RINGKASAN

Indonesia merupakan produsen utama minyak nilam dunia dengan kontribusi sekitar 90% pasokan global. Nilai ekonominya yang tinggi membuat komoditas ini rentan terhadap adulterasi, terutama pencampuran dengan minyak kelapa yang secara fisik serupa dan tidak beraroma kuat. Praktik tersebut berpotensi merugikan pelaku usaha, konsumen, dan reputasi ekspor. Penelitian ini bertujuan untuk mengidentifikasi minyak nilam murni dan yang teradulterasi menggunakan sistem sensor Micro-Electro-Mechanical Systems (MEMS) serta mengevaluasi respons dan akurasi klasifikasinya sebagai alternatif yang lebih objektif dibandingkan penilaian organoleptik pada skala UMKM.

Rancangan penelitian bersifat eksperimental. Sampel meliputi minyak nilam murni, minyak kelapa murni, minyak nilam adulterasi, serta campuran nilam–kelapa pada konsentrasi 1–20% (1, 5, 10, 15, 20%). Dua kondisi diuji—tanpa pemanasan dan dengan pemanasan menggunakan Corning PC-4200—dengan parameter atsiri measurement (Ag) dan sensitivitas (S = Ro/Rg). Data dianalisis menggunakan Principal Component Analysis (PCA) (Minitab) untuk reduksi dimensi dan pemisahan kelas, serta metode Center of Gravity (CoG) dan Euclidean Distance (ED) guna mengkuantifikasi jarak antarkelompok dan menghitung akurasi klasifikasi.

Pengujian disusun dalam empat skenario: (A) pembedaan nilam murni vs kelapa murni; (B) nilam murni vs nilam adulterasi; (C) nilam murni vs nilam tercampur kelapa; dan (D) nilam murni vs campuran nilam–kelapa pada variasi konsentrasi. Pemodelan dilakukan pada data kedua kondisi perlakuan untuk menilai konsistensi respons sensor terhadap keberadaan dan tingkat campuran, sehingga dapat menggambarkan batas kemampuan pemisahan kelas oleh sistem pada rentang konsentrasi yang diuji.

Hasil loading plot PCA menunjukkan sensor M6814, M4541, C811, dan M5524 paling responsif, sedangkan M9541 kurang responsif. Akurasi klasifikasi yang diperoleh melalui score plot PCA, CoG, dan ED mencapai 98,1% (A), 85,6% (B), 85,6% (C), dan 66,7% (D). Temuan ini menegaskan potensi sistem sensor MEMS multi-elemen sebagai pendekatan deteksi adulterasi yang lebih objektif, cepat, dan terstandar untuk pengendalian mutu minyak nilam khususnya pada skala UMKM. Ke depan, optimasi kombinasi sensor, penajaman strategi praperlakuan termal, serta perluasan variasi konsentrasi dan jumlah sampel berpeluang meningkatkan sensitivitas dan akurasi sistem.

SUMMARY

I*ndonesia is a leading producer of patchouli oil, contributing approximately 90% of global supply. Its high economic value renders the commodity vulnerable to adulteration, most commonly through blending with coconut oil, which exhibits similar physical characteristics and a weak odor profile. Such practices risk harming producers, consumers, and export reputation. This study aims to identify both pure and adulterated patchouli oil using a* ***Micro-Electro-Mechanical Systems (MEMS)*** *sensor array and to evaluate sensor responses and classification accuracy as a more objective alternative to organoleptic assessment at the small and medium enterprise (SME) scale.*

*The research employed an experimental design. Samples comprised pure patchouli oil, pure coconut oil, adulterated patchouli oil, and patchouli–coconut mixtures at 1%, 5%, 10%, 15%, and 20% concentrations. Two treatment conditions were applied—without heating and with heating using a Corning PC-4200 hot plate. The recorded parameters included the essential-oil measurement (****Rg****) and sensitivity (****S = Ro/Rg****), where* ***Ro*** *denotes the baseline measurement. Data were analyzed using* ***Principal Component Analysis (PCA)*** *(Minitab) for dimensionality reduction and class separation, alongside* ***Center of Gravity (CoG)*** *and* ***Euclidean Distance (ED)*** *to quantify inter-group distances and compute classification accuracy.*

Four classification scenarios were evaluated: (A) pure patchouli vs. pure coconut; (B) pure patchouli vs. adulterated patchouli; (C) pure patchouli vs. patchouli mixed with coconut oil; and (D) pure patchouli vs. patchouli–coconut mixtures across the 1–20% range. Modeling was conducted on data from both thermal conditions to assess the consistency of sensor responses to the presence and level of blending, thereby delineating the system's class-discrimination limits across the tested concentration range.

PCA loading plots indicate that sensors ***M6814, M4541, C811,*** *and* ***M5524*** *are the most responsive for patchouli identification, whereas* ***M9541*** *is comparatively less responsive. Classification accuracies derived from PCA score plots followed by CoG and ED were* ***98.1%*** *(A),* ***85.6%*** *(B),* ***85.6%*** *(C), and* ***66.7%*** *(D). These findings underscore the potential of a multi-element MEMS sensor system as a more objective, rapid, and standardized approach for detecting patchouli oil adulteration particularly for SME-level quality control. Future work should optimize sensor combinations, refine thermal pre-treatment strategies, and expand concentration ranges and sample sizes to further enhance sensitivity and overall accuracy.*