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Physicochemical Evaluation of Alternative and Conventional Flours: Toward Nutritional Diversification in the Flour-Based Industry

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INTRODUCTION & AIM

The **flour-based industry** constitutes the **second most valued food sector in Portugal**. As consumers seek healthier and functional food options, the industry has invested in the **development of new products linked to health benefits**. In recent years, incorporation of **alternative raw materials beyond conventional wheat flour** has expanded the number of flours available to consumers.

This study aimed to characterize a range of commercially available flours in Portuguese hypermarkets, comprising **seven refined flours** (wheat, rice, oat, carob, almond, maize, and amaranth) and **four wholemeal flours** (oat, wheat, rye, and spelt).

Refined flour

Wholemeal flour

Refined Flours

Samples	Brand	Abbreviation
Wheat	Branca de Neve	W
Rice	Ceifeira	RC
Rice	Origens	RO
Oat	Seara	O
Carob	Seara	C
Almond	Salutem	Al
Maize	Ceifeira	M

Wholemeal Flours

Samples	Brand	Abbreviation
Wheat	Continente	W (WF)
Rye	Nacional	R (WF)
Oat	Nacional	O (WF)
Spelt	Nacional	S (WF)

METHOD

Flours characterization through:

- **Colorimetric parameters** (L*, a*, b*) - Colorimeter (CR-400 Konica Minolta)

- **Mineral elements** - X-ray fluorescence spectroscopy (Olympus Vanta C Series, modelo VCA)

- **Moisture content** - NP 516/2000 (2000) 5 g in an oven (BIOBASE Drying Oven, model BOV-T105F) for 1h30 at 130 °C.

- **Ash content**- 5 g at 900 °C for 2 hours in a muffle furnace (Nabertherm 30-3000 °C B 130). NP 519/1993 (1993),

RESULTS & DISCUSSION

The letters a,b, c, d, e, f, g indicate significant differences between fields flours (statistical analysis using aone-way ANOVA test and the Tukey test to compare means, P ≤ 0.05).

In general, mineral composition did not significantly differ across flour samples (**Tab.1**). However, some exceptions were noted: manganese (Mn) was detected only in rice, almond, and wholewheat flour; selenium (Se) was only detected in wheat flour; and zinc (Zn) presented the higher value in oat flour (although not being significant) (**Tab.1**).

Table 1. Mean ± SE concentration of Zn, Se, Mo, Mn, Fe (ppm), Ca and S (%). BDL: Below detection level

Samples	RO	RC	O	C	Al	M	W	O(WF)	W(WF)	R(WF)	S(WF)
Ca	2,59^{ab} (±0,03)	2,60^{ab} (±0,04)	2,50^{bc} (±0,03)	2,52^{bc} (±0,01)	2,54^{bc} (±0,02)	2,48^{c} (±0,01)	2,54^{bc} (±0,02)	2,57^{abc} (±0,02)	2,57^{abc} (±0,02)	2,59^{ab} (±0,01)	2,65^{a} (±0,02)
S	0,148^{a} (±0,029)	0,180^{a} (±0,009)	0,171^{a} (±0,007)	0,167^{a} (±0,005)	0,165^{a} (±0,022)	0,155^{a} (±0,019)	0,145^{a} (±0,026)	0,203^{a} (±0,056)	0,159^{a} (±0,016)	0,143^{a} (±0,015)	0,163^{a} (±0,020)
Fe	333,00^{a} (±32,08)	350,00^{a} (±20,60)	300,67^{a} (±25,99)	337,00^{a} (±35,35)	332,67^{a} (±23,35)	358,33^{a} (±37,49)	331,67^{a} (±6,17)	295,33^{a} (±12,03)	316,33^{a} (±23,75)	307,67^{a} (±19,94)	365,67^{a} (±3,28)
Mn	134,00^{a} (±4,90)	BDL	BDL	BDL	186,00^{a} (±35,11)	BDL	BDL	BDL	190,00^{a} (±27,76)	BDL	BDL
Mo	19,00^{a} (±2,08)	18,00^{a} (±1,63)	18,67^{a} (±1,76)	17,67^{a} (±0,33)	21,00^{a} (±3,27)	20,00^{a} (±1,63)	22,00^{a} (±0,58)	20,50^{a} (±0,41)	24,33^{a} (±1,86)	LOD	24,00^{a} (±2,45)
Zn	54,00^{ab} (±4,62)	56,67^{ab} (±1,86)	71,33^{a} (±5,17)	48,33^{b} (±4,41)	50,33^{b} (±3,48)	66,67^{ab} (±0,88)	62,67^{ab} (±2,91)	58,67^{ab} (±3,18)	55,67^{ab} (±6,33)	54,33^{ab} (±5,04)	61,33^{ab} (±0,67)
Se	BDL	BDL	BDL	BDL	BDL	BDL	8,00^{a} (±0,00)	BDL	BDL	BDL	BDL

Almond flour exhibited a notably low moisture content and the highest ash level among the alternative flours (**Fig.2-A**). Moisture content varied across the flour samples, with flour M showing the highest percentage and Al the lowest (**Fig.2-A**). Regarding ash content (**Fig.2-B**), Al stood out with the highest ash content, followed by flours C and W, whereas flours M and RC exhibited the lowest values (**Fig.2-B**). These findings highlight the compositional diversity among the flours, which may influence their nutritional value and functional properties in food applications (**Fig.2-B**).

The flours exhibited similar coloration with respect to the L* parameter, although C flour stood out with a lower value (**Fig.1**). In terms of the a* parameter, C flour also distinguished itself by showing a contribution from the red region of the spectrum (**Fig.1**). Regarding the b* parameter, all samples showed a contribution from the yellow region, with some variations among them (**Fig.1**). Notably, flours C, M, and Al demonstrated higher b* values, indicating a more pronounced yellow contribution (**Fig.1**).

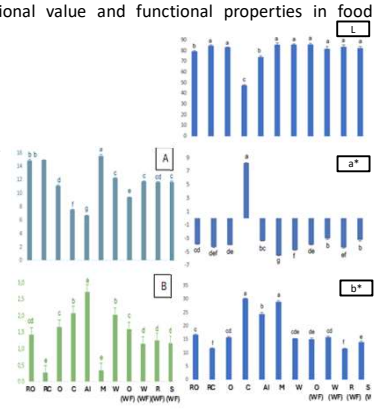

Figure 1. Mean ± SE (n=3) of moisture percentage (A) and ash percentage (B).

Figure 2. Mean ± SE (n=3) of colorimetric parameters (L, a*, b*).

CONCLUSION

- Alternative flours show mineral levels comparable to wheat flour but differ in moisture and ash content—key factors to consider based on the desired end product.
- These differences, when aligned with specific product goals, can serve as valuable assets that reinforce the innovative potential of alternative flours in several food applications.

FUTURE WORK / REFERENCES

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