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Elaboration of pork burger added with prebiotics as a fat substitute

Elaboração de hambúrguer suíno adicionado de prebiótico como substituto de gordura

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ABSTRACT

This study aimed to create pork burgers with polydextrose, developing three formulations: F1 (10% fat), F2 (10% fiber), and F3 (15% fiber). The centesimal composition, oxidative stability (pH, TBARS, color), and water retention capacity (WHC) were evaluated over 120 days of storage. All formulations had 19% protein, with F2 and F3 having the lowest lipid content (1.8% and 1.9%, respectively). pH values remained between 5.36 and 5.50. No lipid oxidation occurred in the polydextrose formulations during the first 60 days. The red color (a*) decreased, indicating myoglobin oxidation. F1 experienced greater water loss (7.9%), while F2 and F3 lost only 3.9%. The study concluded that polydextrose can replace fat in the product, reduce lipid oxidation, and improve yield and quality.

Keywords: low fat; meat derivatives; food fibers

RESUMO

Este estudo teve como objetivo criar hambúrgueres de carne suína com polidextrose, desenvolvendo três formulações: F1 (10% de gordura), F2 (10% de fibra) e F3 (15% de fibra). A composição centesimal, a estabilidade oxidativa (pH, TBARS, cor) e a capacidade de retenção de água (CRA) foram avaliadas ao longo de 120 dias de armazenamento. Todas as formulações apresentaram 19% de proteína, com F2 e F3 apresentando o menor teor de lipídios (1,8% e 1,9%, respectivamente). Os valores de pH permaneceram entre 5,36 e 5,50. Não ocorreu oxidação lipídica nas formulações de polidextrose durante os primeiros 60 dias. A cor vermelha (a*) diminuiu, indicando oxidação da mioglobina. F1 apresentou maior perda de água (7,9%), enquanto F2 e F3 perderam apenas 3,9%. O estudo concluiu que a polidextrose pode substituir a gordura no produto, reduzir a oxidação lipídica e melhorar o rendimento e a qualidade.

Palavras-chave: baixo teor de gordura; derivados de carne; fibras alimentares

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INTRODUCTION

The hamburger is widely consumed in many countries due to its practicality and taste. However, the significant presence of animal fat in its formulation has led to a growing reduction in the consumption of lipid-rich meats, as consumers seek a healthier lifestyle. They are increasingly interested in products that are tasty, nutritious and improve their quality of life. To meet this demand, the food industry has invested in the use of functional ingredients that offer technological benefits. Among the ingredients with functional and technological potential we can mention dietary fibers. These components are classified as soluble, viscous or easily fermentable fibers (Silva *et al.*, 2023; Pasin *et al.*, 2021). A dietetic fiber that is fermented in the colon and recognized for its prebiotic properties, making it popular in the food industry. This fiber offers various technical and functional benefits, serving as a source of fiber and a substitute for fat, sugar, and thickeners, among other uses. Additionally, it promotes digestive health by supporting the growth of beneficial microorganisms. (Silva *et al.*, 2023; Rocca Pereira *et al.*, 2019; Additives & Ingredients, 2016).

Based on the search for healthier foods, this work aimed to develop pork burgers with polydextrose, followed by proximate characterization, determination of the physicochemical and physical characteristics and evaluation of the oxidative stability of these products during 120 days of storage.

MATERIALS AND METHODS

Material and Microbiological Quality of the Raw Material

Pork meat and other ingredients for the burgers were purchased from supermarkets in Fortaleza (CE), while the polydextrose was supplied by a specialized company. The pork underwent microbiological tests for Salmonella, Escherichia coli, coagulase-positive Staphylococcus and mesophilic aerobes, following the APHA methodology (2015) and Brazilian Legislation (BRASIL, 2022).

Burger Preparation

Three pork burger formulations were prepared: F1 (standard, 10% added fat), F2 (10% added fiber), and F3 (15% added fiber). All ingredients, except for polydextrose and water, were used in the same proportions in three formulations: pork meat (80%), fat (10%), salt (0,7%), textured soy protein (2,3%), antioxidant (0,01%). piper (0,2%), garlic (0,5%) and onion (0,3%).

Centesimal Composition and Caloric Value

The moisture, protein, lipid, and ash contents were determined following Aoac (2011), and carbohydrates were calculated by difference. The caloric value was calculated using Atwater's conversion factors (9 kcal/g for lipids, 4 kcal/g for carbohydrates and proteins).

Water holding capacity (WHC/CRA)

The water holding capacity was measured by adding a sodium chloride solution to the hamburger samples, resting them in an ice bath, shaking, and measuring the supernatant volume, expressed as mL per 100g of sample (HONIKEL, 1998).

pH and Color Determinations

pH was measured by weighing 10g of ground meat and using a pH meter (AOAC, 2011). Color was assessed using a colorimeter to obtain CIE values (L*, a*, b*).

Lipid Oxidation (TBARS)

Lipid oxidation was evaluated using the thiobarbituric acid reactive substance assay (TBARS), with modifications from Raharjo *et al.* (1992).

Statistical Analysis

Experiments were performed in triplicate, and results were expressed as mean ± standard deviation or confidence interval. Statistical significance at a 5% level was determined using ANOVA, followed by Tukey's test for pairwise comparisons.

RESULTS AND DISCUSSION

The presence of E. coli, Salmonella sp., mesophilic aerobes and coagulase-positive Staphylococci was not found in the raw material, which confirms compliance with current legislation. Based on this result, the development of burger formulations continued.

The approximate composition of hamburger formulations can be seen in Table 1. It was observed that the moisture content in sample F2 (10% polydextrose) did not differ from the control sample (F1), but in sample F3 (15% polydextrose), the moisture content may have been reduced by the amount of water added to the formulation. The palatability and juiciness of meat products are directly related to moisture content (Borba *et al.*, 2013).

of around 35%, a value above the limit established (25%) by Brazilian legislation.

During the 120 days of storage, the water holding capacity varied from 3.94 to 7.98 (mL 100g-1), with the lowest values in the formulations with polydextrose (F2 and F3) and the highest in the control formulation (F1) (Table 2).

The standard formulation had higher water holding capacity (WHC), likely due to the absence of polydextrose. WHC indicates the amount of water meat remains during processing and is inversely related to water loss during cooking (Warner *et al.*, 2014). Formulations F2 and F3 maintained constant WHC values over 120 days of freezing, likely because polydextrose enhances water holding through hydrogen bonds with water.

Table 1 - Centesimal composition of burgers (F1, F2 and F3)

Parameters	F1	F2	F3
Moisture (%)	68,27a ± 0,54	68,17a ± 0,39	64,64b ± 0,29
Ash (%)	1,15a ± 0,003	1,16a ± 0,02	1,16a ± 0,01
Lipidis (%)	8,82a ± 0,08	1,86b ± 0,04	1,93b ± 0,01
Proteíns (%)	19,93a ± 1,08	19,78a ± 0,34	19,97a ± 0,20
Carboidrathes (%)	1,81a ± 5,35	9,00b ± 5,35	12, 28c ± 5,35
Calorific value (kcal g1)	166,43a	131,94b	146,48c

Source: The authors (2023)
F1 = Burger formulation with added fat (standard formulation); F2 = Burger formulation with the addition of 10% fiber; F3 = hamburger formulation with added 15% fiber. Values expressed as mean ± standard deviation. Different lowercase letters in the same column indicate a significant difference between the samples Tukey's test ($p < 0.05$).

All samples were within the limits established by the Hamburger Quality Identity Technical Regulation (Brasil, 2022) for lipid and protein parameters; exception for the carbohydrate content in formulations F2 and F3, which presented values above the established (3%).Formulations F2 (10% polydextrose) and F3 (15% polydextrose) had a lower lipid content, which can be explained by the addition of polydextrose to replace fat, resulting in lower caloric values, since lipids provide 9 kcal g-1.

Oliveira *et al.* (2014) found a reduction in total lipid content and caloric value when developing hamburgers with flaxseed flour. Araújo (2017), developed four hamburger formulations added with yellow passion fruit pectin and found lipid variations between 2.31 and 13.84%. In another study, Inô *et al.* (2020), developed four formulations of beef burgers added with oat flour and observed a reduction in lipid levels

According to Wang *et al.*, 2013 and Essa & Elsebaie, (2022), carbohydrates contain many hydroxyl groups, which form hydrogen bonds with water, enhancing water holding capacity (WHC). The WHC is influenced by factors such as the ingredients, particle size, hydration time, storage temperature and pH. Additionally, the presence, size and location of ice crystals can affect the water holding capacity.

The pH values varied between 5.36 and 5.50 during the evaluation period and were within the acceptable range, since meat products are suitable for consumption with a pH of up to 6.2-6.4 (Table 3) (Brasil, 2017). This parameter is relevant because it is related to the quality of the product during storage. Increased pH values in meat products indicate microbial or chemical alterations.

The values for TBARS varied between 0.44 and 2.30 mg of MDA kg-1, and it can be observed that up to 60 days of storage there was no lipid oxidation (Table 4).

Although Brazilian legislation does not establish limits for malonaldehyde in meat products, some authors suggest that values below 1.5 mg of MDA per kg of sample do not alter the organoleptic properties of the product, that is, oxidation is not perceived sensorially and does not represent a risk to the consumer's health. (Rosa *et al.*, 2015; Fernandes *et al.*, 2012). In formulation F1, which contained synthetic antioxidant, no lipid oxidation was observed during the 120 days of frozen storage. However, formulations F2 (10% polydextrose) and F3 (15% polydextrose) had higher

Table 2 - Water holding capacity (WHC) of pork burger formulations during 120 days of freezing storage.

WHC (mL 100g1 sample)			
Day	**F1**	**F2**	**F3**
0	7,85a ± 2,26	3,95b ± 2,28	3,94b ± 2,27
120 days	3,97b ± 0,002	3,98b ± 2,29	3,98b ± 2,30

Source: The authors (2023)
F1 = Burger formulation with added fat (standard formulation); F2 = Burger formulation with the addition of 10% fiber; F3 = hamburger formulation with added 15% fiber. Values expressed as mean ± standard deviation. Different lowercase letters in the same column indicate a significant difference between the samples Tukey's test ($p < 0.05$).

Table 3- pH values of pork burger formulations during 120 days of freezing storage.

Freenzing storage in days	Formulations		
	F1	**F2**	**F3**
0	5,36a ± 0,01	5,42b ± 0,01	5,36a ± 0,005
30	5,42a ± 0,03	5,43a ± 0,02	5,39a ± 0,01
60	5,48a ± 0,02	5,59b ± 0,005	5,50a ± 0,01
120	5,44a ± 0,01	5,49b ± 0,01	5,44a ± 0,01

Source: The authors (2023)
F1 = Burger formulation with added fat (standard formulation); F2 = Burger formulation with the addition of 10% fiber; F3 = hamburger formulation with added 15% fiber. Values expressed as mean ± standard deviation. Different lowercase letters in the same column indicate a significant difference between the samples Tukey's test ($p < 0.05$).

Table 4 - Lipid oxidation (TBARS) of pork burger formulations during 120 days of frozen storage.

TBARS (mg de MDA kg^{-1})				
Formulations	**0 day**	**30 days**	**60 days**	**120 days**
F1	0,44Aa ± 0,01	0,47Aa ± 0,01	0,49Aa ± 0,02	0,61Ba ± 0,03
F2	0,91Ab ± 0,007	0,93Ab ± 0,01	0,99Ab ± 0,02	1,55Bb ± 0,14
F3	1,08Ac ± 0,04	1,12ABc ± 0,008	1,21ABc ± 0,02	2,30Cc ± 0,08

Source: The authors (2023)
F1 = Burger formulation with added fat (standard formulation); F2 = Burger formulation with the addition of 10% fiber; F3 = hamburger formulation with added 15% fiber. Values expressed as mean ± standard deviation. Different lowercase letters in the same column indicate a significant difference between the samples Tukey's test ($p < 0.05$).

initial TBARS values compared to the control. This behavior can be attributed not to an effective lipid oxidation process, but rather to analytical interferences that occur in the TBARS method.

During the test, conducted in an acidic medium (5% trichloroacetic acid) and under heating (96 °C) for 50 min, carbohydrates (such as polydextrose) undergo thermal degradation and Maillard-type reactions, generating carbonyl compounds such as furfural and 5-hydroxymethylfurfural (HMFP), capable of reacting with thiobarbituric acid (TBA) and forming chromophores that are also identified in the same range as the MDA-TBA chromophore (532 nm), thus promoting an overestimation in the results (Guillén-Sans, Guzmán-Chozas, 1998; Sun *et al*, 2001; De León, Borges, 2020; El Hosry et al 2025).

Thus, the greater availability of carbohydrates from polydextrose explains the higher initial values in F2 and F3, without this necessarily indicating lipid oxidation (Abeyrathne, Nam, Ahn, 2021). This interpretation is reinforced by the pH results obtained in the formulations (Table 3), which did not show a significant difference at the 5% level at the initial moment and remained stable throughout the storage period, with no signs of oxidation.

Color is a key meat quality indicator, reflecting freshness for consumers (Umaraw *et al.*, 2020). After 120 days of freezing, the formulations showed differences in color parameters a*, b*, and c* (Table 5).

F1 had a significant reduction in all three, with a* (red color) decreasing likely due to myoglobin oxidation. Luminosity (L*) also decreased over 60 days and changes in b* were noted but not significant for fresh meat color (Zhang *et al.*, 2013). The discoloration may be caused by lipid and protein oxidation, their interactions and bacterial growth (Hoa *et al.*, 2022).

CONCLUSION

The addition of polydextrose reduces the fat and calorie content of the hamburger, but may promote oxidative rancidity, color changes due to myoglobin oxidation and sensory changes after 60 days of frozen storage. However, fiber enhances water retention, leading to greater product yield and larger hamburgers, benefiting the processing aspect. Further studies are recommended to better understand the reactions during stability.

Table 5- Color parameters of pork burger formulations at 120°C storage time under freezing

Formulations	L*	a*	b*
Time 0 day			
F1 (%)	65,46a± 0,24	11,76a ± 0,12	40,70a ± 0,47
F2 (%)	53,24b± 0,22	14,82b± 0,12	36,87b± 0,45
F3 (%)	49,78c± 0,54	14,79b± 0,16	36,65b± 0,27
Time 30 days			
F1 (%)	53,08a ±1,00	6,48a ± 1,06	16,67a±1,81
F2 (%)	47,72b± 0,06	6,90a ± 0,19	16,35a± 0,23
F3 (%)	43,96c± 0,90	7,08a ± 0,60	18,45a± 0,36
Time 60 days			
F1 (%)	49,65a± 0,56	7,06a ± 0,48	17,76a ±1,96
F2 (%)	45,36b±0,57	6,70a ± 0,32	15,57a ±0,12
F3 (%)	46,76b± 1,20	7,34a ± 0,25	16,76a ±0,74
Time 120 days			
F1 (%)	50,11a± 0,63	6,15a ± 0,75	17,77a± 1,07
F2 (%)	48,23a± 1,35	6,11a ± 0,37	15,33a± 0,70
F3 (%)	44,95b± 0,85	6,92a ± 0,53	16,50a± 1,22

Source: The authors (2023)

F1 = Burger formulation with added fat (standard formulation); F2 = Burger formulation with the addition of 10% fiber; F3 = hamburger formulation with added 15% fiber. Values expressed as mean ± standard deviation. Different lowercase letters in the same column indicate a significant difference between the samples Tukey's test ($p < 0.05$).

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