71st ICoMST
GIRONA - CATALONIA - SPAIN
3rd-8th August - 2025

EXPLORING THE ANTIOXIDANT POTENTIAL OF YELLOW COSMOS FLOWERS IN SAUSAGE FORMULATIONS

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I. INTRODUCTION

The growing demand for clean label products has driven the search for strategies to replace synthetic antioxidants with natural alternatives in meat products. The flowers of Yellow Cosmos (*Cosmos sulphureus* Cav.) have been used in the preparation of nutritious meals, and scientific studies have highlighted their high content of phenolic compounds [1]. This study evaluated the antioxidant activity of hydroalcoholic extracts from *C. sulphureus* flowers in sausages. The formulations were stored at 0 to 4 °C for 60 days and evaluated for Thiobarbituric Acid Reactive Substances (TBARS), instrumental color, and sensory acceptance.

II. MATERIALS AND METHODS

C. sulphureus whole flour (calyx, corolla, androecium and gynoecium) was obtained in the geographic coordinates (-25.29, -54.10) (Medianeira, Paraná, Brazil). Ultrasound assisted extraction was perfored using 10 g of *C. sulphureus* and 100 mL 70% hydroethanolic solution (v/v) (80 kHz, 100 W, 60 min). The extract was concentrated in a rotary evaporator up to ≈ 20% of the initial volume and lyophilized (- 50 ºC at ≤ 0,8 mBar) and stored at 4 °C until analysis and characterized by water activity at 25 °C, pH and instrumental color (luminosity; *L**, green-red component, *a**, and yellow-blue component; *b**). The sausage elaboration was performed at meat pilot plant of Universidade Tecnológica Federal do Paraná (Table 1).

Table 1 – Sausage formulations.

	Formulations					
Ingredients (%)	F1 (Control)	F2	F3	F4	F5	F6
Mechanically separated chicken meat	58.67	58.75	58.50	58.75	58.25	58.50
Pork fat	25.00	25.00	25.00	25.00	25.00	25.00
Water/Ice	10.00	10.00	10.00	10.00	10.00	10.00
Cassava	1.50	1.50	1.50	1.50	1.50	1.50
Soy protein concentrate	2.00	2.00	2.00	2.00	2.00	2.00
C. sulphureus extract	-	-	0.25	0.25	0.50	0.50
Curing salt (Ibrac)	0.25	0.25	0.25	-	0.25	-
Sodium eritorbate (Ibrac)	0.08	-	-	-	-	-
Sodium tripolyphosphate (Ibrac)	0.50	0.50	0.50	0.50	0.50	0.50
Salt	1.50	1.50	1.50	1.50	1.50	1.50
Sausage condiment (Conditec)	0.50	0.50	0.50	0.50	0.50	0.50
Total	100	100	100	100	100	100

The sausage ingredients were processed in a cutter (Mado, Garant MTK 661, Dornhan, Germany) and stuffed into artificial cellulose casings. These were cooked in a steam oven (Eller, Unimatic 1000, Bolzano, Italy) until reaching 74 °C at the geometric center. After cooling, the casings were removed, and the sausages were colored with natural annatto dye, vacuum-packed, and stored at 0–4 °C for 60 days. TBARS values were monitored over the storage period [2,3], and instrumental color was evaluated on days 0 and 60. F1 (Control) and F5 were submitted to a sensory test with 123 consumers. Acceptance was assessed using a 9-point hedonic scale in a monadic test with randomized blocks. Acceptance data were analyzed by main effects ANOVA, and physicochemical data by one-way ANOVA followed by Tukey's test (5%, Statistica 8.0).

III. RESULTS AND DISCUSSION

C. sulphureus extract had lower water activity (0,46 ± 0,00), acid pH (4,51 ± 0,02) and yellow color predominance (L* = 24,49±0,33; a* = 13,55±0,33; and b* = 18,48±0,57). The TBARS varied between 0.088 and 0.307 mg/kg (Table

2). F1 had the lowest mean for all storage time, except for day 10 and 20. At time 0, F1 with 0.08% sodium erythorbate and 0.25% curing salt had a significant difference with F4 and F6, which contain 0.25% and 0.5% *C. sulphureus* extract, respectively. F2, F3, and F5, which 0.25% curing salt, had similar TBARS values ($p > 0.05$). At time 60 days, F1 had the lowest TBARS value (0.173 mg/kg), followed by F5 (0.227 mg/kg). It is important to emphasize that TBARS results were lower than sensory threshold of 0.50 mg/kg, suggetsing that sausages should be free of rancid aroma and taste.

Table 2 – Sausage formulations result of TBARS (mg of malonaldeído kg^{-1} of sample).

	Storage time (days)						
	0	10	20	30	40	50	60
F1	$0{,}088 \pm 0{,}01^{bE}$	$0{,}153 \pm 0{,}013^{abABC}$	$0{,}125 \pm 0{,}01^{dCD}$	$0{,}113 \pm 0{,}00^{bDE}$	$0{,}159 \pm 0{,}01^{bAB}$	$0{,}130 \pm 0{,}02^{cBCD}$	$0{,}173 \pm 0{,}02^{cA}$
F2	$0{,}113 \pm 0{,}01^{abC}$	$0{,}133 \pm 0{,}013^{bBC}$	$0{,}122 \pm 0{,}00^{dC}$	$0{,}135 \pm 0{,}01^{abBC}$	$0{,}168 \pm 0{,}01^{bB}$	$0{,}176 \pm 0{,}01^{bcB}$	$0{,}306 \pm 0{,}03^{aA}$
F3	$0{,}111 \pm 0{,}01^{abC}$	$0{,}145 \pm 0{,}00^{abBC}$	$0{,}133 \pm 0{,}01^{cdBC}$	$0{,}138 \pm 0{,}01^{abBC}$	$0{,}166 \pm 0{,}01^{bB}$	$0{,}153 \pm 0{,}02^{bcB}$	$0{,}239 \pm 0{,}02^{abcA}$
F4	$0{,}118 \pm 0{,}00^{aB}$	$0{,}167 \pm 0{,}01^{abB}$	$0{,}170 \pm 0{,}00^{aB}$	$0{,}160 \pm 0{,}01^{aB}$	$0{,}269 \pm 0{,}02^{aA}$	$0{,}285 \pm 0{,}03^{aA}$	$0{,}307 \pm 0{,}03^{aA}$
F5	$0{,}104 \pm 0{,}00^{abD}$	$0{,}163 \pm 0{,}01^{abBC}$	$0{,}141 \pm 0{,}00^{bcBCD}$	$0{,}135 \pm 0{,}01^{abCD}$	$0{,}176 \pm 0{,}01^{bB}$	$0{,}153 \pm 0{,}02^{bcBC}$	$0{,}227 \pm 0{,}02^{bcA}$
F6	$0{,}125 \pm 0{,}01^{aD}$	$0{,}175 \pm 0{,}01^{aBC}$	$0{,}151 \pm 0{,}00^{bCD}$	$0{,}156 \pm 0{,}01^{aBCD}$	$0{,}187 \pm 0{,}00^{bB}$	$0{,}184 \pm 0{,}01^{bBC}$	$0{,}270 \pm 0{,}02^{abA}$

Mean ± standard deviation (n = 3 for TBARS). Different lowercase letters in the columns or different uppercase letters in the lines indicate a significant difference ($p \leq 0.05$) by Tukey's test.

Table 3 presents the color parameters at 0 and 60 days and sensory acceptance of the sausages. Significant differences ($p \leq 0.05$) were observed among formulations for *L**, *a**, and *b** at time 0. *L** values tended to decrease with higher concentrations of natural antioxidant. Formulation F1 (with sodium erythorbate) had the highest *a** value (redness), while F4 and F6 (with only *C. sulphureus* extract) had the lowest. For *b** (yellowness), values were higher in formulations containing *C. sulphureus*, with F6 showing the highest. Color remained stable throughout storage. Sensory evaluation showed that F1 had higher scores for appearance, color, aroma, and overall acceptance compared to F5 ($p \leq 0.05$), although texture and flavor were similar ($p > 0.05$). All attributes in both F1 and F5 scored above 6.85, corresponding to an acceptability index above 76%.

Table 3 – Sausages formulations result for L*, a*, b* and sensory acceptance.

Parameters		L*		a*		b*	
Storage time (days)		0	60	0	60	0	60
Color	F1	$57{,}06 \pm 1{,}21^{aA}$	$55{,}03 \pm 0{,}37^{bA}$	$14{,}83 \pm 0{,}27^{aA}$	$14{,}77 \pm 0{,}54^{aA}$	$16{,}68 \pm 1{,}94^{bA}$	$15{,}80 \pm 0{,}56^{dA}$
	F2	$57{,}44 \pm 1{,}02^{aA}$	$57{,}90 \pm 2{,}03^{aA}$	$9{,}81 \pm 0{,}39^{bA}$	$7{,}26 \pm 0{,}41^{bcB}$	$18{,}41 \pm 0{,}58^{abA}$	$17{,}10 \pm 0{,}60^{cdA}$
	F3	$54{,}74 \pm 0{,}71^{abA}$	$53{,}76 \pm 0{,}63^{bcA}$	$7{,}88 \pm 0{,}25^{cA}$	$7{,}44 \pm 0{,}14^{bA}$	$19{,}92 \pm 1{,}73^{aA}$	$18{,}47 \pm 0{,}47^{bcA}$
	F4	$53{,}34 \pm 0{,}48^{bA}$	$51{,}62 \pm 0{,}56^{cdB}$	$4{,}35 \pm 0{,}44^{dB}$	$5{,}44 \pm 0{,}26^{eA}$	$19{,}38 \pm 0{,}78^{abA}$	$18{,}54 \pm 0{,}45^{bcA}$
	F5	$52{,}12 \pm 1{,}16^{bA}$	$50{,}76 \pm 0{,}71^{dA}$	$8{,}48 \pm 0{,}80^{cA}$	$6{,}57 \pm 0{,}21^{cdB}$	$19{,}02 \pm 0{,}27^{abA}$	$18{,}70 \pm 0{,}58^{abA}$
	F6	$52{,}83 \pm 1{,}11^{bA}$	$51{,}31 \pm 0{,}31^{cdA}$	$4{,}17 \pm 0{,}28^{dB}$	$5{,}97 \pm 0{,}08^{deA}$	$20{,}46 \pm 0{,}33^{aA}$	$20{,}01 \pm 0{,}48^{aA}$
Sensory test		Appearence	Color	Aroma	Texture	Flavor	Overall acceptance
	F1	8.05^{a}	7.95^{a}	7.91^{a}	7.70^{a}	8.10^{a}	7.98^{a}
	F5	7.20^{b}	6.85^{b}	7.53^{b}	7.49^{a}	7.84^{a}	7.54^{b}

Mean ± standard deviation (n = 5 for *L**, *a** and *b**; n = 123 for sensory acceptance). Different lowercase letters in the columns or different uppercase letters in the lines indicate a significant difference ($p \leq 0.05$) by Tukey's test.

IV. CONCLUSION

The synthetic antioxidant replacement by *C. sulphureus* extract in sausage formulation promoted lipid stability and ensured sensory acceptance by consumers.

ACKNOWLEDGEMENTS

Concelho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and Fundação Araucária.

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