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**OMEGA-3-enriched Bologna sausages by addition of echium (*Echium plantagineum* L.) oil and chia (*Salvia hispanica* L) Flour (#56)**

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**Introduction**

The consumption of omega-3 fatty acids has been associated with several health benefits, such as reducing the risks of cardiovascular disease, cancer and mental illnesses [1]. *Echium* oil is a vegetable oil that contains significant amounts of stearidonic acid (omega-3; 13 g/100 g)[2] and chia flour has 64.97 g  $\alpha$ -linolenic acid/100 g fat[3]. Therefore, the use of *Echium* oil and chia flour can be an interesting alternative to improve the omega-3 content of meat products. Thus, the present study aimed to produce a healthier Bologna sausage through the replacement of pork back fat with *Echium* oil and the partial replacement of beef meat with chia flour and to evaluate the fatty acids profile of the obtained sausages.

**Methods**

Four treatments were processed, according to Trindade et al.[4]: Control (17 g pork back fat /100 g, TE (13 g *Echium* oil/100 g), T10CF (13 g *Echium* oil/100 g + 10 g chia flour/100 g) and T20CF (13 g *Echium* oil/100 g + 20 g chia flour/100 g). The formulations of Bologna sausages are showed in Table 1. Duplicates were carried out at processing level for all treatments. For the fatty acids profile determination, the lipids were extracted by the Bligh & Dyer method[5]. The fatty acids contents were determined by GC chromatography, equipped with G3243A MS detector (Agilent 7890 A GC System, Agilent technologies Inc., Santa Clara, USA). Results were expressed as g fatty acid/100 g oil. The results were evaluated by ANOVA using the generalized linear models in the randomized complete block design, considering the treatments as a fixed effect, and the experiment replications as a random effect. The means were compared by Tukey test, at 5% of significance.

**Results**

Table 2 presents the results of the fatty acid profile of the Bologna sausages. The addition of *Echium* oil (TE) alone or together with chia flour (T10CF and T20CF) to Bologna sausages reduced ( $P < 0.05$ ) their SFA and MUFA contents. Conversely, an increase ( $P < 0.05$ ) in PUFAs was observed. This effect is mainly due to the increase in the omega-3 contents by adding chia flour (alpha-linolenic acid) and *Echium* oil and (stearidonic acid). A desirable decrease ( $P < 0.05$ ) in the n-6:n-3 ratio was also observed in all tested formulation (TE, T10CF and T20CF) when compared to Control, with all these treatments reaching the nutritional recommendation ( $n-6:n-3 \leq 5:1$ )[7]. However, no ( $P > 0.05$ ) further improvements were obtained by increasing the replacement of beef meat with chia flour from 10% to 20%.

**Conclusion**

The replacement of 100% added pork back fat (17 g pork back fat /100 g product) with of *Echium* oil (13 g *Echium* oil/100 g) and the partial replacement of beef meat with chia flour (10 g or 20 g chia flour / 100 g product) were effective to improve the lipid profile of Bologna sausages.

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**Literature**

1. Shahidi, F., & Ambigaipalan, P.(2018).Omega-3 polyunsaturated fatty acids and their health benefits.*Annual Review of Food Science and Technology*, 9, 345-38
2. Mir, M.(2008).Echium oil: a valuable source of n-3 and n-6 fatty acids. *Oléagineux, Corps gras, Lipides*, 15, 252-256.
3. Barros, J.C., Munekata, P.E.S., Pires, M.A., Rodrigues, I., Andaloussi, O.S., Rodrigues, C.E.C., & Trindade, M.A.(2018).Omega-3- and fibre-enriched chicken nuggets by replacement of chicken skin with chia (*Salvia hispanica* L.) flour.*LWT-Food Science and Technology*, 90, 283–289.
4. Trindade, M.A., Thomazine, M., Oliveira, J.M., Balieiro, J.C., & Favaro-Trindade, C.S.(2010).Oxidative, microbiological and sensory stability of mortadella containing soybean oil, stored at 0 °C for 60 days.*Brazilian Journal of Food Technology*,13, 165-173.
5. Bligh, E.G. & Dyer, W. J.(1959).A rapid method of total lipid extraction and purification.*Canadian Journal of Biochemistry and Physiology*,37, 911-917.
6. WHO/FAO.(1994).*Fats and oils in human nutrition*. Report 57 of a Joint FAO/WHO Expert Consultation Rome: Food and Agriculture Organization of the United Nations. Retrieved from <<http://www.fao.org/docrep/V4700E/V4700E06.htm#General%20conclusions%20and%20recommendations%20of%20the%20consultation>>.Accessed agost 28 2018.

## Notes

**Table 1.** Reformulations of Bologna sausages.

Ingredients (g/100 g)	Treatments			
	Control	TE	T10CF	T20CF
Lean beef meat	69	70	60	50
Pork back fat	17	-	-	-
Echium oil	-	13	13	13
Chia flour	-	-	10	20
Cassava starch	5	5	2.5	-
Salt (NaCl)	2.1	2.1	2.1	2.1
Sodium Nitrate	0.015	0.015	0.015	0.015
Spice mix	0.6	0.6	0.6	0.6
Garlic powder	0.3	0.3	0.3	0.3
White pepper	0.1	0.1	0.1	0.1
Water or ice	5.885	8.885	11.385	13.885

**Table 1. Reformulations of Bologna sausages.**

This figure (Table 1) should appear together with Methods part of the Abstract

**Table 2.** Fatty acid profile (mean ± standard error) of Bologna sausage.

Fatty acid (g/100 g)	Treatments			
	Control	TE	T10CF	T20CF
C12:0	0.05±0.03 <sup>a</sup>	0.00±0.00 <sup>b</sup>	0.00±0.00 <sup>b</sup>	0.00±0.00 <sup>b</sup>
C14:0	1.38±0.04 <sup>a</sup>	0.36±0.07 <sup>b</sup>	0.19±0.03 <sup>c</sup>	0.14±0.06 <sup>c</sup>
C15:0	0.11±0.02 <sup>a</sup>	0.04±0.03 <sup>b</sup>	0.03±0.01 <sup>b</sup>	0.03±0.03 <sup>b</sup>
C16:0	24.69±0.21 <sup>a</sup>	12.91±0.47 <sup>b</sup>	9.56±0.10 <sup>b</sup>	10.15±0.19 <sup>b</sup>
C17:0	0.60±0.06 <sup>a</sup>	0.18±0.02 <sup>b</sup>	0.15±0.02 <sup>bc</sup>	0.11±0.03 <sup>bc</sup>
C18:0	11.95±0.22 <sup>a</sup>	6.30±0.09 <sup>b</sup>	5.44±0.08 <sup>bc</sup>	5.00±0.10 <sup>bc</sup>
C20:0	0.15±0.03 <sup>b</sup>	0.16±0.03 <sup>ab</sup>	0.20±0.03 <sup>a</sup>	0.20±0.04 <sup>a</sup>
<b>SFA</b>	<b>38.92±0.13<sup>a</sup></b>	<b>19.96±0.47<sup>b</sup></b>	<b>15.56±0.12<sup>c</sup></b>	<b>15.64±0.16<sup>c</sup></b>
C14:1n-7	0.10±0.04 <sup>a</sup>	0.07±0.04 <sup>ab</sup>	0.06±0.02 <sup>bc</sup>	0.03±0.03 <sup>c</sup>
C16:1n-7	0.41±0.04 <sup>a</sup>	0.14±0.03 <sup>b</sup>	0.09±0.02 <sup>c</sup>	0.09±0.02 <sup>c</sup>
C17:1n-7	0.70±0.07 <sup>a</sup>	0.13±0.02 <sup>b</sup>	0.09±0.02 <sup>b</sup>	0.06±0.03 <sup>b</sup>
C18:1n-7	4.45±0.11 <sup>a</sup>	1.00±0.05 <sup>b</sup>	0.89±0.03 <sup>b</sup>	0.88±0.06 <sup>b</sup>
C20:1n-7	0.80±0.07 <sup>b</sup>	1.18±0.09 <sup>a</sup>	1.24±0.04 <sup>a</sup>	0.95±0.09 <sup>b</sup>
C16:1n-9	3.14±0.08 <sup>a</sup>	0.61±0.08 <sup>b</sup>	0.33±0.03 <sup>c</sup>	0.28±0.04 <sup>c</sup>
C18:1n-9	41.27±0.19 <sup>a</sup>	19.73±0.20 <sup>b</sup>	15.89±0.08 <sup>c</sup>	15.02±0.12 <sup>c</sup>
<b>MUFA</b>	<b>50.88±0.20<sup>a</sup></b>	<b>22.86±0.20<sup>b</sup></b>	<b>18.59±0.08<sup>c</sup></b>	<b>17.32±0.12<sup>d</sup></b>
C18:2n-6 (LNA)	8.74±0.20 <sup>d</sup>	14.28±0.12 <sup>c</sup>	15.96±0.07 <sup>b</sup>	16.99±0.13 <sup>a</sup>
C20:2n-6 (EDA)	0.32±0.05 <sup>a</sup>	0.11±0.03 <sup>b</sup>	0.11±0.02 <sup>b</sup>	0.09±0.04 <sup>b</sup>
C18:3n-6 (GLA)	0.00±0.00 <sup>c</sup>	8.84±0.22 <sup>a</sup>	8.71±0.07 <sup>a</sup>	7.28±0.10 <sup>b</sup>
C20:4n-6 (ARA)	0.29±0.04 <sup>a</sup>	0.13±0.04 <sup>b</sup>	0.08±0.02 <sup>c</sup>	0.05±0.02 <sup>c</sup>
C18:3n-3 (ALA)	0.85±0.14 <sup>d</sup>	23.53±0.37 <sup>c</sup>	30.90±0.09 <sup>b</sup>	34.30±0.18 <sup>a</sup>
C18:4n-3 (SDA)	0.00±0.00 <sup>c</sup>	10.28±0.24 <sup>a</sup>	10.09±0.08 <sup>a</sup>	8.35±0.11 <sup>b</sup>
<b>PUFA</b>	<b>10.21±0.20<sup>c</sup></b>	<b>57.18±0.51<sup>b</sup></b>	<b>65.84±0.14<sup>a</sup></b>	<b>67.04±0.19<sup>a</sup></b>
<b>n-6:n-3</b>	<b>12.12±0.51<sup>a</sup></b>	<b>0.69±0.05<sup>b</sup></b>	<b>0.61±0.01<sup>b</sup></b>	<b>0.57±0.02<sup>b</sup></b>

<sup>a,b,c,d</sup>Mean values not followed by common letters in the same row differ significantly ( $P<0.05$ ). Control: 17 g pork back fat/100 g, TE: 13 g Echium oil/100 g, T10CF: 13 g Echium oil/100 g + 10 g chia flour/100 g, T20CF: 13 g Echium oil/100 g + 20 g chia flour/100 g. SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids; LNA: Linoleic acid; EDA: Eicosadienoic acid; GLA:  $\gamma$ -Linolenic acid; ARA: Arachidonic acid; ALA:  $\alpha$ -linolenic acid; SDA: Stearidonic acid.

**Table 2. Fatty acid profile (mean ± standard error) of Bologna sausage.**

This Figure (Table 2) should appear together with the Results part.

## Notes