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Sensory Characterization of Odors in Used Disposable Absorbent Incontinence Products

Heléne Widén ♦ Susanne Alenljung ♦ Ulla Forsgren-Brusk ♦ Gunnar Hall

ABSTRACT

PURPOSE: The objectives of this study were to characterize the odors of used incontinence products by descriptive analysis and to define attributes to be used in the analysis. A further objective was to investigate to what extent the odor profiles of used incontinence products differed from each other and, if possible, to group these profiles into classes.

SUBJECTS AND SETTING: Used incontinence products were collected from 14 residents with urinary incontinence living in geriatric nursing homes in the Gothenburg area, Sweden.

METHODS: Pieces were cut from the wet area of used incontinence products. They were placed in glass bottles and kept frozen until odor analysis was completed. A trained panel consisting of 8 judges experienced in this area of investigation defined terminology for odor attributes. The intensities of these attributes in the used products were determined by descriptive odor analysis. Data were analyzed both by analysis of variance (ANOVA) followed by the Tukey post hoc test and by principal component analysis and cluster analysis.

RESULTS: An odor wheel, with 10 descriptive attributes, was developed. The total odor intensity, and the intensities of the attributes, varied considerably between different, used incontinence products. The typical odors varied from “sweetish” to “urinal,” “ammonia,” and “smoked.” Cluster analysis showed that the used products, based on the quantitative odor data, could be divided into 5 odor classes with different profiles.

CONCLUSIONS: The used products varied considerably in odor character and intensity. Findings suggest that odors in used absorptive products are caused by different types of compounds that may vary in concentration.

KEY WORDS: Absorbent product, Cluster analysis, Descriptive odor analysis, Incontinence product, Odor profile, PCA, Urinary incontinence.

INTRODUCTION

Urinary incontinence (UI) has been defined as a “complaint of involuntary loss of urine”¹; it affects approximately 400 million individuals worldwide.² One way to manage UI is through the use of disposable absorbent incontinence products. The primary aim of these products is to absorb and contain leaked urine; users have identified their ability to reduce

odors as one of their most important characteristics.^{3,4} This increases the demands on scientific knowledge on odor in used incontinence products.

Research focusing on the perceived odor in connection with the use of incontinence products is scarce. Odor measurement has been reported for a small number of used incontinence products by the use of an olfactometric technique called dilution to threshold (D/T).⁵ However, this method does not give any information about the character of these odors.

Multiple factors contribute to the odor produced by used incontinence products. One of these is the urine itself that can contain odorous compounds depending on diet,⁶⁻⁹ drugs, and comorbid conditions.¹⁰⁻¹² The urine may also contain bacteria, a condition that is prevalent in persons suffering from UI.¹³ During use, an incontinence product will come in close contact with the urogenital area and may consequently contain different biological materials such as sweat, stool, and urogenital microflora. Over time, volatile compounds can be formed due to bacterial metabolism^{14,15} and different chemical and enzymatic reactions. Also, the incontinence product itself may emit volatile compounds from wood pulp and other materials.

Odor perception is generally considered to be subjective and difficult to measure objectively. Nevertheless, objective methods for evaluating odors are widely used, particularly in the food and consumer goods areas.¹⁶ According to the American Society for Testing and Materials International, “The discipline of sensory analysis requires the use of a panel of human

Heléne Widén, PhD, Sensory and Flavor Science, SP Technical Research Institute of Sweden, Food and Bioscience, Gothenburg, Sweden.

Susanne Alenljung, MSc, Hygiene and Odor, SCA Hygiene Products AB, Gothenburg, Sweden.

Ulla Forsgren-Brusk, MSc, Hygiene and Odor, SCA Hygiene Products AB, Gothenburg, Sweden.

Gunnar Hall, PhD, Sensory and Flavor Science, SP Technical Research Institute of Sweden, Food and Bioscience, Gothenburg, Sweden.

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Correspondence: Susanne Alenljung, MSc, SCA Hygiene Products AB, SE-405 03 Gothenburg, Sweden (susanne.alenljung@sca.com).

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evaluators, wherein test results are recorded based on their responses to the products under test. Statistical analysis is then employed to generate inferences and insights regarding the product.^{16(p1)}

The sensory analysis “tool box” contains a range of techniques; descriptive sensory analysis is considered one of the most powerful.^{17,18} Sensory analysis uses an expert panel to objectively measure the sensory characteristics of products. It has been used to describe both foods and nonfood products, for example, skin feel of personal care products and hand feel of fabrics and paper.¹⁹ Descriptive odor analysis was recently used in studies of car odors²⁰ and composting of wastewater biosolids.²¹

The objectives of this study were to characterize the odors of used incontinence products by descriptive odor analysis and to define attributes to be used in subsequent analyses. In order to characterize as many relevant odors as possible, the study was based on used products from 14 nursing home residents. An additional study aim was to investigate variability among different incontinence products and, if possible, to group them into odor classes based on data obtained from sensory analysis. To our knowledge, this is the first study describing the perceived odor characters of used disposable absorbent incontinence products.

MATERIALS AND METHODS

Used incontinence products were collected from 14 residents (13 females, 1 male; aged 64–90 years old) living at geriatric nursing homes in the Gothenburg area, Sweden. The personnel were asked to collect products with noticeable odor from residents who frequently had odorous products. Thus, products with no odor or very faint odor were not sampled. Products containing faces were excluded. No data on medications and medical diagnoses were collected.

The collection done, by the Swedish market research institute ScandInfo, was conducted in accordance with Swedish data privacy legislation (the Swedish Personal Data Act 1998) and the ICC/ESOMAR International Code on Market and Social Research in order to ensure the residents' privacy. Under Swedish Legislation, this type of study does not require review or approval by the Regional Ethical Review Boards. Specifically, the study did not involve any humans, only collection of used products, and there was no direct contact between ScandInfo's personnel and the residents. The nursing homes' Local Authority Senior Medicine Advisor as well as the nursing home managers reviewed and approved the study.

Descriptive Odor Analysis

Procedures for handling the used incontinence products have been described elsewhere.²² The odor of each used product was characterized by descriptive odor analysis according to general principles described in the International Standard ISO 6658:2005.¹⁷ The exact details of the odor analysis, including the design of the score sheet to be used, were defined within the study jointly with the judges in the panel. The panel comprised 1 male and 7 female judges. Panelists were recruited from SP Food and Bioscience's external analytical panel and selected according to the International Standardization Organization's (ISO's) document 8586-1:1993.²³ All judges have extensive experience in descriptive sensory analysis of both food and nonfood products.

Five 2-hour training sessions were held to define and reach consensus on the meaning of attributes for description of odors of used incontinence products. During these sessions, used products, collected from 6 of the residents, were presented to the judges who

first carried out judgments individually and then gathered for consensus discussions. During the training sessions, the judges were also familiarized with the intensity scale, a 10-cm structured line with markings from 0 to 10. The markings were used to represent the following: 0 = no odor; 1–2 = very weak; 3–4 = weak; 5–6 = intermediate; 7–8 = strong; and 9–10 = very strong odor. The judges were instructed to make their markings anywhere on the line. The odor attributes with their intensity scales were presented on score sheets, one for each sample to each judge. Since the training had not included samples from all residents, the judges were asked to write down and rate intensities of any additional attribute that might appear during the final evaluation sessions.

The odor evaluation was carried out during four 2-hour sessions on 4 days. The samples, labeled with 3-digit codes, were presented to the judges in different orders. The judges were seated well apart to avoid bias. The evaluation of each sample required approximately 1 to 2 minutes. Usually a resting time of up to a couple of minutes is used in odor studies, but in this study the judges paused approximately 10 minutes before proceeding with the next sample. Since some of each resident's sample bottles were to be used in a parallel study of volatile odorous compounds, the number of samples in each set was not large enough to allow for one sample per judge in this study. Therefore, each sample was used for odor evaluation by 2 judges. After the first judge's evaluation was carried out, the bottle was left standing closed for at least 15 minutes for the odor to recover before the evaluation by the second judgment was carried out. Since a trained sensory panel was used, no specific interrater reliability test was performed.

Data Analysis

Two-way analysis of variance with products and assessors as factors was calculated for each attribute. For attributes where a significant ($P \leq .05$) effect of the factor product was found, the Tukey post hoc test was used to reveal significant product differences.

Mean intensities of the attributes were used as input in the multivariate analyses. Principal component analysis (PCA) based on the covariance matrix was performed to visually depict the relationships between all attributes, including total intensity, and all products. Ascending hierarchical clustering (via the Ward method and based on Euclidean distances) was used to group the products into subgroups defined by their odor profiles, but not including total intensity. Statistical analyses were performed via the FIZZ 2.47B software (Biosystèmes, Couteron, France).

RESULTS

Ten descriptive odor attributes, plus total odor intensity, were defined by the panel (Table 1). These attributes were used for describing odors of the used incontinence products. The average total odor intensities, as well as the average intensities of all descriptive attributes in the samples from the 14 incontinence products, are presented in Table 2. The total odor intensity was intermediate to strong in most products, but in some products it was fairly weak. For 13 of the 14 products, the strongest of the 10 descriptive attributes were either “urinal” (7 products) or “smoked” (6 products). The second strongest attributes were usually “urinal,” “ammonia,” or “smoked.”

The 7 attributes “ammonia,” “urinal,” “smoked,” “sulfur,” “sourish,” “rotten hey,” and “fishy” could be used to statistically differentiate the used incontinence products ($P \leq .01$ and $P \leq .001$). Although contributing to the total odor character, the attributes sweetish, salmiak, and wet wool did not differ between products.

TABLE 1. Odor Attributes Defined During the Training Sessions With the Panel

Attribute Number	Attribute	Panel's Definition
A1	Total odor intensity	The total odor intensity, regardless of odor character
A2	Ammonia	Like ammonia
A3	Urinal	Reminiscent of the smell of toilets not well cleaned, which differs from ammonia odor
A4	Smoked	Smoked sausage, smoked fish, burnt, barbecue odor
A5	Sulfur	Water from a sulfurous well
A6	Sweetish	Odor associated with sweets
A7	Sourish	Like the smell of milk that has become sour
A8	Rotten hay	Rotten hay
A9	"Salmiak"	Odor associated with salty liquorice (which is flavored with ammonium chloride)
A10	Wet wool	Wet woolen blanket, wet dog
A11	Fishy	Like the smell of old wooden fish boxes, the smell of old fish

There was a wide variation in the used incontinence products' odor character and intensity; the odor profiles of product S5 and S11 in Figure 1 exemplify this. The total odor intensity was high in S5 and the intensities of many descriptive attributes were among the highest in this product. The odor of S11 clearly deviated from most other products. Its total odor intensity was low and its odor character was mainly sweetish, with virtually no reference to the smell of urinal

or ammonia. The judges' additional comments were that S11 had an odor like toffee, sponge cake, almond paste, and butterscotch, all referring to sweet products with typically sweetish odors.

Principal Component Analysis

Since the total number of odor attributes was 11, the original set of odor data can be said to be 11-dimensional. However,

TABLE 2. Average Intensities of All Odor Attributes and Outcomes of the Analysis of Variance (ANOVA) and the Tukey Post Hoc Test

ANOVA ^a	Odor Attribute																					
	Total Odor Intensity ^b		Ammonia ^b		Urinal ^b		Smoked ^b		Sulfur ^b		Sweetish (ns)		Sourish ^c		Rotten Hay ^c		"Salmiak" (ns)		Wet Wool (ns)		Fishy ^b	
	Int ^d	Tuk ^e	Int ^d	Tuk ^e	Int ^d	Tuk ^e	Int ^d	Tuk ^e	Int ^d	Tuk ^e	Int ^d	Tuk ^e	Int ^d	Tuk ^e	Int ^d	Tuk ^e	Int ^d	Tuk ^e	Int ^d	Tuk ^e	Int ^d	Tuk ^e
S1	5.2	abc	2.8	abc	2.9	bc	2.3	b	1.9	ab	2.4	–	1.4	bc	1.4	ab	0.4	–	1.8	–	0.6	b
S2	6.8	ab	3.9	abc	4.6	ab	6.3	a	2.6	ab	3.6	–	2.8	abc	2.3	ab	1.8	–	1.4	–	2.4	ab
S3	7.6	a	5.1	a	5.6	a	4.2	ab	2.5	ab	4.0	–	3.0	abc	1.8	ab	0.3	–	1.4	–	1.6	ab
S4	6.0	abc	3.3	abc	4.9	ab	3.4	ab	1.7	ab	2.3	–	3.0	abc	1.8	ab	0.5	–	1.5	–	1.2	b
S5	6.9	ab	4.8	ab	4.9	ab	5.6	a	2.5	ab	3.6	–	2.2	abc	2.0	ab	1.2	–	1.2	–	2.4	ab
S6	7.0	ab	5.0	a	5.3	ab	4.8	ab	2.3	ab	3.5	–	3.1	abc	2.6	a	1.3	–	1.0	–	3.4	a
S7	6.2	ab	3.2	abc	3.5	abc	5.8	a	2.3	ab	3.1	–	2.5	abc	1.7	ab	0.7	–	0.9	–	1.7	ab
S8	4.6	bc	1.9	bc	2.9	bc	3.6	ab	1.5	ab	2.8	–	1.9	abc	0.8	ab	0.0	–	1.5	–	1.2	b
S9	7.2	a	4.0	abc	4.6	ab	3.7	ab	2.1	ab	4.0	–	4.2	a	1.3	ab	0.1	–	1.4	–	1.4	ab
S10	6.0	abc	3.7	abc	4.2	ab	4.3	ab	1.8	ab	3.1	–	2.9	abc	1.6	ab	0.6	–	1.5	–	1.7	ab
S11	3.8	a	1.0	c	1.0	c	2.0	b	0.6	b	3.8	–	1.0	c	0.5	b	0.0	–	1.2	–	0.4	b
S12	6.9	ab	3.6	abc	4.4	ab	4.7	ab	2.4	ab	3.7	–	1.9	abc	1.4	ab	0.1	–	1.8	–	1.2	b
S13	7.2	a	4.6	ab	5.3	ab	4.6	ab	3.2	a	4.1	–	3.4	ab	2.7	a	1.1	–	2.1	–	3.4	a
S14	7.0	ab	4.8	ab	4.9	ab	4.7	ab	2.8	a	3.6	–	3.0	abc	1.4	ab	0.8	–	1.3	–	2.0	ab

Abbreviations: ANOVA, analysis of variance; ns = not significant; Tuk = Tukey post hoc test.
^aSignificant difference between 2 or more products, within an attribute column, are indicated by:
^bP ≤ .001;
^cP ≤ .01;
^dAverage intensities across all 8 judges.
^eProducts that share the same letter(s) within a particular column did not differ significantly in odor intensity of that attribute. An empty column denotes that ANOVA indicated no significant effect; hence, no Tukey post hoc test was done.

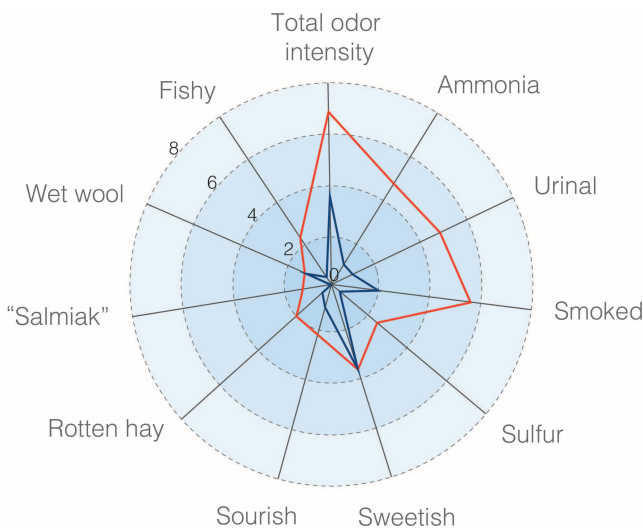


Figure 1. Odor profiles of 2 used incontinence products (S5 in red, S11 in black) with widely different odor characteristics. Salmiak = salted liquorice.

in the PCA, the first principal component explained 73.8% of the variation in the data and the second and third principal component explained another 10.7% and 4.7%, respectively. This indicates that the odor space of used incontinence products had fewer dimensions than 11.

The biplot in Figure 2 (depicting the first 2 principal components) summarizes the outcome of the PCA. It can be described as an odor map of used incontinence products. The closer the products are located to each other in the biplot, the more similar their odors are. Closer positioning of the various odor attributes also indicates how strongly they are associated. An attribute that is positioned close to a particular product contributed strongly to the product's characteristic odor.

The distribution of products along the first principal component (the x -axis) is mainly explained by the variation in total odor intensity, which was positively correlated with intensity variations in several descriptive attributes. The single most

important attribute for the distribution of the products along the second principal component (the y -axis) was the attribute A4 ("smoked").

The fairly isolated location of product S11 in Figure 2 shows very clearly that the odor profile of this product differed considerably from the odor profiles of the other products. Also, products S1 and S8 were clearly separated from the remaining 11 products along the first PC, an indication of that also these products had deviating odor profiles.

Cluster Analysis

The PCA indicated that there might be groups of products with closely similar odor profiles. Therefore, cluster analysis was used to group the products into fewer groups based on similarities and differences in their odor profiles. However, since the PCA had indicated that total odor intensity was strongly correlated to the intensity of several of the descriptive attributes, cluster analysis was based on the intensities of the 10 descriptive attributes. The dendrogram in Figure 3 shows the outcome of this analysis. At the highest level, products were grouped into 2 main clusters, called A and B, which on a lower level, chosen somewhat arbitrarily, consisted of 2 and 3 subclusters (odor classes), respectively.

The average odor profiles of all 5 odor classes, A1, A2, B1, B2, and B3, are shown in Figure 4. This is a means to visually demonstrate the profiles and compare their differences. In this study, the profiles generally showed a similar pattern, although differing in intensities. One exception is profile A2, with low intensities except for sweetish.

DISCUSSION

The odor wheel was first used to systematize attributes used to describe wine aroma²⁴ and has since then been applied to systematize other types of odors.²⁵ We now suggest, as an outcome of this study, using an odor wheel with 10 descriptive odor attributes for used incontinence products (Figure 5). The 10 attributes in the odor wheel were selected by the sensory panel judges to define the odor of used incontinence products.

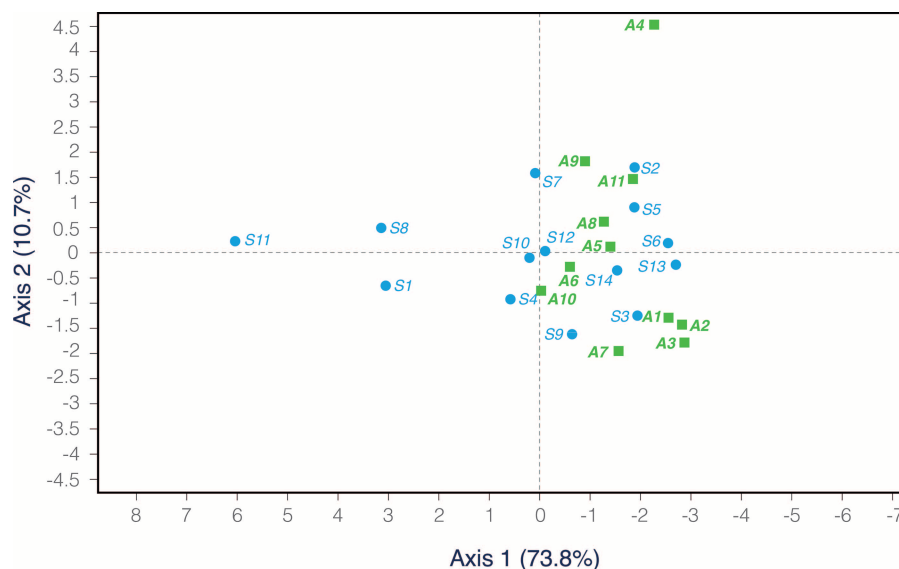


Figure 2. Principal component analysis (PCA) biplot showing the distribution of all 14 used incontinence products (S1-S14) and all 11 odor attributes (A1-A11) along the first 2 principal components. See Table 1 for an explanation of the attribute labels.

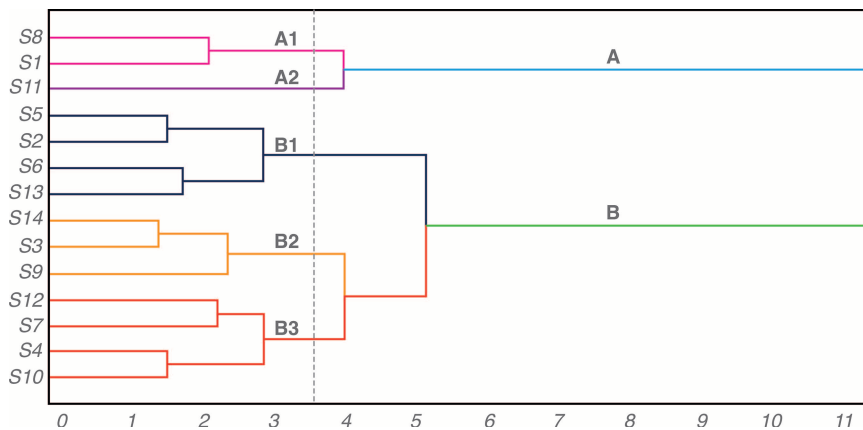


Figure 3. Dendrogram (cluster tree) showing the partitioning of the used incontinence products (S1-S14) into clusters (odor classes) based on the products’ odor characteristics. The further to the right that products or clusters are connected, the more dissimilar their odor profiles.

Although 3 of the attributes did not vary significantly between the products, all 10 attributes are needed to describe the odor character of the products. Larger studies may develop the odor wheel even more.

Some of the 10 attributes in the odor wheel of used incontinence products were more expected than others. “Ammonia,” “urinal,” “fishy,” as well as “sourish” odors are probably recognized by many. Other attributes, like “smoked” or “sweetish,” may be more unexpected. Generally, the word “ammonia” is used to describe the odor of both urine and incontinence products. The attributes “urinal odor” or “smoked” were generally perceived to be the strongest. “Ammonia” was the second strongest attribute in 5 products. Considered collectively, these findings suggest that the odors of used incontinence products are complex and differ between products. Pooling of samples, sometimes used, may dilute odors and, more important, interesting odor differences might not be detected.

One product (S11; Figure 1) was mainly sweetish with virtually no urinal or ammonia notes at all. Although the

“sweetish” attribute was not significantly higher in this sample than in other samples, there was no other, stronger attribute to conceal the sweetish odor. This might indicate that many used products have a sweetish background odor that becomes masked when additional odors are present. The balance between various attributes defines the odor of each used product. In the odor profiles (exemplified in Figure 1), total odor intensity was included. This is to visually differentiate the products, both regarding total intensity and the different attributes. The total odor intensity was not used to cluster the products into odor classes.

In this study, the result represents the odors of products used by residents with UI living in the selected geriatric nursing homes. For cost reasons, a limited number of products were analyzed. The rationale for using samples from 14 residents (as opposed to 3 samples from 5 residents) was to characterize and define as many relevant odors as possible and to facilitate straightforward statistical analyses. In addition, using several samples from each resident would require a more advanced

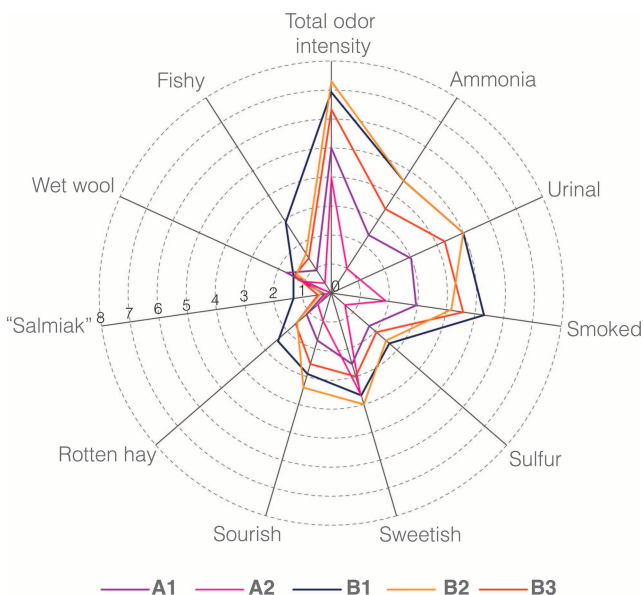


Figure 4. Odor profiles of 5 odor classes based on the cluster analysis. Salmiak = salted liquorice.



Figure 5. Odor wheel for used disposable absorbent incontinence products. Salmiak = salted liquorice.

statistical method with repeated measures that would not allow for the simple analyses used here.

The odor of used incontinence products varied in both intensity and character. This indicates that the odors were caused by different types of volatile (odorous) compounds that may vary in concentration and may have different origins. In a separate paper, we present key odorants identified by gas chromatography–olfactometry.²² Further research is needed to determine the various factors that influence the odor produced by absorptive products. This is, however, beyond the scope of the present study. Such factors include medical conditions, drugs, and bacteria colonization, hydration and others that also may have clinical implications when assessing and managing a frail elder patient using absorptive products for management of UI.

Many patients are suffering from UI and have a constant fear of odor. In developing incontinence products, there is a need for better knowledge to minimize the discomfort of odor. The result of this article is a contribution to increased knowledge to help developing disposable absorbent incontinence products with effective odor control.

STRENGTHS AND LIMITATIONS

This study is to be seen as a first study in this research area where only a limited number of incontinence products were analyzed. Additional testing needs to be done in different patient groups including young and older healthy adults, and different medical diagnoses and medications. With an increased number of products and patient groups, the odors associated with the use of incontinence products will be even wider and the odor wheel will be further developed. Nevertheless, the findings in this study give a first characterization of the odors of used incontinence products.

CONCLUSIONS

Odors produced by used disposable absorbent incontinence products varied in overall intensity and the intensities of various descriptive odor attributes. The strongest and second strongest attributes were “urinal,” “smoked,” or “ammonia.” Based on the quantitative odor intensity data, the products could be divided into 5 odor classes with different odor profiles. The variations in odor character and intensity indicate that the odors in used products are caused by different types of odorous compounds that may vary in concentration.

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