

REFERENCES

- Arshak, K., Moore, E., Lyons, G.M., Harris, J., and Clifford, S., 2004, A review of gas sensors employed in electronic nose applications, *Emerald Group*.
- Baiano, A., Siciliano, P., Taurino, A.M., Presicce, D.S., Gambacorta, G., Lamacchia, C., Pati, S., and La Notte, E., 2007, Electronic nose and GC-MS to investigate the volatile component of an Italian traditional pasta, *Cereal Foods World*, 52, 3, 138–143.
- Baietto, M. and Wilson, A.D., 2015, *Electronic-nose applications for fruit identification, ripeness and quality grading*, *Sensors (Switzerland)*.
- Brandusoju, I. and Todorean, G., 2013, Churn Prediction Modeling in Mobile Telecommunications Industry Using Decision Trees, *Journal of Computer Science and Control Systems*, 6, 1, 14–19.
- Buratti, S., Casiraghi, A., Minghetti, P., and Giovanelli, G., 2013, The Joint Use of Electronic Nose and Electronic Tongue for the Evaluation of the Sensorial Properties of Green and Black Tea Infusions as Related to Their Chemical Composition, 605–615.
- Bhattacharyya, N. and Bandhopadhyay, R., 2010, *Nondestructive Evaluation of Food Quality*, Springer Heidelberg Dordrecht London.
- Bok, D., Shin, Y., Hyun, G., Min, Y., Mi, C., Yeong, E., Yeon, J., Jamila, N., Khan, N., and Su, K., 2017, Determination of volatile organic compounds, catechins, caffeine and theanine in Jukro tea at three growth stages by chromatographic and spectrometric methods, *Food Chemistry*, 219, 443–452.
- Brândușoiu, I. B., and Todorean, G., 2013, Churn prediction modeling in mobile telecommunications industry using decision trees, University of Oradea, *Journal of Computer Science and Control Systems*, 6, 1.
- Capone, S., Tufariello, M., Francioso, L., Montagna, G., Casino, F., and Leone, A., 2013, Aroma analysis by GC-MS and electronic nose dedicated to Negroamaro and Primitivo typical Italian Apulian wines, *Sensors and Actuators BioChemical*, 179(2), 259–269.
- Cui, S., Wu, J., Wang, J., and Wang, X., 2017, Discrimination of American ginseng and Asian ginseng using electronic nose and gas chromatography–mass spectrometry coupled with chemometrics, *Journal of Ginseng Research*, 41(1), 85–95.
- Chi, T., and Huang D., 2008, Implementation Study of an Electronic Nose System Based on Computing Mechanisms, *Fourth International Conference on Natural Computation IEEE Electronic Society*.

- Chen, L., Feng, X., Chen, C., Shang, M. Y., Zhang, C. Y., Jie, and Y., 2013, Comparative analysis of two species of Asari Radix at Rhizoma by electronic nose, headspace GC-MS, with chemometrics, *Journal of Pharmaceutical and Biomedical Analysis*, 85(11), 231–238.
- Chen, Q., Zhao, J., Huang, X., Zhang, H., and Liu, M., 2006, Simultaneous determination of total polyphenols and caffeine contents of green tea by near-infrared reflectance spectroscopy, *Microchemical Journal*, 83(1), 42–47.
- Cheng, H., Chen, J., Chen, S., Wu, D., Liu, D., and Ye, X., 2015, Characterization of aroma-active volatiles in three Chinese bayberry (*Myrica rubra*) cultivars using GC-MS-olfactometry and an electronic nose combined with principal component analysis, *International Food Research*, 72, 8–15.
- Cloughley J.B., 1983, Factors influencing the caffeine content of black tea. Part 2. The effect of production variables, *Food Chemistry*, 10, 25–34.
- Deb, S. and Jolvis Pou, K.R., 2016, A Review of Withering in the Processing of Black Tea, *Journal of Biosystems Engineering*, 41, 4, 365–372.
- Dong, W., Zhao, J., Hu, R., Dong, Y., and Tan, L., 2017, Differentiation of Chinese robusta coffees according to species using a combined electronic nose and tongue with the aid of chemometrics, *Food Chemistry*, 229, 743–751.
- Dutta, R., Hines, E.L., Gardner, J.W., Kashwan, K.R., and Bhuyan, M., 2003, Tea quality prediction using a tin oxide-based electronic nose: an artificial intelligence approach, 94, 228–237.
- Dutta, R., Kashwan, K. R., Bhuyan, M., Hines, E. L., and Gardner, J. W., 2003, Electronic nose-based tea quality standardization. *Neural Networks*, 16(5-6), 847-853.
- Figaro, 2005, Technical Information on Usage of TGS Sensors for Toxic and Explosive Gas Leak Detectors, [http://www.figarosensor.com/products/common\(1104\).pdf](http://www.figarosensor.com/products/common(1104).pdf), accessed on 20 August 2018.
- Falasconi, M., Concina, I., Gobbi, E., Sberveglieri, V., Pulvirenti, A., and Sberveglieri, G., 2012, Electronic nose for microbiological quality control of food products, *International Journal of Electrochemistry*, 1–12.
- Forrest, D., 1985, *The World Tea Trade: A Survey of the Production, Distribution and Consumption of Tea*, Cambridge, Wood head-Faulkner Ltd.
- Fend, R., 2004, Development of medical point-of-care applications for renal medicine and tuberculosis based on electronic nose technology, *Institute of BioScience and Technology* 1–275.
- Fujioka, K., Tomizawa, Y., Shimizu, N., Ikeda, K., and Manome, Y., 2015, Improving the performance of an electronic nose by wine aroma training to distinguish between drip coffee and canned coffee, *Sensors (Switzerland)*, 15, 1, 1354–1364.
- Fujioka, K., Tomizawa, Y., Shimizu, N., Manome, Y., 2014, Description of Coffee Aroma with the Electronic Nose which Learned Wine Aromas, “Le Nez du Vin,”

Gardner, J.W. and Bartlett, P. N., 1999, *Electronic noses: principles and applications*, 233. Oxford University Press, NEW YORK, U.S.A.

Ghasemi-Varnamkhasti, M., and Aghbashlo, M., 2014, Electronic nose and electronic mucosa as innovative instruments for real-time monitoring of food dryers, *Food Science and Technology*, 38, 158-16

Ghasemi-Varnamkhasti, M., Mohtasebi, S. S., Siadat, M., and Balasubramanian, S., 2009, Meat quality assessment by electronic nose (machine olfaction technology) sensors, 9, 6058–6083.

Graham, H.N., 1984, Tea; the plant and its manufacture; chemistry and consumption of the beverage, In: *Spiller, G.A., ed., the Methylxanthine Beverages and Foods: Chemistry, Consumption and Health Effects*, New York, 29–4.

Graham, H.N. 1983, Tea. In: Mark, H.F., Othmer, D. R., Overberger, C.G., Seaborg, G.T. and Grayson, M., *kirk-Othmer Encyclopedia of Chemical Technology*, 3rd ed., New York, John Wiley and Sons, 628–644.

Haddi, Z., Amari, A., Alami, H., El Bari, N., Llobet, E. and Bouchikhi, B., 2011, A portable electronic nose system for the identification of cannabis-based drugs, *Sensors Actuators, B Chem.*, 155, 2, 456–463.

<https://en.wikipedia.org/wiki/Tea>.

<https://dir.indiamart.com/chennai/oolong-tea-premium.html>, accessed on 30 August 2018.

https://www.greenhilltea.com/organic_matcha_tea_p/id82.htm, accessed on 30 August 2018.

[https://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/images/Camellia sinensis \(Tea_Plant\)/camellia_sinensis_02](https://keys.lucidcentral.org/keys/v3/eafrinet/weeds/key/weeds/Media/Html/images/Camellia sinensis (Tea_Plant)/camellia_sinensis_02), accessed on 20 August 2018.

http://www.sccg.sk/~haladova/principal_components.pdf, accessed on 22 August 2018.

<https://www.shutterstock.com/search/black+tea+powder.pdf>, accessed on 30 August 2018.

Ikeda, R. A., Warshamana, G. S., and Chang, L. L., 1992, In vivo and in vitro activities of point mutants of the bacteriophage T7 RNA polymerase promoter, 22; 31(37), 9073–80.

International Organization for Standardization, 1981, *Black Tea Specification (International Standard (ISO 3720))*, London.

Jeon, D. B., Hong, Y. S., Lee, G. H, Park, Y., M., Lee, C. M., Nho, E. Y., Choi, J.Y., Jamila, N., Khan, N., and Kyon, 2016, Determination of volatile organic compounds, catechins, caffeine and theanine in Jukro tea at three growth stages by chromatographic and spectrometric methods.

Jolliffe, I.T., 2002, *Principal Component Analysis*, 2nd Ed., Springer, New York.

Kaipainen, A., Ylisuutari, S., Moy, L., and Lucas, Q., 1996, Comparison of two techniques

for the analysis of headspace aroma profiles of sugar. thermal desorption GC-MS and electronic nose. Olfaction and Electronic Nose, *3rd International Symposium, Toulouse*.

- Kashwan, K.R., and Bhuyan, M., 2005, Robust electronic-nose system with temperature and humidity drift compensation for tea and spice flavor discrimination. *In: Sensors Int. Conf. new Tech. Pharm. Biomed. Res. Asian Conf.*, 154–158
- Kawakami, M., Subhendu, N., Ganguly, J., Banerjee, and Kobayashi, A., 1995, Aroma Composition of Oolong Tea and Black Tea by Brewed Extraction Method and Characterizing Compounds of Darjeeling Tea Aroma, *Journal of Agricultural and Food Chemistry*, 43(1), 200–207.
- Kiani, S., Minaei, S., and Ghasemi-Varnamkhasti, M., 2016, A portable electronic nose as an expert system for aroma-based classification of saffron, *Chemometrics and Intelligent Laboratory Systems*, 156, 148–156.
- Kiani, S., Minaei, S., and Ghasemi-Varnamkhasti, M., 2016, Application of electronic nose systems for assessing quality of medicinal and aromatic plant products, *Journal of Applied Research on Medicinal and Aromatic Plants*, 3, 1, 1–9.
- Lelono, D., Triyana, K., Hartati, S., and Istiyanto, J.E., 2016, principal component analysis Classification of Indonesia Black Teas Based on Quality by Using Electronic Nose and Principal Component Analysis, 020003.
- Loutfi, A., Coradeschi, S., Mani, G.K., Shankar, P., and Rayappan, J.B.B., 2015, Electronic noses for food quality, A review, *Journal of Food Engineering*, 144, 103–111.
- Li, C., Xu, F., Cao, C., Shang, M., Zhang, C., Yu, J., Liu, G., Wang, X., and Cai, S., 2013, Comparative analysis of two species of Asari Radix et Rhizoma by electronic nose, headspace GC – MS and chemometrics, *Journal of Pharmaceutical and Biomedical Analysis*, 85, 231–238.
- Li, Y., and Xie, X., 2008, Churn prediction with Linear Discriminant Boosting algorithm, *International Conference on Machine-Learning and Cybernetics*.
- Liu, G , Xu, S , Wang, X., Jin, Q, Shen, Y , Xu, G , and Zhang, H., 2016, Determination of volatile organic compounds, catechins, caffeine and theanine in Jukro tea at three growth stages by chromatographic and spectrometric methods.
- Loutfi, A., Coradeschi, S., Mani, G.K., Shankar, P., and Rayappan, J.B.B., 2015, Electronic noses for food quality: A review, *Journal of Food Engineering*, 144, 103–111
- Magwaza, L. S., and Opara, U. L., 2015, Analytical methods for determination of sugars and sweetness of horticultural products, A review, *Scientia Horticulturae*, 184, 179–192.
- Marina, A. M., Che Man, Y. B., and Amin, I., 2009, Use of the SAW Sensor Electronic Nose for Detecting the Adulteration of Virgin Coconut Oil with RBD Palm Kernel Olein, AOCS.
- Men, H., Fu, S., Yang, J., Cheng, M., Shi, Y., and Liu, J., 2018, Comparison of SVM, RF and ELM on an electronic nose for the intelligent evaluation of paraffin samples. *Sensors (Switzerland)*, 18(1), 1–17.
- Ni, K., Wang, J., Zhang, Q., Yi, X., Ma, L., Shi, Y., and Ruan, J., 2018, Multi-element

- composition and isotopic signatures for the geographical origin discrimination of green tea in China: A case study of Xihu Longjing, *Journal of Food Composition Analysis*, 67, January, 104–109.
- O’Sullivan, M. G., Byrne, D. V., Jensen, M. T., Andersen, H. J., and Vestergaard, J., 2003, A comparison of warmed-over flavor in pork by sensory analysis, GC/MS and the electronic nose. *Meat Science*, 65(3), 1125–1138.
- Panigrahi, S., Balasubramanian, S., Gu, H., Logue, C.M., and Marchello, M., 2006, Design and development of a metal oxide based electronic nose for spoilage classification of beef, 119, 2–14.
- Papadopoulou, O.S., Tassou, C.C., Schiavo, L., and Panagou, E.Z., 2011, Rapid assessment of meat quality by means of an electronic nose and support vector machines, *Ital. Oral Surg.*, 1, 2003–2006.
- Pearce, T. C., Schiffman, S.S., Nagle, H.T., Gardner, J.W., 2003, Handbook of Machine Olfaction: Electronic Nose Technology, *Wiley-VCH Verlag GmbH and Co. KGaA, Weinheim, Germany*.
- Polikar, R., Shinar, R., Honavar, V., Udpa, L., and Porter, M. D, 2001, Detection and identification of odorants using an electronic nose, *IEEE International Conference on Acoustics, Speech, and Signal*, 3137–3140.
- Pennazza, G., Fanali, C., Santonico, M., Dugo, L., Cucchiaroni, L., and Dacha, M., 2013, Electronic nose and GC-MS analysis of volatile compounds in Tuber magnatum Pico: evaluation of different storage conditions, *Food Chemistry*, 136(2), 668–674.
- Peris, M., and Escuder-Gilabert, L., 2009, A 21st century technique for food control: electronic noses. *Analytica Chimica Acta*, 63(1), 1–15.
- Ravichandran, R., and Parthiban, R., 1998, The impact of processing techniques on tea volatiles, *Food Chemistry*, 62, 347–353.
- Ropodi, A.I., Panagou, E.Z., and Nychas, G.E., 2016, Trends in Food Science & Technology Data mining derived from food analyses using non-invasive / non- destructive analytical techniques; determination of food authenticity, quality & safety in tandem with computer science disciplines, *Trends in Food Science & Technology*, 50, 11–25.
- Rumpler, W., Seale, J., Clevidence, B., Judd, J., Wiley, E., Yamamoto, S., Komatsu, T. Sawaki, T., Ishikura, Y., and Hosoda, K., 2001, Oolong tea increases metabolic rate and fat oxidation in men., *Journal of Nutrition*, 131(11), 2848–52.
- Sahar, F., 2018, Machine-Learning Techniques for Customer Retention: A Comparative Study, *International Journal of Advanced Computer Science and Applications (IJACSA)*, 9, 2, 273–281.
- Sayeed, A. and Shameem, M.S., 2011, Electronic Nose, *Adv. Med. Informatics*, 1, 1, 06–09.
- Siegmund, B. and Werner, P., 1999, Changes of the volatile fraction of cooked chicken meat during chill storing: results obtained by the electronic nose in comparison to GC-MS and GC olfactometry, *Springer-VerlagZ Lebensm Unters Forsch*, 208, 336–341.

Smith, L.I., 2002, A tutorial on Principal Components Analysis.

Soo, K., Ho, H., Soo, C., and Woong, C., 2011, Comparison of k -nearest neighbor, quadratic discriminant and linear discriminant analysis in classification of electromyogram signals based on the wrist-motion directions, *Current Applied Physics*, 11, 3, 740–745.

Sun, Y., Wang, J., and Cheng, S., 2017, Discrimination among tea plants either with different invasive severities or different invasive times using MOS electronic nose combined with a new feature extraction method, *Computers and Electronics in Agriculture*, 143, December 2016, 293–301.

Tibshirani, Jerome, Friedman Trevor, and Hastie Robert. 2008. The Elements of Statistical Learning Data Mining, Inference and Prediction. 2nd ed. New York: Springer New York.

Togari, N., Kobayashi, A., and Aishima, T., 1995, Relating sensory properties of tea aroma to gas chromatographic data by chemometric calibration methods, 28(5), 485–493.

Triyana, K., Subekti, M.T., Aji, P., Hidayat, S.H., and Rohman, A., 2015, Development of Electronic Nose with Low-Cost Dynamic Headspace for Classifying Vegetable Oils and Animal Fats, 771, 50-54.

Wight, D., 1994, Boys' Thoughts and Talk about Sex in a Working Class Locality of Glasgow, *Sociology Review*, 42, 4, 703–737.

Wilson, A.D. and Baietto, M., 2011, Advances in electronic-nose technologies developed for biomedical applications, *Sensors*, 11, 1, 1105–1176.

Wu, B., Abbott, T., Fishman, D., McMurray, W., Mor, G., Stone, K., Ward, D., Williams, K. and Zhao, H., 2003, Comparison of statistical methods for classification of ovarian cancer using mass spectrometry data, *Bioinformatics*, 19, 13, 1636–43.

Xin, R., Liu, X., Wei, C., Yang, C., Liu, H., Cao, X., and Wu, D., 2018, E-Nose and GC-MS Reveal a Difference in the Volatile Profiles of White- and Red-Fleshed Peach Fruit 18(11), 765.

Yan, J., Guo, X., Duan, S., Jia, P., Wang, L., Peng, C. and Zhang, S., 2015, Electronic nose feature extraction methods: A review, *Sensors (Switzerland)*, 15, 11, 27804–27831.

Yao, Y., Pan, S., Fan, G., Dong, L., Ren, J., and Zhu, Y., 2015, Evaluation of volatile profile of Sichuan dongcai, a traditional salted vegetable, by SPME- GC-MS and E-nose, *LWT-Food Science and Technology*, 64(2), 528–535.

Yan, J., Guo, X., Duan, S., Jia, P., Wang, L., Peng, C., and Zhang, S., 2015, Electronic Nose Feature Extraction Methods, A Review. *Sensors*, 15(11), 27804–27831.

Yan, S. H., 2007, NIR evaluation of the quality of tea and its market price. *Spectroscopy Asia*, 19(2), 16–19.

Yanagimoto, K., Ochi, H., Lee, K. G., and Shibamoto, T., 2003, Antioxidative activities of volatile extracts from green tea, oolong tea, and black tea, *Journal of Agricultural and Food Chemistry*, 51, 7396–401.



UNIVERSITAS
GADJAH MADA

IMPLEMENTATION OF PATTERN RECOGNITION TECHNIQUES COMBINING WITH FEATURE EXTRACTION METHODS TO DISCRIMINATE BLACK TEAS ACCORDING TO THE QUALITIES MEASURED USING ELECTRONIC NOSE

KOMBO, KOMBO, Dr. Eng. Kuwat Triyana, M.Si.

Universitas Gadjah Mada, 2019. Diunduh dari: <http://etd.repository.ugm.ac.id/>

Yang, Y. Q., Yin, H. X., Yuan, H. B., Jiang, Y. W., Dong, C. W., and Deng, Y. L., 2018, Characterization of the volatile components in green tea by IRAE-HS-SPME/GC-MS combined with multivariate analysis, *Plos One*, 13(3), e0193393.

Yokogoshi, H., Kobayashi, M., Mochizuki, M., and Terashima, T., 1998, Effect of theanine, r-glutamylethylamide, on brain monoamines and striatal dopamine release in conscious rats, *Neurochem Research*, 23(5), 2848–52.

Yu, H., Wang, J., Yao, C., Zhang, H., and Yu, Y., 2008, Quality grade identification of green tea using e-nose by CA and ANN, *LWT - Food Science and Technology*, 41(7), 1268–1273.

Yu, H., Wang, J., Xiao, H., and Liu, M., 2009, Sensors and Actuators B: Chemical Quality grade identification of green tea using the eigenvalues of PCA based on the E-nose signals, 140, 378–382.

Zhou, B., Wang, J., Qi, J., 2012, Identification of different wheat seeds by electronic nose, *International Agrophysics*, 26, 4, 413–418.