countries (Machado et al., 2020; Hussein and Seid, 2024). Studies on Portuguese and Italian monofloral honeys further demonstrate that parameters such as electrical conductivity, color, sugar spectrum, diastase activity, and specific VOCs allow discrimination among floral types, underscoring the tight link between single dominant nectar sources and honey composition (Ballarin et al., 2022).

Multifloral honeys, in contrast, result from bees collecting nectar from many species simultaneously, reflecting high floral richness and flexible foraging strategies. Pollen analyses in Ethiopia and other regions reveal that a substantial proportion of harvested honeys are multifloral or bifloral, often containing dozens of pollen types and integrating contributions from herbs, shrubs, and trees across habitats (Tesfu and Habte, 2021; Bratosin et al., 2025). Diet studies using pollen traps and landscape analysis show that, even where mass-flowering crops dominate nectar intake, a wide diversity of wild and weed species contributes to pollen and, to a lesser extent, nectar, particularly between major crop flowering peaks (Inaudi et al., 2025). Consequently, multifloral honeys often show more complex but less predictable profiles, and their quality depends strongly on the composition and continuity of surrounding floral communities (Machado et al., 2022).

4.2 Impact of plant species on honey composition

Individual plant species imprint specific chemical signatures on honey through their nectar and secondary metabolites. Comparative analyses of honeys from sunflower, linden, rapeseed, acacia, and other floral types show that botanical origin significantly affects moisture, sugars, electrical conductivity, free acidity, phenolics, flavonoids, and antioxidant activity. For example, sunflower honey has been reported with particularly high conductivity and phenolic and flavonoid contents, while multifloral honeys in the same region exhibit higher total sugars, illustrating how plant traits translate into distinct nutritional and technological properties (Machado et al., 2022). Similarly, monofloral honeys from thyme, linden, and buckwheat often contain markedly higher total phenolics and antioxidant capacities than acacia honeys, reflecting species-specific phenolic profiles (Jaśkiewicz et al., 2025).

Beyond bulk parameters, plant species influence detailed phenolic and volatile fingerprints that support authentication and origin differentiation. Studies on varietal honeys show that particular phenolic acids and flavonoids (e.g., caffeic, p-coumaric acids, quercetin, hesperetin, chrysin) reach characteristic levels in honeys from thyme, coriander, jujube or other specific plants, enabling chemometric models to classify monofloral types with high accuracy (Akbari et al., 2020). Reviews of honey volatiles identify dominant aroma compounds associated with citrus, chestnut, eucalyptus, lavender, rosemary, and other sources, while also highlighting that interactions with geography and processing can complicate marker selection (Machado et al., 2020; Hussein and Seid, 2024). Overall, the plant species providing nectar act as primary drivers of compositional diversity, setting the baseline upon which environmental and management factors further operate.

4.3 Analysis of flowering cycles and nectar source stability

Flowering phenology and seasonal continuity of nectar sources critically influence both the botanical origin of honeys and the stability of their quality. Whole-farm and landscape-scale studies reveal strong seasonal fluctuations in nectar production, with clear peaks and “gaps” when floral resources are scarce relative to pollinator demand (Vîjan et al., 2023). In temperate farmlands, two main nectar peaks often occur around mass-flowering crops, separated by a late-spring dearth (“June gap”), and further periods of low availability in early spring and late summer-autumn (Figure 1) (Inaudi et al., 2025). These temporal mismatches affect which plant species dominate nectar flows at different times, creating seasons where monofloral honeys (e.g., rapeseed, sunflower) are likely, and intervening periods when bees rely more on diverse weeds, hedgerows, and semi-natural habitats, favoring multifloral profiles (Inaudi et al., 2025).

At regional scales, characterization of honeybee floras and flowering seasons shows that specific months can be classified as major nectar flow and honey flow periods linked to key plant species, while other months act as dearth or minor harvest seasons with different dominant flora (Silva et al., 2025). For instance, highland and lowland areas may produce monofloral honeys from distinct species in separate peak seasons, with additional minor harvests from other taxa in between (Tesfu and Habte, 2021). Longitudinal studies of pollen diversity also