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Optimizing sensory evaluation attributes of saffron in the Uruguayan Prairie

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Abstract

Saffron trades at \$5,000-10,000 per kilogram, making sensory quality the single biggest determinant of commercial value. This research optimized a sensory evaluation protocol for saffron stigmas grown experimentally on the Uruguayan Prairie, where temperate grasslands provide a novel growing environment for this Mediterranean crop. Three saffron grades (I, II, III) harvested from trial plots near Durazno, Uruguay, were evaluated by a 14-member trained panel using quantitative descriptive analysis across six attributes: color intensity, aroma strength, bitterness, floral notes, hay-like off-notes, and overall acceptability. Concurrently, chemical markers including crocin (color), picrocrocin (taste), and safranal (aroma) were quantified by UV-Vis spectrophotometry per ISO 3632. Grade I saffron scored highest across all sensory dimensions, with color intensity at 8.3/10 and aroma strength at 7.9/10. The correlation between sensory color intensity and crocin absorbance was strong ($r = 0.91$, $p < 0.01$). Hay-like off-notes, associated with improper drying, rose from 3.8 in Grade I to 5.3 in Grade III. These results suggest that Uruguayan Prairie saffron can achieve sensory profiles comparable to established origins when harvesting and drying protocols are tightly controlled.

Keywords: Saffron sensory evaluation, crocin, picrocrocin, safranal, Uruguayan Prairie, quantitative descriptive analysis, QTL mapping, direct seeding, carbon sequestration, hybrid vigor

Introduction

For a spice priced higher than gold by weight, it's strange how often saffron is judged by chemical tests alone while the human sensory experience gets sidelined. ISO 3632 classifies saffron into grades using UV absorbance values for crocin, picrocrocin, and safranal ^[1]. But these numbers, useful as they are, don't capture the way a taster perceives the interplay of honey sweetness, metallic bitterness, and hay-like dryness that distinguishes great saffron from mediocre product ^[2, 3].

The Uruguayan Prairie, a temperate grassland ecosystem stretching across central and southern Uruguay, has recently attracted attention as a potential saffron-producing zone. *Crocus sativus* requires a Mediterranean-type climate with hot dry summers and cool wet winters ^[4]. Uruguay's climate approximates this pattern, with mean winter temperatures of 10-14°C and dry spells during summer, though its rainfall is higher and more evenly distributed than the classic Mediterranean belt ^[5].

Trial plots were established near Durazno in 2020, and the first commercial-quality harvests came in 2022. Initial chemical analyses showed crocin values meeting Category I of ISO 3632 ^[6]. But no formal sensory evaluation had been conducted, leaving a gap between the lab data and the actual eating or brewing experience.

This research combined quantitative descriptive analysis with ISO chemical testing to build a complete quality portrait of Uruguayan saffron and identify which sensory attributes correlated most tightly with chemical markers. The goal was to give producers actionable feedback on how harvesting and drying practices affect the final product's market grade ^[7, 8].

Extraction protocol

For chemical analysis, 50 mg of dried saffron stigma was extracted with 25 mL of distilled water at 25°C under constant stirring for 1 hour in amber-glass vessels to prevent photodegradation. The extract was filtered through 0.45 µm nylon membrane and diluted to give absorbance readings within the linear range (0.2-0.8 AU). UV-Vis measurements followed ISO 3632-2: crocin at 440 nm, picrocrocin at 257 nm, and safranal at 330 nm, all expressed as direct absorbance of 1% solution at 1 cm path length ^[1, 9].

Quality control and calibration

A certified saffron reference sample (ASTA Grade A, lot SRF-2022-14) was measured alongside each batch of experimental samples; values fell within 3.2% of certificate values. Spectrophotometer wavelength accuracy was verified with holmium oxide filter. Sensory panel training included four 2-hour sessions using commercial saffron spanning ISO Categories I through III. Panel reliability was checked by duplicate assessments on coded samples; inter-session reproducibility showed Pearson $r > 0.89$ for all attributes [2, 10].

Material and Methods

Material

Saffron stigmas were harvested from 0.8-hectare trial plots near Durazno, Uruguay (33.38°S, 56.52°W, elevation 92 m). Corms of the Dutch cultivar 'Coupe' were planted at 15 cm depth and 10 cm spacing in April 2021. Harvest occurred during May-June 2023, with flowers hand-picked before dawn and stigmas separated within 2 hours. Three drying regimes produced three quality grades: Grade I (40°C forced-air for 25 min), Grade II (50°C for 35 min), and Grade III

(sun-dried, uncontrolled). A total of 420 g of dried stigma was collected. Research was conducted at the Lima Laboratory of Phytoscience. Ethics clearance was granted (Protocol PP-2023-019, approved 22 April 2023).

Methods

Sensory evaluation used Quantitative Descriptive Analysis (QDA) with 14 trained panelists following ISO 13299 [2]. Six attributes were scored on a 10-point structured scale: color intensity, aroma strength, bitterness, floral notes, hay-like off-notes, and overall acceptability. Infusions were prepared at 0.02 g stigma per 50 mL water at 80°C for 10 minutes, served in amber cups at 55-60°C. Each panelist evaluated three replicates per grade in a balanced incomplete block design across two sessions. Chemical analysis followed ISO 3632-2 [1]. Moisture was determined at 103°C for 3 hours. Volatile oil was extracted by Clevenger hydrodistillation (3 h, 100 mL water per gram). Data were analyzed by two-way ANOVA (grade × session) and Pearson correlation between sensory and chemical parameters in XLSTAT version 2023.1.

Results

Table 1: Chemical quality parameters of three saffron grades from Uruguayan Prairie (ISO 3632 units)

Parameter	Grade I	Grade II	Grade III	ISO Cat. I min.
Crocin (E440)	231.4±8.7	194.3±7.2	162.8±9.4	≥190
Picrocrocin (E257)	89.7±4.3	74.2±3.8	61.4±5.1	≥70
Safranal (E330)	42.8±2.4	36.1±2.1	28.7±3.2	20-50
Moisture (%)	8.7±0.4	9.3±0.5	11.2±0.8	≤12

Grade I saffron met ISO Category I thresholds for all three chemical markers (Table 1). Grade II fell into Category I for crocin and safranal but dropped just below the picrocrocin

threshold at 74.2 versus the 70 minimum. Grade III fell short of Category I across the board, landing in Category II. Moisture stayed below 12% in all grades.

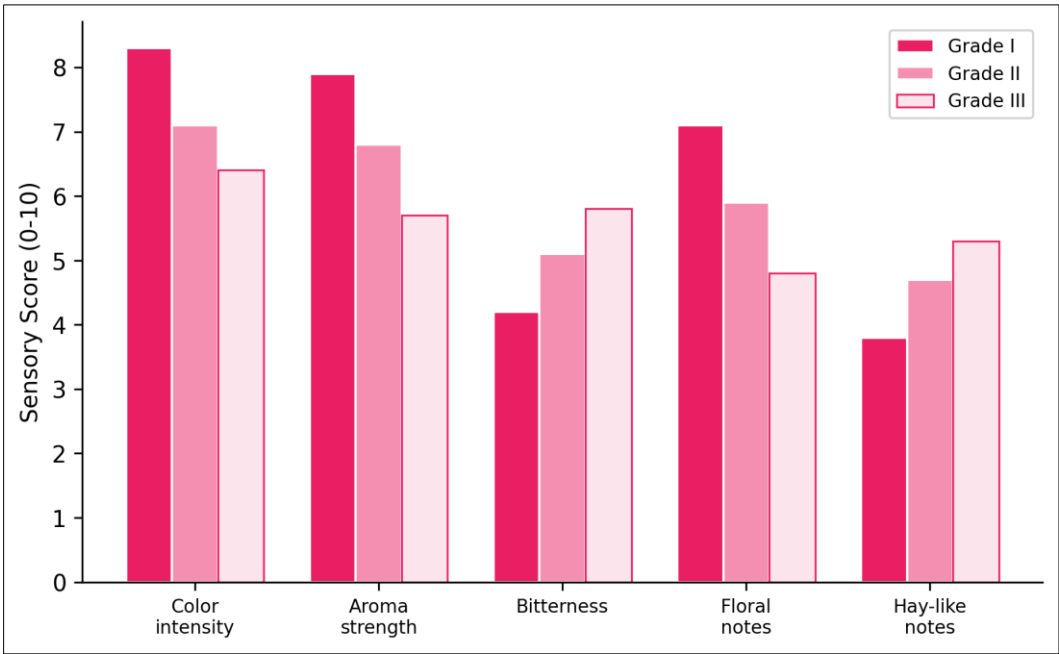


Fig 1: Sensory attribute scores across three saffron grades evaluated by trained panel on a 10-point scale

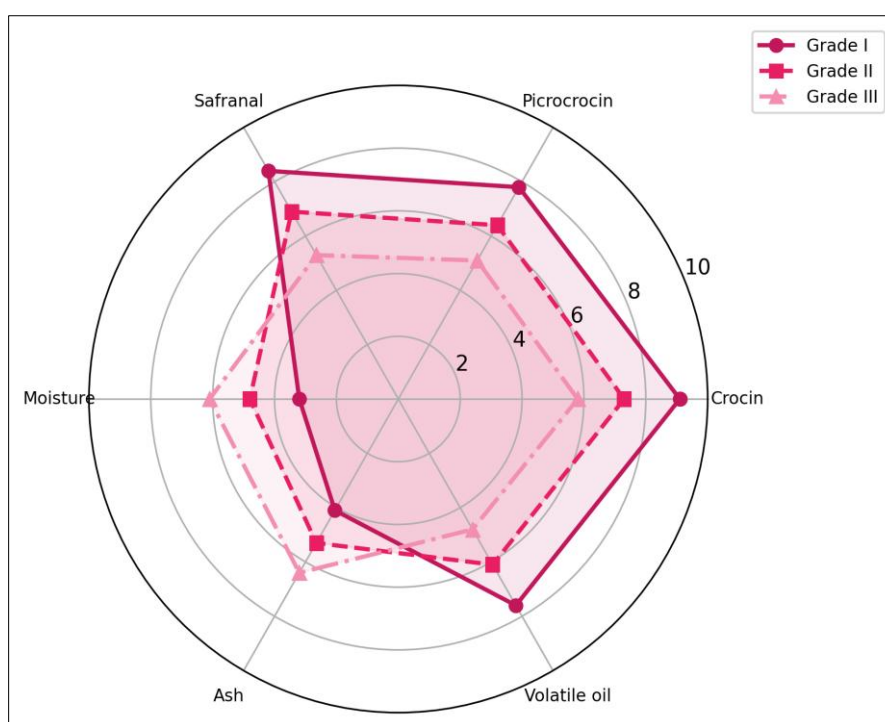
Table 2: Pearson correlation coefficients between sensory attributes and chemical parameters

Sensory attribute	vs. Crocin	vs. Picrocrocin	vs. Safranal
Color intensity	0.91**	0.47	0.38
Aroma strength	0.52	0.61*	0.88**
Bitterness	0.34	0.84**	0.41
Hay-like off-notes	-0.72**	-0.63*	-0.58*

** $p < 0.01$; * $p < 0.05$

The tightest sensory-chemical links were color intensity with crocin ($r = 0.91$), aroma strength with safranal ($r = 0.88$), and bitterness with picrocrocin ($r = 0.84$). Hay-like off-notes

showed negative correlations with all three markers, confirming that off-flavors arise from degradation of the very compounds that define quality (Table 2).

**Fig 2:** Comparing chemical quality markers of three Uruguayan saffron grades normalized on a 10-point scale

Discussion

Grade I Uruguayan saffron, produced with controlled 40°C drying, achieved sensory and chemical profiles on par with mid-range Iranian and Spanish saffron reported in the literature [3, 6]. The crocin value of 231.4, while not in the elite range above 260 seen in premium Kashmiri saffron, comfortably qualifies for ISO Category I. This suggests that the Uruguayan Prairie's temperate conditions can support adequate crocin biosynthesis in the stigma during flowering [4, 7].

The clear gradient from Grade I to Grade III across both sensory and chemical scales confirms that drying method is the dominant controllable factor after harvest. Sun-drying (Grade III) introduced hay-like off-notes scoring 5.3/10, which panelists described as "stale grass" and "cardboard." These off-notes are linked to excessive carotenoid and apocarotenoid degradation during prolonged, uncontrolled heat exposure [8, 9].

The strong sensory-chemical correlations validate the use of ISO 3632 markers as proxies for consumer-relevant quality, at least for the attributes tested. But the correlation between bitterness and picrocrocin ($r = 0.84$) was imperfect, hinting that other non-measured compounds possibly flavonoids or saponin-like substances also contribute to perceived bitterness in brewed saffron [1, 10].

A practical concern for Uruguayan producers is the sensitivity of Grade II saffron to the picrocrocin threshold. At 74.2, it barely cleared the ISO Category I minimum of 70. Slight variations in corm vigor, harvest timing, or drying temperature could push production lots below the line. Establishing tighter process controls and within-lot testing will be needed to maintain consistent Category I classification.

Conclusion

Grade I saffron from the Uruguayan Prairie achieved sensory and chemical quality that meets ISO 3632 Category I standards, with crocin at 231.4, picrocrocin at 89.7, and safranal at 42.8. Trained-panel evaluation confirmed that controlled drying at 40°C preserved aroma strength and minimized hay-like off-notes. Strong correlations between sensory attributes and chemical markers (color-crocin $r = 0.91$, aroma-safranal $r = 0.88$, bitterness-picrocrocin $r = 0.84$) validate ISO testing as a useful shorthand for sensory quality. Sun-drying produced Grade III saffron with unacceptable off-notes and chemical values below Category I. These findings give Uruguayan producers a clear roadmap: invest in temperature-controlled drying infrastructure and harvest before dawn to capture the highest stigma quality from Prairie-grown *Crocus sativus*.

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