Effects of Addition of Wheat Fiber on Color and pH of Hamburger

Efeitos da Adição de Fibra de Trigo na Cor e pH de Hambúrguer de Carne Bovina

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Abstract

The development of beef burger with added wheat fiber is an interesting alternative with functional appeal because burgers are part of the routine diet of most Brazilians due to its sensory characteristics and ease of preparation. However, understanding the technological aspects and the best method to apply functional ingredients to meat products are essential so that the products do not lose their characteristics. The objective of this study was to evaluate the effects of addition of wheat fiber with different particle sizes on color and pH of hamburger during 75 days of storage at -18 °C. The results indicated that the addition of wheat fiber with different particle sizes into beef burgers did not influence the pH but affected the color of the products (L*, a* and b* parameters). The mixture of fibers in the proportions tested (4% or 8%) negatively affected the color of the product during the 75 days at -18 °C. The dietary fiber presenting smaller particle size (35 µm length and 20 µm thickness) that was tested until 4% level has shown to be a viable alternative for the development of a functional beef burger. The good results obtained for this fiber can be explained by its better distribution and interaction with the meat mixture, minimizing the effects of color change, which were worse for the products containing dietary fiber with larger particle (250 µm length and 25 µm thickness).

Keywords: Food. Color. Hydrogen-Ion Concentration.

Resumo

O desenvolvimento de hambúrguer adicionado de fibra de trigo é uma alternativa interessante de alimento com apelo funcional, pois este produto já faz parte da rotina alimentar da maioria dos brasileiros, em virtude de suas características sensoriais e facilidade de preparo. No entanto, o entendimento dos aspectos tecnológicos e a melhor forma de aplicar os ingredientes funcionais aos produtos cárneos são fundamentais para que estes não percam suas características. O objetivo deste estudo foi avaliar os efeitos da adição de fibra de trigo com diferentes granulometrias na cor e no pH de hambúrguer durante 75 dias de estocagem a -18 °C. Os resultados indicaram que a adição de fibra com diferentes granulometrias não afetou o pH, mas afetou a cor dos produtos (parâmetros L, a* e b*). A mistura das fibras nas proporções testadas (4% ou 8%) afetou negativamente a cor dos produtos durante os 75 dias de estocagem a -18 °C. A fibra de menor granulometria (35 µm de comprimento e 20 µm de espessura), que foi testada até o nível de 4%, mostrou ser uma alternativa viável para o desenvolvimento de hambúrguer com apelo funcional. Os bons resultados obtidos por esta fibra podem ser explicados pela sua melhor distribuição e interação com a massa cárnea, minimizando os efeitos da mudança de cor que foram piores para a fibra de maior granulometria (250 µm de comprimento e 25 µm de espessura).*

Palavras-chave: *Alimentos. Cor. Concentração de Íons de Hidrogênio.*

1 Introduction

Dietary fiber consists of substances originates from either animal or plant sources, being resistant to the hydrolysis of enzymes in the gastrointestinal tract[1]. The presence of fiber in food is of great interest in terms of health; numerous studies have reported the role of dietary fiber in the prevention of certain diseases such as diverticulitis, colon cancer, obesity, diabetes and cardiovascular problems[2-5]. The dietary fiber is desirable not only for its nutritional properties, but also due to its functional, technological and economic properties that form gel, retain water and fat, increase viscosity, and influence texture, formation and stability of emulsions[6,7]. However, understanding the technological aspects and the best method of applying functional ingredients to meat products are essential so that they do not lose their physicochemical and sensory characteristics.

Some research has been carried out on the use of fiber from orange, rice bran, sugar beet, and wheat in gels and emulsified meat products such as sausage and bologna[4,8-11]. However, there are few studies on restructured products such as hamburgers [12,13] and there is also little research assessing the effect of the addition of wheat fiber with different particle sizes on pH and color of the product. Furthermore, the development of hamburger with added wheat fiber is an interesting alternative with functional appeal because this product is part of the diet of most Brazilians due to its sensory characteristics and ease of preparation.

The objective of this study was to evaluated the effects of addition of wheat fiber with different particle sizes in color and pH of hamburger during 75 days of storage at -18° C.

2 Material and Methods

The experiments were performed in the laboratories of the Department of Food Science and Technology (DTCA) of the Federal University of Santa Maria (UFSM). The project was approved by the Ethics Committee (CAAE: 07188612.6.0000.5346). For the development of the burger formulations, the Technical Regulation of Identity and Quality of Burgers[14], Ordinance No. 1004[15] was followed, and a 2^2 central composite design was used. The raw material consisted of beef donated by the Cooperative of Central Western Santa Catarina (Aurora Alimentos).

The raw material (84%) was crushed (5 mm disc) and mixed with the following ingredients and additives: water (3%), soy protein (4%), sodium chloride (0.7%), garlic powder (1.2%), sodium glutamate (0.3%), maltodextrin (0.3%), tripolyphosphate (0.5%), parsley (0.2%), hamburger seasoning (1.5%), erythorbate (0.1%), sodium lactate (0.01%), smoke (0.04%), nitrite (0.01%) and carmine dye (0.002%). The addition of dietary fiber was carried out according to the experimental design shown in Table 1.

Table 1: Central composite design (CCD) 2^2 for the development of hamburgers containing wheat fiber (real and coded values).

Ingredients*	Fiber 200 (%)	Fiber 600/30 (%)
T1	0.0	0.0
	(-1)	(-1)
T2	4.0	0.0
	(+1)	(-1)
T3	0.0	4.0
	(-1)	(+1)
T4	4.0	4.0
	(+1)	(+1)
T5**	2.0	2.0
	(0)	(0)

* % refers to the percentage of ingredients added in the final product.
** refers to the Central Point (CP).

The fibers were donated by the Rettenmaier Latinoamericana company (São Paulo, SP) and were Fiber 200 (250 mm in length and 25 mm in thickness) and Fiber 600/30 (35 mm in length and 20 mm in thickness), both of which were manufactured by Vitacel®, and which comprised 74 % cellulose, 26 % hemicellulose, and 0.5 % lignin (supplier data).

After the preparation of the meat mixture and manual molding, the samples were packaged and stored at -18° C in low-density polyethylene package prior to analysis. The following determinations were performed: pH by electrometric determination according to the official methodology[16], and color measurements.

For pH determination, the samples were thawed in a refrigerator (4° C) and ground prior to analysis. For color measurements, the frozen samples were evaluated and color was measured according to the CIE system, using the L*, a* and b* coordinates (CIELAB scale) where L* is brightness, a* is intensity of red, and b* is intensity of yellow. A calibrated colorimetric spectrophotometer, Minolta® CR-310 (Konica Minolta Sensing Americas Inc., Ramsey, New Jersey, USA) with D65A illuminant was used, and the readings were taken on the surface of the products.

Three replicates were performed for each treatment and the samples were analyzed every fifteen days until 75 days of storage at -18° C (the expiration date commonly used by the producing industries). The results were submitted to analysis of variance (ANOVA) and Tukey's test with a significance level of 5%. All these analyses were performed using Statistica® 9.0 (STATSOFT, INC).

3 Results and Discussion

Despite a significant difference ($p<0.05$) was observed for pH values of the samples during the follow-up period no significant difference ($p>0.05$) was found for all samples, on the 75th day (final pH) (Table 2).

Table 2: pH values over 75 days for the hamburgers stored at -18° C

Storage time (days)	T1	T2	T3	T4	T5
15	6.35^{aAB}±0.04	6.33^{abAB}±0.05	6.30^{bcA}±0.00	6.42^{bB}±0.02	6.37^{bAB}±0.04
30	6.48^{aA}±0.23	6.50^{bcA} ±0.10	6.35^{cA} ±0.11	6.50^{bcA}±0.03	6.58^{bA} ±0.16
45	6.45^{aA} ±0.17	6.66^{cA} ±0.13	6.60^{dA} ±0.04	6.63^{cA}±0.07	6.62^{bA} ±0.05
60	6.24^{aAB}±0.08	6.15^{aAB} ±0.13	6.13^{abA}±0.11	6.40^{bB}±0.02	6.36^{bAB}±0.06
75	6.14^{aA} ±0.03	6.08^{aA} ±0.05	6.01^{aA} ±0.06	6.09^{aA}±0.09	5.98^{aA} ±0.10

* Means with different lower case letters in the column differ significantly ($p<0.05$) and means with different upper case letters in the row differ significantly ($p<0.05$).
**T1: 0 % fiber, T2: 4 % Fiber 200, T3: 4 % Fiber 600/30, T4: 4 % Fiber 200 + 4 % Fiber 600/30 and T5: 2 % Fiber 200 + 2 % Fiber 600/30.

The addition of dietary fiber did not alter the final pH of the samples for all treatments. The results were consistent with the values from 5.9 to 6.1 suggested as adequate[17,18]. Prestes[19] also found a reduction in the pH of chicken ham after 60 days of storage, and Yilmaz and Daglioglu[20] reported that the addition of oat bran into meatballs resulted in an increased pH. Casarotto[21] also found a variation in pH values in sausages during storage (4° C for 60 days), in which the pH decreased until the 45th day, and then increased at the end of the storage.

The slight variations during storage and the lower values at the end of monitoring can be justified by the protein oxidation during storage (alkaline compounds)[22] and also due to the presence of metabolites of deteriorative microorganisms.

There was a significant difference ($p<0.05$) for L* values over the follow-up period except for T4, where the brightness remained during the 75 days; the other treatments showed an increase in brightness over time (Table 3). The addition of fiber and fiber mixtures reduced the L* values of the treated samples when compared with T1 (without fiber addition). The fiber with larger particle size (Fiber 200) showed less reduction in L* when compared to the fiber with smaller particle size (Fiber 600/30) or to the fiber mixtures, probably because the lower granulometry allows appropriately mixing. The reduction in brightness was a negative result since it affects the appearance and acceptance of the product, which may keep brightness during shelf-life.

Table 3: Color parameters L* (lightness), a* (red) and b* (yellow) over 75 days stored at -18° C for different formulations of beef hamburgers containing wheat fiber with different particle sizes (T1 to T5).

Storage time (days)	L*				
	T1	**T2**	**T3**	**T4**	**T5**
15	55.19^{bBC}±0.26	57.09^{dD} ±0.18	52.81^{abAB}±0.73	55.39^{aC} ±0.61	51.8^{bA}± 1.15
30	51.26^{aA} ±0.25	53.86^{aBC}±0.17	52.31^{aAB}±0.47	54.52^{aC} ±2.14	51.50^{bA}±0.27
45	53.56^{bB} ± 0.20	54.88^{bC} ±0.15	53.31^{bcB} ±0.48	54.45^{aC} ±0.29	50.08^{aA}±0.18
60	57.22^{cE} ±0.16	55.84^{cD} ±0.13	55.14^{dC} ±0.10	53.73^{aB} ±0.19	50.44^{aA}±0.14
75	57.20^{cE} ± 0.0	55.88^{cD} ±0.16	53.60^{cB} ± 0.18	54.64^{aC} ±0.11	52.82^{cA}±0.54
Days	**a***				
	T1	**T2**	**T3**	**T4**	**T5**
15	13.81^{dD}±0.67	12.34^{cC}±0.45	14.74^{cE}±0.48	9.94^{bA}±0.37	11.48^{bB}±0.41
30	11.73^{cB}±0.07	12.06^{cC}±0.07	12.27^{bD}±0.09	10.03^{bcA}±0.04	12.33^{cD}±0.06
45	11.66^{cC}±0.05	10.87^{bB}±0.03	10.91^{aB}±0.10	10.30^{cA}±0.04	12.59^{cD}±0.06
60	8.06^{aA}±0.02	10.41^{aC}±0.04	12.40^{bD}±0.06	9.34^{bB}±0.03	13.19^{dE}±0.05
75	9.14^{bA}±0.01	10.75^{abC}±0.03	10.97^{aD}±0.06	9.03^{aA}±0.08	9.96^{aB}±0.12
Days	**b***				
	T1	**T2**	**T3**	**T4**	**T5**
15	13.79^{cB}±0.,26	13.50^{cB}±0.11	13.39^{bB}±0.36	14.44^{cC}±0.20	12.24^{bA}±0.39
30	13.09^{aC}±0.09	12.53^{aA}±0.03	12.84^{aB}±0.15	12.93^{aB}±0.03	12.44^{bA}±0.05
45	13.30^{aD}±0.06	12.77^{bB}±0.04	13.52^{bE}±0.14	12.96^{aC}±0.05	12.45^{bA}±0.08
60	13.56^{bB}±0.06	13.78^{dC}±0.06	13.88^{cD}±0.04	13.41^{bD}±0.24	12.53^{bA}±0.09
75	13.31^{aC}±0.03	13.80^{dE}±0.06	12.70^{aB}±0.06	13.46^{bD}±0.02	10.00^{aA}±0.05

*Means with different lower case letters in the colunm differ significantly ($p<0.05$) and means with different upper case letters in the row differ significantly ($p<0.05$). **T1: 0 % fiber, T2: 4 % Fiber 200, T3: 4 % Fiber 600/30, T4: 4 % Fiber 200 + 4 % Fiber 600/30 and T5: 2 % Fiber 200 + 2 % Fiber 600/30.

Youssef and Barbut[23] reported that the addition of soy protein at a concentration of 1.50 % in emulsions also reduced L* values due to the reduction of myoglobin concentration, which results in darker products.

There was a significant difference ($p< 0.05$) for a* values for all experiments over 75 days (Table 3), and all samples showed reduced a* values (red color reduction) over time, which was expected due to lipid oxidation. T4 showed the lowest a* value due to the higher percentage of fiber in the product (4 % Fiber 600/30 and 4 % Fiber 200). When the fibers were used alone (T2 and T3) better results were observed (higher a* values), since a* values were higher than the standard (T1 formulation without fiber).

Table 4 shows the effects of the input variables (% of Fiber 200, Fiber 600/30 and their mixtures) in the variable response a* (R^2 = 89.67%). It can be observed that all the effects were significant ($p<0.05$). It was noted that both variables studied had a negative effect on the a* coordinate, which is detrimental to the product because it indicates a decrease in red color. The effects of the fiber mixture were smaller than the effect of Fiber 200 alone. In a study by Choe *et al*.[24], the L* and a* values were affected ($p<0.05$) due to an increase in the concentration of wheat fiber in sausage. These same authors also reported a decrease in L* and a* values in meat gels with added rice bran.

Table 4: Effects of the input variables Fiber 200, Fiber 600/30 and their mixtures in response to the variable a* (red) for the hamburger formulations.

	a*		
	Effects	**Standard Variation**	**p**
Mean/Interaction	12.705	0.110	< 0.001*
(1) Fiber 200	-3.218	0.245	< 0.001*
(2) Fiber 600/30	-0.798	0.245	< 0.023*
1X2	-1.637	0.245	< 0.001*

*Significance of 5 %.

Jiménez-Colmenero *et al*.[25] also found a reduction of a* (3.50 to 2.80) and an increase in b* (9.90 to 10.20) values in sausages with a reduced content of sodium caseinate, wheat fiber (the same as used in the present study) and transglutaminase. Sánchez-Alonso *et al.*[13] also tested 3 and 6 % WF200 fiber (Vitacel®) in surimi, and found decreased L* and increased b* values. In both studies the storage of the products was not studied.

The reduction in a* values has a negative impact on the final product because it reduces the bright red color that is attractive to consumers. An explanation for this behavior is that the proteins typically absorb light in the UV region (280 nm), and the interaction with the fiber (mainly smaller grain size) probably causes an increase in absorption, leaving it to near 400 nm. Other factors, such as the oxidation of substances present in the product including polysaccharides may also cause an increase in absorption.

There was a significant difference ($p< 0.05$) in the b* values for all samples over 75 days and between treatments (Table 3). T2 (4 % Fiber 200) showed higher b* values at the end of the storage, i.e. a more yellow product, while T5 (2 % Fiber 600/30 and 2 % Fiber 200) had lower b* values, even better than the standard (T1).

Choe *et al*.[24] tested various fat substitutes in sausages and observed an increase in b* values from 12.94 ± 0.49 to 13.86 ± 0.56 for the formulations with 20 % fat replacement by a mixture of pig skin and wheat fiber.

There is some unanimity that the addition of carbohydrates (fiber and maltodextrins) in meat products leads to a reduction in L* and a* and an increase in b* values, as reported in other studies[9,19]. These differences in L*, a* and b* values negatively affect the product, but they are not always perceived by consumers.

Although the fibers tested in the present study presented the same composition, the effects on the color of the product differed, showing that the structural features of fibers must be taken into account when they are applied to meat products. The fiber with smaller particle size (Fiber 600/30 of 35 mm length and 20 mm thickness) tested until 4% level was shown to be a viable alternative for the development of a functional beef burger. The good results obtained for this fiber can be explained by its better distribution and interaction with the meat mixture, minimizing the effects of color change, which were worse for the products containing dietary fiber with larger particle (250 mm length and 25 mm thickness).

4 Conclusion

The addition of wheat fiber with different particle sizes into hamburger did not influence the pH at the end of 75 days but affected the color of the products (L*, a* and b* parameters). The mixture of fibers (larger and smaller particle size) in the proportions studied negatively affected the color of the product during the 75 days at -18° C, and thus would not be suitable for the development of a hamburger with functional appeal. Although the color change does not directly characterize the reduction of product quality, it could lead to rejection by consumers. The best results were found for Treatment T3, which used dietary fiber with the smallest particle size (35 mm length and 20 mm in thickness).

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