sample were determined using procedures described by Tarladgis et al (1960) as modified by Rhee et al (1978). Absorbance was measured at 530 nm using a DU-7 spectrophotometer (Beckman Instruments Inc., Fulerton, CA). Purge was measured by weighing the packaged patties, removing the two patties and re-weighing the package materials with the remaining exudates. Weight of the package materials was determined and subtracted from both values to obtain the weight of the patties and the exudates.

Two patties per treatment were cooked to an internal temperature of 73°C on an electrical grill. Internal temperatures were monitored by a copper-constantan thermocouple (Omega Engineering, Stanford, CT) inserted into the geometric center of each patty. The patty was cut into eight equal wedges and served warm to the panelists, within 5 minutes post cooking. Each panelist received two wedges for evaluation. The panel consisted of a six member trained flavor and texture descriptive attribute sensory panel based on AMSA (1995) and Meilgaard et al (1999). Flavor, basic taste, mouth feel, after-taste, and texture attributes were determined during ballot development sessions. The lexicon for warmed over flavor in beef was used as a basis for descriptive attributes (Johnson and Civille, 1987). Panelists were provided samples of ground beef patties similar to treatments defined in the study for ballot development. After the attributes for the ballot were defined, training sessions were conducted. The study was conducted after panelists could consistently and accurately identify sensory attributes (AMSA, 1995). Each panelist was seated in individual booths equipped with red theater gel lights.

Samples were served in a random order and identified using three-digit codes. Unsalted saltine crackers and double distilled, deionized water were provided to the panelists between samples to cleanse their palates. The panelists evaluated each sample using a 15-point universal scale with 0 = none and 15 = extremely intense for attributes defined from ballot development sessions (AMSA, 1995). Three sessions were conducted with six treatment sample evaluations per session. A twenty minute break was given between sessions and samples were served a minimum of four minutes apart.

Data were analyzed as a factorial arrangement by Analysis of Variance using the general linear model (GLM) procedure of SAS (Version 6.12, Cary, NC, 1998) with a predetermined significance level of $P \leq 0.05$. For chemical data, processing day, treatment, fat level and storage day were defined as main effects. Two-way interactions for all main effects were examined and remained in the model if they were significant ($P<0.05$). For sensory data, the data were analyzed to determine the effect of panel and panel interactions. These data then were averaged within panelists and analyzed as defined for the chemical data. Least squares means were calculated and when differences were defined by Analysis of Variance, least squares means were separated using the stderr pdiff function.

Results & Discussion

TBARS

Controls over time had increased TBAR values, indicating oxidation was occurring in the ground beef patties during storage (Figure 1). However, TBAR values were not greater than 1 after five days of storage, demonstrating oxidation was occurring in the patties, but not at a rapid rate. The patties from the treatments containing antioxidants had lower TBAR values after 1, 3, and 5 days of storage when compared to control patties. The TBAR values were slightly greater in the patties at the end of storage (day 5). Jenschke et al. (2004) showed a more pronounced effect in ground beef patties stored for up to fourteen days in an 80% oxygen /20% carbon dioxide environment.

Controls at different fat levels also had increased TBAR values (Figure 2). TBAR values were the highest in the 10% fat patties. As lean meat contains a high proportion of muscle fibers and the phospholipid component in muscle fiber membranes have greater susceptibility to oxidation, these results were expected. Patties containing antioxidant treatments had lower TBAR values when compared to control patties at all fat levels.

Purge, pH and color

Purge was not affected by treatment, fat level or storage day ($P<0.05$). The addition of sorghum tended to increase pH and patties containing a high level of sorghum had the highest pH values (Table 1). Patties with higher fat levels were higher in pH and as storage time increased, pH increased slightly. The addition of rosemary or BHA/BHT resulted in lighter (higher L* color space values and higher sensory lean color scores), were slightly more yellow, had slightly less discoloration and of the lean that was discolored, the discoloration was lighter than control patties. Sorghum bran addition impacted ground beef color (Table 1). Sorghum bran addition at the high level resulted in darker ground beef patties that were less red and yellow. Patties containing sorghum bran has similar discoloration percentage as control patties and the color of the discoloration tended to be lighter than control patties. As fat level increased, ground beef patties were lighter, redder, and had more yellow. Increased storage days resulted in ground beef patties that were darker, less red and yellow, and had higher amounts of discoloration and the discoloration color became darker. Jenschke et al. (2004) found that the addition of sorghum bran at 2.0% of the meat weight resulted in lower raw color scores, greater amounts of discoloration, and darker discoloration. At the lower levels used in this study (high level = 1.0% meat weight), the sorghum bran patties were slightly darker, but differences were less pronounced than in Jenschke et al. (2004).

Sensory

The addition of rosemary and BHA/BHT to ground beef patties were similar in sensory flavor and basic taste attributes to control patties, except patties containing rosemary had less cooked beefy/brothy flavor aromatics than control patties (Tables 2 and 3). However, rosemary, BHA/BHT, and sorghum bran treated patties were harder and more springy than control patties. The addition of sorghum bran resulted in patties with lower levels of cooked beefy/brothy flavor aromatics. The patties containing the medium and high sorghum bran levels had less serumy flavor aromatics, and higher grainy and sorghum flavor aromatics when compared to control patties. Ground beef patties containing the high level of sorghum were slightly more bitter than control patties. Ground beef patties did not contain high levels of cardboardy, painty or fishy flavor aromatics (data not presented). Increasing levels of these aromatics are associated with increased lipid oxidation. As TBARS values were low, high levels of these aromatics would not be expected.

As fat level increased, patties had slightly higher levels of cooked beef fat, and serumy flavor aromatics, less bitter basic tastes, and the patties were softer, juicier and at the highest fat level, patties were more springy.

As storage day increased, patties had lower levels of cooked beefy/brothy flavor aromatics, and higher levels of cooked beef fat and browned flavor aromatics. Patties were harder and more springy with increased storage time.

Jenschke et al. (2004) found multiple off-flavor aromatics in ground beef patties containing 2.0% sorghum bran. By decreasing the level of sorghum bran addition to the patties, high levels of off-flavors were not detected.

Conclusions

Data from this study indicated that the addition of sorghum bran from low to high levels had comparable antioxidant properties to the commonly used food antioxidants, BHA/BHT and rosemary. However, as treated patties had low levels of oxidation, even with up to five days of storage, significant differences between treatments were not found. Except for the control patties, oxidation rates and levels were found to be very low within the patties at different fat levels and over storage time.

Although the addition of sorghum bran reduces TBARS values over time when compared to the controls, the addition of the high sorghum bran level resulted in lower raw color scores, greater amounts of discoloration, darker discoloration, and slightly increased bitter basic taste. Moreover, the addition of sorghum bran reduced TBARS values over time and did not drastically affect color and sensory flavor attributes. Further research to isolate and extract the antioxidant components (anthocyanins and tannins) might reduce the negative effects on color and sensory characteristics of the higher sorghum level by removing unwanted or unnecessary compounds.

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Tables and Figures

Figure 1. Interaction of treatments and storage time on TBARS values for ground beef patties (P=0.04).

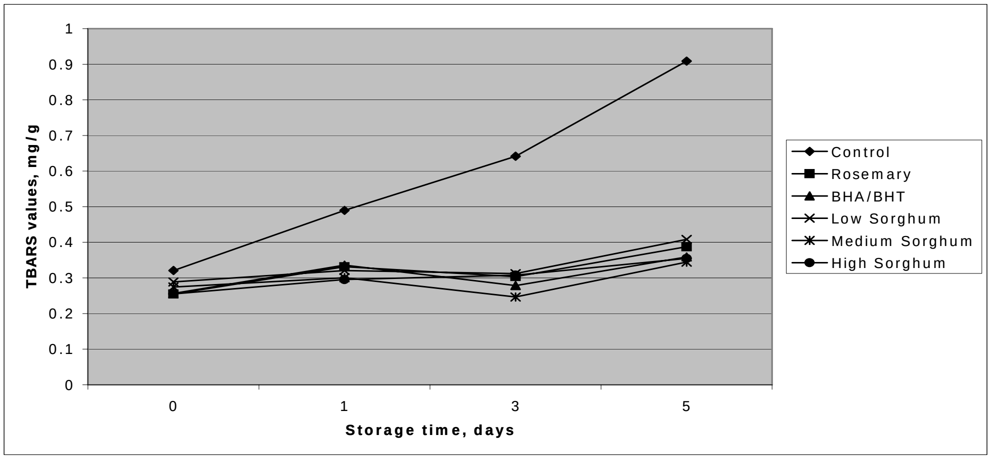

Figure 2. Effect of treatments and fat level on TBARS values of ground beef patties (P=0.02).

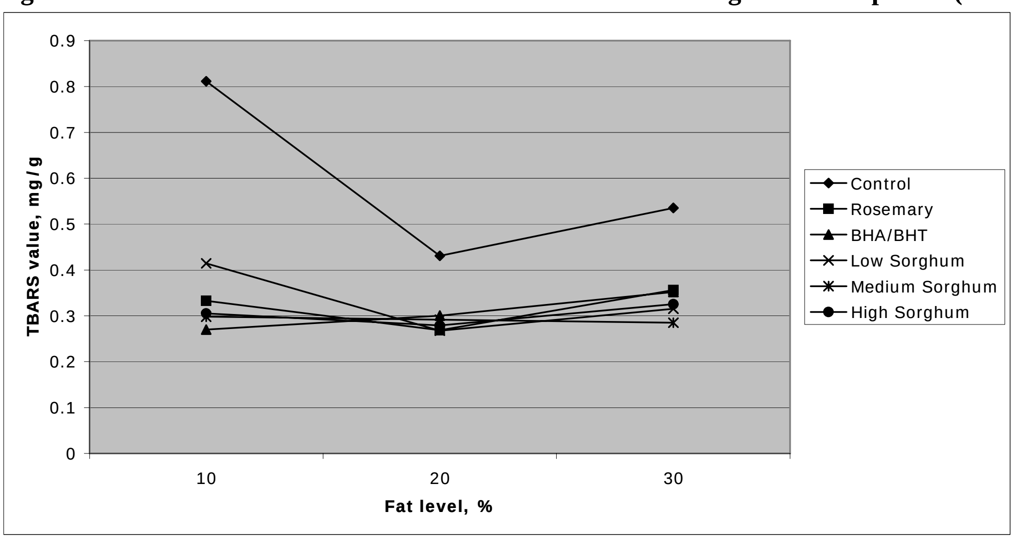

Table 1. Least squares means for main effects pH, Minolta color space values and trained descriptive sensory color attributes.

Effect	pH	Minolta color space values L*	a*	b*	Lean color[a]	Discolor-ation, %[b]	Color of Dis-coloration[a]
Treatment[c]	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.005*	*0.0001*
Control	6.33[de]	47.62[e]	18.92[g]	10.16[f]	2.9[f]	1.3[f]	0.70[g]
Rosemary	6.33[de]	48.85[f]	9.39[g]	10.66[g]	3.3[g]	1.1[d]	0.22[d]
BHA/BHT	6.30[d]	49.36[f]	19.59[g]	10.65[g]	3.3[g]	1.1[de]	0.27[de]
Low sorghum	6.35[e]	47.79[e]	17.85[c]	10.01[f]	2.9[f]	1.3[ef]	0.40[ef]
Medium sorghum	6.36[e]	47.35[de]	16.39[e]	9.58[e]	2.5[e]	1.4[f]	0.52[fg]
High sorghum	6.41[f]	46.51[d]	15.32[d]	8.87[d]	2.0[d]	1.2[def]	0.44[ef]
Fat Level, %[b]	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.0001***	***0.07***	***0.002***
10	6.29[d]	44.88[d]	17.00[d]	8.73[d]	2.2[d]	1.1[d]	0.30[d]
20	6.38[e]	47.95[e]	17.86[e]	10.05[e]	2.8[e]	1.3[e]	0.44[e]
30	6.37[e]	50.91[f]	18.87[f]	11.19[f]	3.6[f]	1.2[de]	0.54[e]
Storage Day[b]	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*	*0.0001*
0	6.24[d]	49.62[f]	21.56[g]	11.16[g]	3.5[g]	1.0[d]	0.08[d]
1	6.47[f]	47.94[e]	18.74[f]	10.16[f]	3.0[f]	1.0[d]	0.09[d]
3	6.26[d]	46.87[d]	17.24[e]	9.52[e]	2.6[e]	1.2[e]	0.49[e]
5	6.41[e]	47.23[de]	14.10[d]	9.14[d]	2.4[d]	1.7[f]	1.04[f]
Root MSE	*0.088*	*2.100*	*1.637*	*0.758*	*0.38*	*0.35*	*0.40*

[a]1=very dark red; 8=light, grayish red.
[b]1=none or 0%; 7=total discoloration or 100%.
[c]P-value from analysis of variance tables.
[def] Mean values within a column and a main effect followed by the same letter are not significantly different ($P > 0.05$).

Table 2. Least squares means for main effects for trained sensory flavor aromatics descriptive attributes[a].

Effect	Cooked Beefy/Brothy	Cooked Beef Fat	Serumy	Grainy	Browned	Sorghum
Treatment[b]	*0.0001*	*0.25*	*0.0001*	*0.0001*	*0.017*	*0.0002*
Control	5.00[f]	3.28[c]	1.86[d]	0.58[c]	1.27[c]	0.24[c]
Rosemary	4.68[de]	3.45[cd]	2.03[d]	0.71[c]	1.25[c]	0.25[c]
BHA/BHT	4.86[ef]	3.32[cd]	1.94[d]	0.58[c]	1.48[cd]	0.24[c]
Low sorghum	4.59[d]	3.51[d]	1.93[d]	0.73[c]	1.27[c]	0.37[cd]
Medium sorghum	4.63[d]	3.40[cd]	1.45[c]	1.04[d]	1.70[d]	0.60[de]
High sorghum	4.36[c]	3.40[cd]	1.40[c]	1.12[d]	1.55[cd]	0.68[e]
Fat Level, %[b]	***0.029***	***0.0001***	***0.39***	***0.35***	***0.58***	***0.66***
10	4.61[c]	3.16[c]	1.71[c]	0.85[c]	1.42[c]	0.37[c]
20	4.79[d]	3.44[d]	1.82[c]	0.75[c]	1.48[c]	0.37[c]
30	4.62[c]	3.58[d]	1.78[c]	0.72[c]	1.36[c]	0.44[c]
Storage Day[b]	*0.0005*	*0.026*	*0.22*	*0.15*	*0.034*	*0.25*
1	4.78[d]	3.33[c]	1.81[c]	0.75[c]	1.33[c]	0.36[c]
5	4.57[c]	3.46[d]	1.73[c]	0.84[c]	1.51[d]	0.43[c]
Root MSE	***0.309***	***0.308***	***0.438***	***0.318***	***0.455***	***0.355***

[a]Aromatics: 0=none; 15=extremely intense.

[b]P-value from analysis of variance tables.

[cdef]Mean values within a column and a main effect followed by the same letter are not significantly different ($P > 0.05$).

Table 3. Least squares means for main effects for trained sensory texture and bitter basic taste descriptive attributes.

	Basic Tastes	Texture			
Effect	Bitter[a]	Hardness[b]	Juiciness[c]	Springiness[d]	
Treatment[e]	*0.0069*	*0.0001*	*0.60*	*0.002*	
Control	2.47[f]	5.78[f]	2.77[f]	6.93[f]	
Rosemary	2.61[fgh]	6.13[g]	2.91[f]	7.38[g]	
BHA/BHT	2.76[h]	6.26[g]	2.76[f]	7.49[g]	
Low sorghum	2.49[fg]	6.33[g]	2.84[f]	7.55[g]	
Medium sorghum	2.57[fg]	6.33[g]	2.79[f]	7.41[g]	
High sorghum	2.65[gh]	6.23[g]	2.89[f]	7.38[g]	
Fat Level, %[e]	***0.048***	***0.0002***	***0.01***	***0.017***	
10	2.66[g]	6.35[h]	2.70[f]	7.48[g]	
20	2.59[fg]	6.17[g]	2.91[g]	7.42[g]	
30	2.52[f]	6.01[f]	2.87[g]	7.17[f]	
Storage Day[e]	*0.19*	*0.0001*	*0.09*	*0.001*	
1	2.56[f]	5.98[f]	2.77[f]	7.11[f]	
5	2.62[f]	6.37[g]	2.88[f]	7.61[g]	
Root MSE	***0.331***		***0.311***	***0.468***	***0.242***

[a]Basic tastes: 0=none; 15=extremely intense.
[b]1=very soft; 15=very hard.
[c]1=none; 15=very juicy.
[d]1=not springy; 15=very springy.
[e]P-value from analysis of variance tables.
[fgh]Mean values within a column and a main effect followed by the same letter are not significantly different ($P > 0.05$).