THE FISH BURGER QUALITY OF MECHANICALLY RECOVERED MEAT FROM TILAPIA USING ADDED WHEAT FIBRE AND CORN OIL

QUALIDADE DO FISHBURGER DE CARNE MECANICAMENTE SEPARADA DE TILÁPIA DO NILO ADICIONADO DE FIBRA DE TRIGO E ÓLEO DE MILHO

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SUMMARY

Fish burgers were made using mechanically recovered meat (MRM) from tilapia in a 2^2 full factorial design to determine the effect of wheat fibre and corn oil shrinkage on the water retention capacity of fish burgers. The best formulation was obtained using 1% corn oil and 2.5% wheat fibre, which resulted in a 4.3% shrinkage rate and 87% water retention capacity. In the second step, the best formulation was again prepared in four batches and subjected to bacteriological, physico-chemical and sensory tests in triplicate. The fish burgers were found to be within the standard microbiological and physical chemical parameters required by Brazilian law. Fibre from wheat and vegetable oil corn can be used to prepare fish burgers from MRM tilapia with excellent sensory acceptance.

KEY WORDS: quantitative descriptive analysis, hamburger, fish.

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RESUMO

Hambúrgueres de peixes foram elaborados a partir de carne mecanicamente separada (CMS) de tilápia do Nilo em um arranjo fatorial completo de 2^2 para determinar o efeito de fibra de trigo e do óleo de milho sobre o índice de encolhimento e a capacidade de retenção de água do produto final. A melhor adequação foi a formulação obtida usando 1% de óleo de milho e 2,5 % de fibra de trigo, que resultou numa taxa de encolhimento 4,3% e capacidade de retenção de água de 87%. A posteriori esta formulação foi de novo elaborada em quatro lotes e submetidos a testes bacteriológicos, físico-químicas e sensorial. Os hambúrgueres de peixe obtidos atenderam aos padrões microbiológicos e físico-químicos exigidos pela legislação brasileira. A Fibra de trigo e o óleo de milho pode ser utilizado para preparar hambúrgueres de peixe a partir de CMS tilápia do Nilo com excelente aceitação sensorial.

PALAVRAS-CHAVE: análise descritiva quantitativa, hambúrguer, peixe.

INTRODUCTION

The growth of the world's production of tilapia increased from approximately 2.8 million tons in 2008 to 3.0 million tons in 2010 (FITZSIMMONS, 2009). This fish meets the nutritional needs of consumers because it is an easily digested food, contains proteins of a high biological value and contains minerals, especially calcium and phosphorus, and vitamins A, D and B (SIMÕES et al., 2004). In the case of Nile tilapia, this meat has a lower fat content, which can range from 1.88 to 5.92% in fish fillets produced in captivity, and is rich in polyunsaturated fatty acids, especially omega-6 (LEONHARDT et al., 2006).

The mechanically recovered meat (MRM) butchering of animals can be used in developing high value added products to reach certain market segments or to meet the social demand for animal proteins that are of top-quality and affordable (KUNH & SMITH, 2002). However, MRM regulations for fish have not yet been enforced, and there is a proposal to amend the Regulation of Industrial and Sanitary Inspection of Animal Products (RIISPOA). MRM fish are defined as frozen products obtained from fish that have been headed, gutted, and cleaned and from which the meat has been mechanically recovered from the muscles and

structures inherent to the species' bones. Bones and skin can be washed out or not, and there are no additives. Depending on the species of fish and its features, meat can also be obtained from carcasses (BRAZIL, 2008).

Mechanically recovered fish meat has been employed in the development of new products, *e.g*., sausages, nuggets and fish burgers (VIEGAS & OLIVEIRA, 2008).

Excess fat is demonstrably harmful to health, especially the cholesterol contained within the fat. There is a need to reduce or replace this fat with other fats more suited to human needs, *e.g*., less saturated fatty acids and more monounsaturated (oleic) and polyunsaturated fatty acids that are cholesterol-free. In this sense, vegetable oils, such as corn, cotton and olive oil, are ideal and have been used for this purpose in products, such as sausages (JIMENEZ-COLMENERO et al., 2001).

The development of meat products with a lower fat content has been a goal of the industrial sector to provide the consumer market with the option of healthier diets, *i.e*., reduced calorie foods (FIGUEREDO et al., 2002). The use of dietary fibre in food is nutritionally important and positively influences the processing of products. Added fibre in meat products improves cooking performance and enhances the water holding capacity of meats, which reduces the cost of design and improves the texture of the food (CARBONELL et al., 2005).

Thus, the objective of this study was to evaluate MRM tilapia as a feedstock for the production of fish burgers through the addition of insoluble wheat fibre and vegetable oil to verify the effect of these components on the quality of the fish burger produced.

MATERIAL AND METHODS

Response surface methodology (Kruri & Cornell, 1996) was used to evaluate the influence of variables during the formulation of fish burgers. Experimental tests were performed according to a 2^2 full factorial design with four factor scores (levels ± 1), four

central points (level 0) and four axial points (± α) for a total of 12 formulations. The objective was to evaluate the effect of the amount of corn oil (O) and wheat fibre (F) (independent variables) on the shrinkage response (E) and water retention capacity (C) at the end of the process. The data were adjusted to the following mathematical model: Y = φ (E, C) = β0 β1 + β2 F + O + O2 + β11 β22 β12 OF F2 + (Equation 1), where the regression coefficients are the Y response in the question (E and C) and F-coded independent variables (% of corn oil and wheat fibre).

To preparation of fish burger the MRM acquired was tilapia frozen in packs of 2 kg from a fish industry located in the state of Pernambuco. The fish burgers were prepared manually at the Department of Home Federal Rural University of Pernambuco (UFRPE). The MRM was thawed for 24 h at 50°C. The ingredients used included soy protein isolate (3.21%), cassava starch (1.60%), salt (0.82%), spices (onion, coriander, mustard, nutmeg, cumin, ginger, garlic (1.64%)), polyphosphates (0.29%), colour fixative (0.51%), water (11.28%) and curing salt (0.12%) and were the same for all formulations. The percentage of corn oil and wheat fibre varied according to each formulation. The mass was shaped into fish burgers, and each burger was packed in polyethylene film and frozen at -180°C. An analysis of shrinkage (Mansour & Khalil, 1997) and a determination of the water retention capacity (WRC), as described by Hamm (1960), were subsequently performed at the Laboratory for the Inspection of Meat and Milk (LICAL) of the UFRPE.

The MRM, fish burgers and tilapia were examined bacteriologically at the LICAL UFRPE for coagulase-positive staphylococcal counts and most probable number (MPN) counts of coliform organisms, *i.e.*, *Escherichia coli* and *Salmonella* spp. (BRAZIL, 2003). The analysis of the most probable number of sulphite-reducing clostridia was performed only for the MRM and according to Brazil, (1992).

Analytical samples were taken in triplicate (physico-chemical analyses) from the MRM fish burgers of each batch to determine the chemical composition, calcium content, pH and crude fibre content according to the Association of Analytical Communities (AOAC) procedures (2006). Carbohydrates were estimated using a previously described calculation (Ascar, 1985). For colour analyses, a colourimeter (Minolta Colour Reader CR-400) was used to take three measurements at different parts of the product.

Sensorial analysis was performed according to the precepts of resolution number 196/96 of the National Health Committee (Brazil). The fish burgers were previously heated using a grill plate oiled with vegetable oil. The burgers were moved from one side to the other every one minute during the grilling process. The total grill time was nine minutes (ARISSETO & POLLONIO, 2005).

A quantitative descriptive analysis (QDA) was performed according to the procedures described by Stone & Sidel (1998).

A global acceptance test was conducted in the laboratory using 50 untrained panelists and a hedonic scale of 7 points (with 7 = "like extremely" and 1 = “dislike extremely”) to rate attributes of colour, uniformity and aroma, and, for the flavour of freshwater fish, the attributes of spice, tenderness, juiciness and overall quality were also rated (STONE & SIDEL 1998).

In the attitude test for purchase, a 5-point scale, where 5 = "I will buy” and 1 = "I will never buy,” was used. This test was conducted in the laboratory and with the participation of 50 untrained panelists (STONE & SIDEL 1998).

Standard deviations were calculated, and analysis of variance (ANOVA) was performed. The means were then compared using Tukey’s test with a 5% significance level.

RESULTS AND DISCUSSION

144 Table 1 describes the independent variables, corn oil and wheat fibre insoluble forms
145 encoded and decoded and the results of the dependent variables, shrinkage and water retention
146 capacity following the response surface methodology.
147 The most appropriate response was a formulation that utilised 1% oil and 2.5% fibre,
148 which showed the lowest shrinkage (4.3%) and greatest capacity for water retention (87%)
149 compared to the other formulations. These results were better adjusted than those found by
150 Braga et al. (2002), who performed research on fish burgers formulated from minced tilapia
151 with added starch and oatmeal and calculated shrinkage values of 14.51%.
152 The interaction between the corn oil and wheat fibre, in terms of the shrinkage
153 percentage of the fish burger, was positive when using 1% corn oil combined with 2.5%
154 wheat fibre, when was obtained a better (lower) rate (4.3%) of fish burger shrinkage.
155 The equation set used was obtained from the following: Y (E) = 8.4443 to 1.4206 O - F
156 0.5607 - 0.1524 OF O2 + 1.24 - 0.6047 F2 R^2 = 0.868, where E = % shrinkage of the % of
157 corn oil and F% of wheat fibre.
158 The effect of the interaction between corn oil and wheat fibre on the water retention
159 capacity (WRC) was The highest capacity (87%) and was obtained when a combination of
160 1% corn oil and 2.5% wheat fibre was added. The equation that represents this behaviour is as
161 follows: Y (C) = 75.4675 + 2.6069 + 8.6977 The F - 0.2439 02 to 1.8667 OF - 1.1312 F2 R2
162 = 0.917, where C = water retention capacity of the % of corn oil and F% of wheat fibre. This
163 calculated water retention capacity is of a greater magnitude than values reported for fish
164 burger pulp made using tilapia, where the obtained water retention capacity (78.59%) was not
165 affected by the addition of cassava starch and oatmeal (BRAGA et al., 2010). This
166 formulation displayed the best results based on the experimental design when compared to the
167 other 2^2 and was again prepared in four batches and subjected to bacteriological, physico-
168 chemical and sensory tests in triplicate.

169 The results of the bacteriological analyses of the MRM are shown in Table 2. The CMS
170 was within the microbiological standards established by legislation (DRC N012 ANVISA;
171 Brazil, 2001) for the most probable number (MPN) for faecal coliform and *Escherichia coli*
172 research. These results are similar to those obtained by Kirschnik & Macedo-Viegas (2009),
173 who analysed MRM tilapia. However, the results obtained by several authors (Marengoni et
174 al., 2009), who detected *E. coli* in all analysed MRM tilapia samples, differ.
175 All analysed samples were negative for *Salmonella*, which is similar to the results found
176 by Kirschnik & Macedo-Viegas (2009) while researching MRM. With respect to sulphite-
177 reducing clostridia, although the legislation does not affect similar products like surimi and
178 fish-based products, MRM is required to be analysed for other species because food safety
179 counts have previously been made for this group of bacteria. In this context, the MRM
180 surveyed showed similar results for both staphylococci and clostridia to those found by
181 González-Fando et al., (2005). while researching staphylococci and clostridia in sliced
182 salmon.
183 Table 3 presents the results physico-chemical obtained in the analytic MRM
184 determinations. The moisture content of the MRM tilapia is probably due to the washing
185 process, which removes soluble proteins, minerals and lipids and results in an increased
186 moisture content (GRYSCHEK, OETTERER & GALLO, 2003). It is important to note that
187 the moisture values of washed MRM can differ greatly depending on the washing process and
188 the withdrawal of the used water.
189 The values obtained in this study were lower than those found by Leyva-Mayorga et al.
190 (2002), who investigated the chemical composition of fresh Nile tilapia surimi and found a
191 moisture value of 78.3%.
192 The protein content found in MRM is in line with that set out in the legislation for
193 MRM (Brazil, 2000a), which is at least 12%. These levels are slightly higher than those found

194 by Leyva-Mayorga et al. (2002) in surimi (approximately 12%). This result is probably due to
195 the removal of most of the soluble sarcoplasmic protein, which has also been observed by
196 other authors Adu et al. (1983), who have reported considerable losses of protein and other
197 soluble components after washing MRM tilapia.
198 The lipid content conforms to the legal limit, which can be a maximum of 30%.
199 However, these values were higher than those obtained by other researchers, *e.g*., Eymard et
200 al., (2005) found a value of 3.6% and Gryschek, Oetterer & Gallo (2003) found a value of
201 4.23% while performing research with unwashed MRM tilapia. The amount of calcium
202 present in the MRM was consistent with the values cited in the relevant legislation, which is
203 up to 1.5% of the dry weight (BRAZIL, 2000a).
204 The results of the bacteriological analyses of the fish burgers are described in Table 2.
205 The fish burgers were within the microbiological standards established in legislation (DRC
206 N0 12 ANVISA; Brazil, 2001) for all microorganisms studied. Although the MRM presented
207 a high load of faecal coliform, the fish burgers were within the standards of the legislation,
208 which is up to 103. Therefore, the condiments and additives used in the process were
209 sufficient to eradicate these organisms. For the MPNs of faecal coliforms and *Escherichia*
210 *coli*, these results differed from those found by other authors (Marengoni et al., 2009), who
211 detected the presence of *E. coli* in all of the analysed fish burger samples.
212 The counting results indicated that the coagulase-positive staphylococci were within the
213 established limits. However, the count was high.
214 All of the fish burger samples were negative for *Salmonella*, which complies with
215 current legislation and correlates with research conducted on fish burgers (KIRSCHNIK &
216 MACEDO-VIEGAS, 2009).
217 The results of the physical and chemical analyses in fish burg are shown in Table 3. The
218 moisture values of the products are superior to those found by Coelho et al., (2007) and

219 similar to values obtained by Marengoni *et al*. (2009) when evaluating the four fish burger
220 tilapia pulp formulations.
221 The protein levels were slightly higher than those found by Coelho et al., (2007). When
222 these authors examined fish burgers made from Merluccius hub surimi, they determined the
223 protein levels to be from 10.6 to 11.8%.
224 Lipid values are very significant in fish burgers. These values were determined to be
225 lower compared to the values established by law for hamburger, beef, pork and poultry, which
226 is 23% (BRAZIL, 2000b). Thus, the lipid values of the fish burgers in this study were
227 reduced, which is a consumer benefit.
228 The calcium content of the fish burgers represents a quantified value lower than that
229 recommended by the standard for the identity and the quality of hamburgers, which indicates
230 that up to 0.1% of the dry content of the raw hamburger meat should be calcium (BRAZIL
231 2000b).
232 The crude fibre content present in fish burgers ranged from 1.81 to 2.57 g/100 g. This
233 range is consistent with results reported by Clariant (2001), who determined that only 1%
234 wheat fibre is required to obtain significant functional improvements in meat products. The
235 most important consumer benefit of this product addition is that fish burgers can now be
236 assigned the phrase "contains fibre", which is a beneficial food class and terminology for
237 consumers.
238 The pH values shown in Table 3 were probably the result of using polyphosphate and
239 erythorbate during the preparation of the fish burgers, which shifted the pH. A similar result
240 has been reported by Konno (1992), when using these same additives.
241 The fish burgers presented a lightness (L *) of 61.69 ± 1.24, an intense red colour (a *)
242 of 1.88 ± 0.30 and an intense yellow colour (b *) of 19.44 ± 0.51. The more yellowish tint of
243 the fish burgers could be correlated to the spices used. It is also important to consider

variations in the thickness of the product and the colour of the surface where the product was analysed (SANCHEZ-ZAPATA et al., 2011).

The results of the sensory analysis by Quantitative Descriptive Analysis (QDA) are described in Table 4. The final evaluation of the QDA was performed by eight trained judges who graded nine attributes (colour, uniformity, freshwater fish aroma, spice aroma, freshwater fish flavour, flavoured condiments, tenderness, juiciness and overall assessment). It is worth noting that among the averages, the upper limit was 8.2 for juiciness and the lower was 5.6 for the spice aroma. The average obtained for the overall assessment indicates a consistency among the judges with respect to all determined attributes.

In studies of consumer acceptance, beef tenderness is often the most important attribute for obtaining overall consumer satisfaction (LAWRIE, 2005). During tilapia fish burger studies, Tokur et al. (2004) achieved average values from 7.8 to 9.0 for the colour, odour, flavour, and texture attributes during evaluations by seven trained panelists. QDA is a way to identify important attributes during the development of a new product. When a panel has trained sensory acuity, this method remains the most comprehensive and provides detailed information about the properties of products (MURRAY et al., 2001).

The results obtained for the acceptance test are shown in Figure 1. When acceptance is over 70%, the product can be considered inserted in trade (TEIXEIRA et al., 1987). These results were higher than those found by Braga et al., (2010) who tested four different formulations of fish burgers based on pulp tilapia for aroma, flavour, and tenderness attributes and presented notes corresponding to "liked moderately."

In Attitude test purchase was found that 84% of the panellists assigned grades that were in the range from "buy" to "possibly buy" while 16% assigned a grade of "may buy" / "might not buy." These data are similar to those obtained by Marengoni *et al*. (2009), who studied the

intent to purchase for four formulations of MRM tilapia fish burgers and achieved results ranging from "possibly buy the product" to "might buy" / "will not buy".

CONCLUSIONS

Fish burgers can be prepared using mechanically recovered meat from tilapia with good consumer acceptance.

In terms of the analyses required by relevant legislation, the fish burgers are within the required standards, especially in terms of physical and chemical parameters.

The resulting product is low in lipids.

The large sensory acceptance of the fish burgers indicates that wheat fibre and vegetable (corn) oil can be added to fish burgers during their preparation.

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Table 1. Responses to the dependent variables according to the factorial design of the fish burger formulation of mechanically recovered meat (MRM) made from Nile tilapia added to insoluble wheat fibre and corn oil.

Formulations	*Independent Variables*				*Dependent Variables*	
	Coded		Decoded			
	O	F	O(%)	F(%)	E(%)	C(%)

1	-1	-1	1	1	6.50	84
2	+1	-1	3.5	1	4.70	83
3	-1	+1	1	2.5	4.30	87
4	+1	+1	3.5	2.5	7.15	79
5	-1.41	0	0.5	1,75	6.50	87
6	+1.41	0	4	1.75	6.20	81
7	0	-1.41	2.25	0.7	6.00	82
8	0	+1.41	2.25	2.80	6.30	85
9	0	0	2.25	1.75	6.52	85
10	0	0	2.25	1.75	6.62	84
11	0	0	2.25	1.75	6.52	85
12	0	0	2.25	1.75	6.42	84

443 O = corn oil (%); F = wheat fibre (%); E = shrinkage (%); C = water retention capacity (%).
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Table 2. Bacteriological analyses of mechanically recovered meat (MRM) and fish burgers composed of mechanically recovered meat (MRM) made from Nile tilapia added to insoluble wheat fibre and corn oil.

Analysis	Thermotolerant coliform (NMP/g)	*E. coli* research	Counts coagulase positive staphylococci (UFC/g)	*Salmonella* research	Clostridium, sulfite-reducer (NMP/g)
MRM	21	Negative	3.5×10^2	Absent	<0.3
	<3.0	Negative	<0.3	Absent	<0.3

	<3.0	Negative	<0.3	Absent	<0.3
	240	Negative	<0.3	Absent	<0.3
Fish burgers	<3.0	Negative	<0.3	Absent	-
	<3.0	Negative	<0.3	Absent	-
	<3.0	Negative	<0.3	Absent	-
	<3.0	Negative	<0.3	Absent	-

MPN – Most Probable Number; CFU – Colony-Forming Unit

Table 3. Physical and chemical analyses of mechanically recovered meat (MRM) and the fish burgers composed of Nile tilapia added to insoluble wheat fibre and corn oil.

Amostras	MRM	Fish burgers
Humidity	72.75 ±1.3	71.16±0.7
Protein (g/100 g)	13.02±0.3	12.58±0,6
Ashes (g/100 g)	1.08±0.3	1.81±0.3
Lipids (g/100 g	11.03±0.5	9.2±0.24

Carboydrates (g/100 g)	2.09±1.2	5.1±0.9
Calcium (mg/100 g)	23.58±11.4	36.30±11.7
Crude fibre (g/100 g)	1.43±0.6	2.19±0.38
pH	6.29±0.1	6.33±0.0

Mean and standard deviation

Table 4. Mean values given by the judges for the attributes of the Quantitative Descriptive Analysis (QDA) for fish burgers composed of mechanically recovered meat (MRM) made from Nile tilapia added to insoluble wheat fibre and corn oil

Parameter	**Mean**	**SD**	**VC (%)**
Colour	6.9	0.56	7.43
Uniformity	7.9	0.55	4.53
Freshwater fish aroma	6.0	0.44	5.20

Spice aroma	5.6	0.74	1.36
Freshwater fish flavour	7.8	0.45	4.40
Spice flavour	6.1	0.49	5.20
Softness	8.1	0.41	4.30
Succulence	8.2	0.36	3.20
Overall evaluation	7.0	0.32	2.95

507 VC – Variation coefficient; SD – Standard deviation

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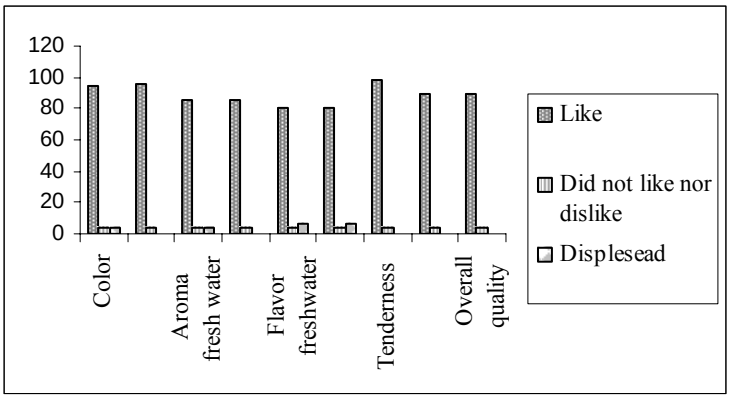

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Figure 1. Percentage of responses given by the tasters for the attributes for acceptance testing

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of mechanically recovered meat fish burgers composed of Nile tilapia added to insoluble

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wheat fibre and corn oil.

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