Mandom Identifies Odor Compounds Produced by Middle-aged Men

For the First Time, the Causative Compound of Middle-aged OilyOily Odor, Diacetyl, Discovered using an Original Method

Flavonoid-containing Plant Extracts Suppress the Gneration of Diacetyl Odor

Mandom Corporation (Headquarters: Osaka; President Executive Officer, Motonobu Nishimura; hereafter, Mandom) has, to our knowledge, for the first time, discovered using an original analytical method that **the compound that causes unpleasant, oily smell common among middle-aged men in their 30s and 40s—middle-aged oily odor—is the molecule diacetyl,** secreted from the scalp and surrounding area. We found that diacetyl is formed when skin bacteria such as Staphylococcus epidermidis metabolize lactic acid contained in sweat, and that various types of flavonoid-containing plant extracts inhibit the lactic acid metabolism of skin bacteria, by effectively suppressing diacetyl production. We intend to implement this "middle-aged oily odor suppression technology" in a deodorant for middle-aged men.

This body of research was presented in June 2013 at the 38th Annual Meeting of the Japanese Cosmetic Science Society, in September at the 47th Annual Meeting of the Japanese Association for the Study of Taste and Smell and the 65th Annual Meeting of the Society of Biotechnology of Japan, and in October at the 8th Metabolome Symposium and the IFSCC 2013 Conference in Rio de Janeiro. At the 65th Annual Meeting of the Society of Biotechnology of Japan, it was selected for a meeting topic lecture as an attention-worthy research result related to the application of biotechnology to industry.

1. Research Background

In recent years, issues such as global warming and energy conservation initiatives have increased the situation in which an individual can sweat more prevalently, and consumer awareness of body odor is known to increase annually. Further, terms such as "smell harassment" indicate that body odor is no longer a private problem and has developed into a social issue that affects the quality of life of consumers. At Mandom, we conducted a great deal of research into the body odor of men. We analyzed the "unique body odor of middle-aged men" in remarkable detail, identified the compounds associated with the odor, and developed technologies that effectively suppress it.

2. It Is Not Aging? Identifying the "Middle-aged Oily Odor" Produced by Middle-aged Men and the Compound Diacetyl that Causes It

(1) Consumers' Perception of the Body Odor of Middle-aged Men

The results of an awareness survey conducted among normal male and female customers by Mandom on the topic of body odor of men indicated that approximately half of all consumers noticed a change in the body odor of men in their 30s and 40s (Figure 1). Thus far, the production of the widely known compound in "old-people odor," 2-nonenal, was believed to become more prominent only after the age of 50 years. That is, we discovered a gap in knowledge of the average consumer. This result implies that a different odor compound—apart from the one known to contribute to old-

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people odor—is involved in the production of body odor of middle-aged men. In addition, a poll in the same survey "in what body part [respondents] detected a change in male body odor," many indicated that they noticed a change on the scalp and surrounding areas. This trend was especially clear among women (Figure 2).

(2) The "Oily odor" Unique to Middle-aged Men and the Causative Compound, Diacetyl

Thus, we assembled a special olfactory panel, which included odor judges, to directly perform the olfactory measure of the odor strength of various body parts of males in their 40s and 50s. We found that the scalp had the strongest odor, and that the back of the ears—thought to be the origin point of old-people odor—was only weakly odorous (Figure 3). Next, after the scalp odor characteristics (odor type) of men in their 40s and 50s were compared with those of men in their 20s, we found that the scalps and pillows of men in their 40s and 50s possessed, compared to those of men in their 20s, a strong "oily odor" (Figure 4).

In order to discover the compound responsible for this oily odor, we extracted odor compounds from the scalps and pillows of men in their 40s and 50s and analyzed them and identified the causative compound as diacetyl (Figure 5). After the relationship between the amounts of this compound produced on the scalp and age was investigated, we found that diacetyl production is the greatest in men in their 40s, and that its production tended to increase between the ages of 20 and 40 years (Figure 6). This trend coincided with the ages at which consumers tended to notice a change in body odor, supporting the finding that increasing amounts of diacetyl on the scalp is the causative phenomenon for the distinctive middle-aged man odor.

At Mandom, we named this unique middle-aged man odor caused by diacetyl "middle-aged oily odor." Since it was the primary odor among middle-aged men, we developed technologies to suppress the effects of this odor-causing compound.

3. Explaining the Mechanism of the Middle-aged Oily Odor Caused by Diacetyl, and Developing Technology to Suppress It

(1) The Odor Generation Mechanism of Diacetyl, the Compound Responsible for Middle-aged Oily Odor

In order to develop a technology to effectively suppress diacetyl production, we attempted to identify the sweat compounds that give rise to diacetyl on the skin and the skin bacteria that produce it. We incubated the human skin bacteria with metabolites from sweat and analyzed diacetyl production. We found that bacteria in the ever-present *Staphylococcus* family (*Staphylococcus epidermidis* and *Staphylococcus aureus*) take in and metabolize lactic acid in the sweat and produce diacetyl (Table 1, Figure 7).

(2) Flavonoid-containing Plant Extracts Suppress Diacetyl Production

In order to identify a compound that can effectively suppress diacetyl—responsible for middle-aged oily odor—we evaluated the diacetyl-suppressing effects of 102 types of plant extracts. We found that several flavonoid-containing plant extracts, such as those of licorice and cinnamon, effectively suppressed the production of diacetyl by skin bacteria (Figure 8). The effects of these plant extracts do not involve the reduction of skin flora. Thus, these extracts are likely not antimicrobial in nature, but instead inhibit the metabolic pathways involved in diacetyl synthesis. Thus, we confirmed the effect of plant extracts on diacetyl metabolism and found that they reduce the speed at which lactic acid is metabolized into pyruvate and limit its uptake into bacterial cells (Figure 9). These results suggested that the inhibitory effects of these flavonoid-containing plant extracts on diacetyl synthesis are attributed to their ability to suppress the metabolism of lactic acid into pyruvate (Figure 10).

Our new findings have clarified the actual state of body odor of middle-aged men (Figure 11). By detecting the existence of another type of main body odor apart from the sweaty smell of the armpits and the old-people odor that becomes more prominent in individuals in their 50s—the middle-aged oily odor—we could better understand the body odor changes occurring in middle–aged men and developed appropriate and effective treatments for it.

In the future, we aim to apply this knowledge in the development of effective deodorants designed to counteract the effects of the causative compound of middle-aged oily odor—diacetyl.

<Reference Materials>

Figure 1: The Age at which Consumers Believe an Age-related Change in Body Odor Occurs

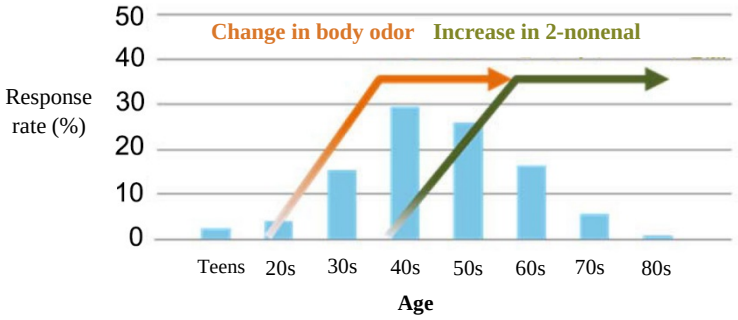


Figure 2: Body Parts in which a Change in Body Odor is Detected

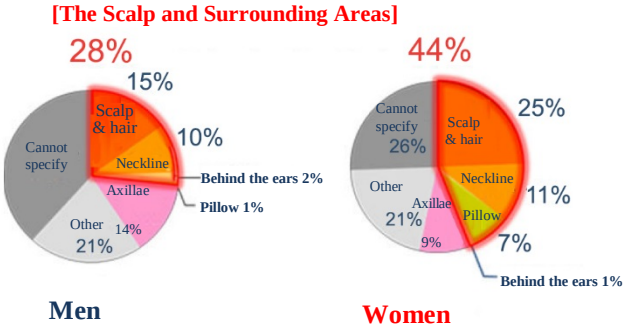


Figure 3: Partwise Comparison of Odor Strengths in Middle-aged Men (24 h after Bathing)

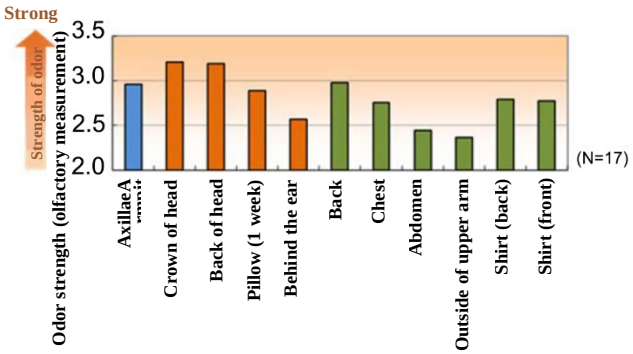


Figure 4: Year- and Partwise Differences in Oilly Odor on the Scalp

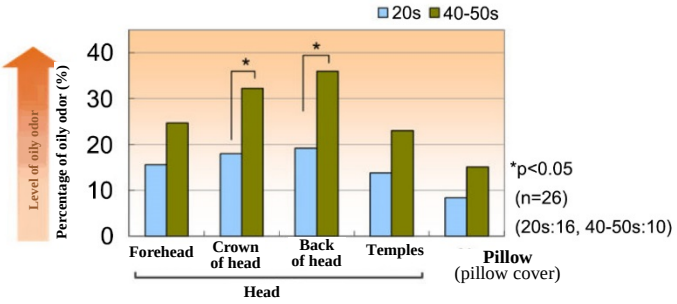


Figure 5: Characteristics of Diacetyl

Diacetyl

- A compound with a smell reminiscent of old, used oil. In alcoholic beverages, it is known as a foul-smelling compound (off-flavor compound) that affects fragrance and flavor.s
- Can be detected in smaller amounts than even the strong-smelling components of bad breath and foot odor. Highly odorous compound.
- In middle-aged men, increased diacetyl production on the scalp and the surrounding area causes it to mix with the existing smell compounds of the scalp (medium-chain oily acids, etc.) and produce that characteristic, unpleasant “middle-aged oily” odor common among middle-aged men.

- Structural formula 
- Molecular weight
- Boiling point: 88 °C (high diffusibility)
- Smell characteristics: old oil, butter
- Olfactory threshold: 0.05 ppb
- Primary aroma component of fermented foods
- such as yogurt, cheese, and butter
- In alcoholic beverages (beer, sake, etc.), it is known as an
- off-flavor compound (nauseating smell) that affects fragrance and flavor.

Figure 6: Relationship between Diacetyl Concentration from head and Age

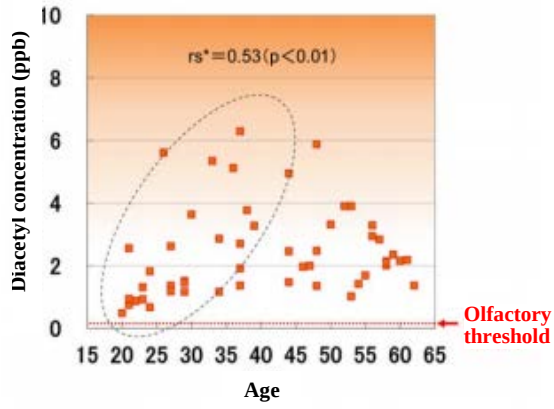


Table 1: Skin Bacteria that Produce Diacetyl

Skin bacteria		Diacetyl production (μM)	Acetoin production (μM)
Staphylococcus	*Staphylococcus aureus*	2.0	125.0
	Staphylococcus epidermidis	1.0	70.7
	S. hominis	0	10.1
	S. haemolyticus	0	0.1
Corynebacterium	*C.jeikeium*	0	0
	C. xerosis	0	6.2
	C. minutissumum	0	0
	C. striatum	0	0

Figure 7: Sweat Compounds That Produce Diacetyl

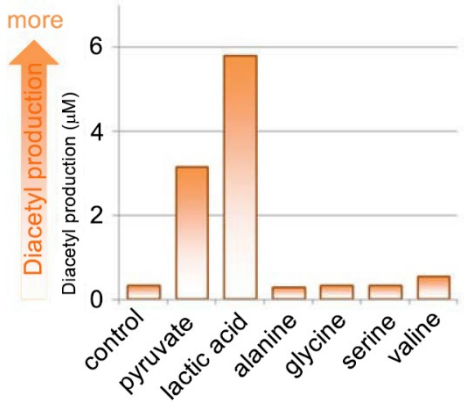


Figure 8: Diacetyl-suppressive Effect of Plant Extracts

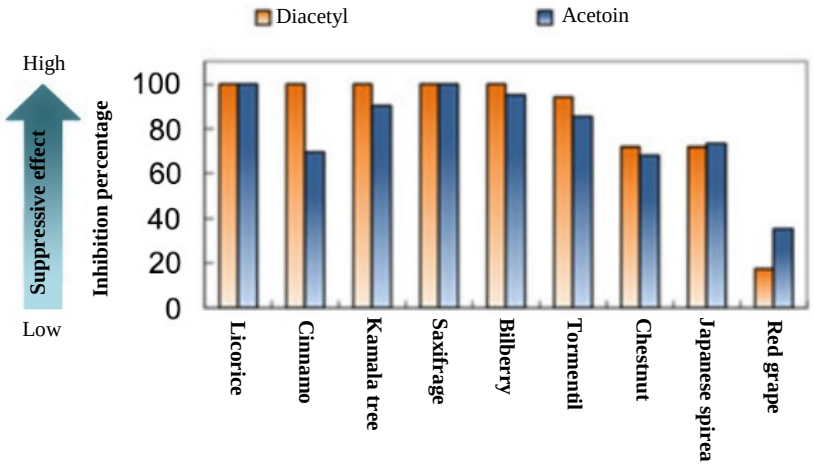


Figure 9: Suppression of Lactic Acid Metabolism by Plant Extracts

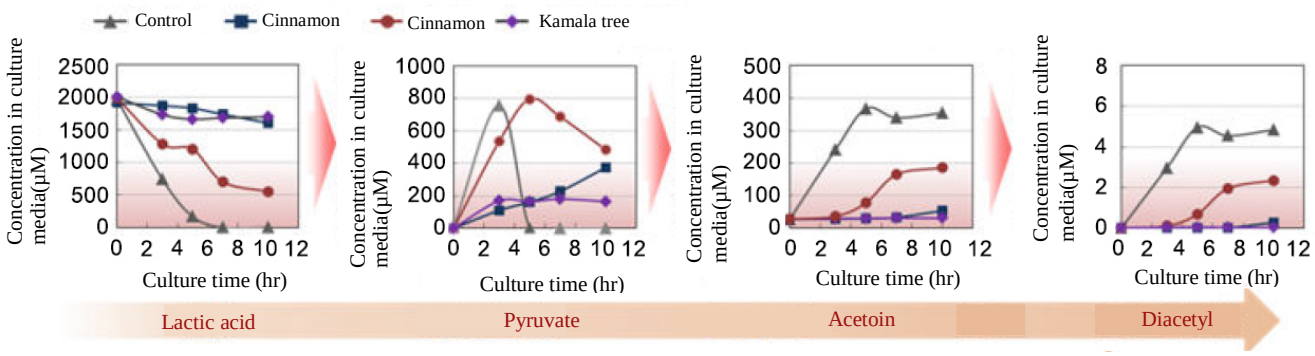


Figure 10: Mechanism of Diacetyl Suppression by Flavonoid-containing Plant Extracts:

Mechanism of Diacetyl Suppression

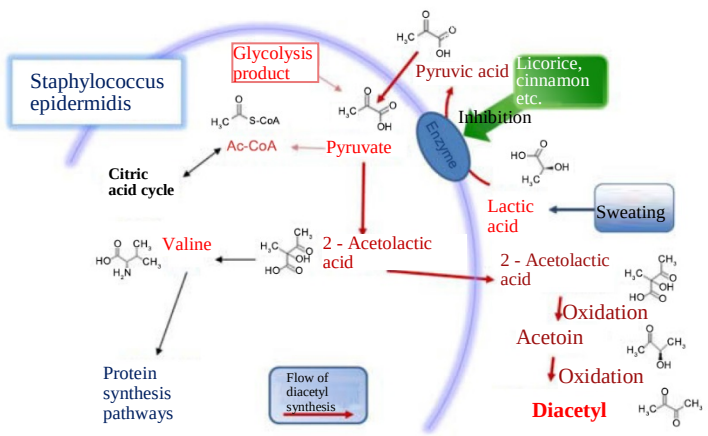
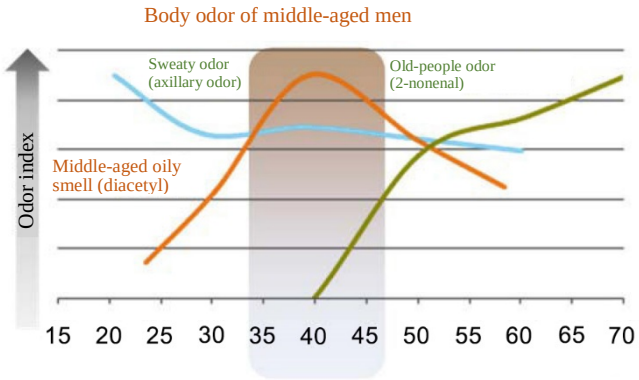


Figure 11: Changes in Body Odor of Men Due to Aging



Sweaty odor:	An index for the relative strength of axillary odor strength across ages. The highest value (mean at ages 18–24 years) set to 100, and odor discrimination threshold (level 2) set to 0.
Middle-aged oily odor:	An index for diacetyl production at the scalp, the cause of middle-aged oily odor. The highest value (mean at ages 35–44 years) set to 0, and the lowest value (1 ppb) set to 0.
Old-people odor:	An index for nonenal production on the back, the cause of old-people odor. The highest value (mean at ages 65–75 years) set to 0, and the lowest value (0 ng) set to 0.