ATO

Transmission of strawberry odour to mushrooms due to joint storage and transport

Projectnr 44030.02, June 2002

GMO-number 3.100

Confidential

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Contents

page

1 Introduction

The Greenery is a marketing and sales organisation of the cooperative Voeding Tuinbouw Nederland with a large assortment of fresh fruits and vegetables, amongst which are mushrooms and strawberries. These products arrive at the warehouse of the Greenery in Breda from the growers, where they remain until they are transported to the retailer. To a certain extent mushrooms and strawberries are in the same physical space during storage and transport. The Greenery wants to find out if the odour of strawberries can be transmitted to the mushrooms in such an extent that it can be perceived by the senses. On request of the Greenery ATO has conducted a sensory test to study this possibility. A sensory triangle test was conducted to investigate whether mushrooms stored and transported together with strawberries smell similar to mushrooms stored and transported without strawberries. If this is the case, the Greenery wants to continue to combine their storage and transportation.

The objective of the study was:

- to test for similarity in smell of mushrooms stored with and without strawberries following predetermined storage conditions

2 Materials and methods

2.1 Products and treatment

Information on the usual process of storage and transportation was provided by the Greenery, including information on volume of storage rooms, temperature, maximum duration of stay, maximum amount of product in storage or transportation space, ventilation and volume of strawberries and mushrooms. This information served as the basis for the storage conditions of the mushrooms at ATO prior to the sensory test. Storage conditions were chosen to reflect the regular process at the Greenery. Where variance in characteristics was observed (e.g. in temperature), the condition was chosen that was expected to contribute most to a possible odour transmission ("worst case"). Agreement on the storage conditions was obtained from the Greenery prior to the experiment.

For the experiment 180 kg of white mushrooms and 100 kg of strawberries were delivered by the Greenery and stored at ATO in mechanically cooled storage rooms at 12°C. The relative humidity was regulated at 95%. Mushrooms were delivered in blue containers without coverage, containing 500 gram of product (class 1, size large). Strawberries were delivered in transparent containers without coverage, equally containing 500 gram of product per container.

For the experiment, 66 kg of mushrooms were stored in a separate storage room without strawberries, representing the control sample. In a second storage room 114 kg of mushrooms and 100 kg of strawberries were stored, representing the treatment sample. The following procedures were applied to both samples:

* To represent the storage part of the process:
  - Storage in storage room of 18 m^3
  - Temperature of 12°C
  - No ventilation
  - Duration of 22 hours

* To represent the transportation phase of the process, one part of the product was transferred after 22 hours to a Conditioned Atmosphere Container which was placed within the storage room:
  - Volume of CA container is approximately 550 l
  - 66 kg of mushrooms and 16.5 kg of strawberries
  - Ratio of 20% strawberries and 80% mushrooms (control sample only 66 kg of mushrooms)
  - Temperature of 6°C
  - Minimum amount of ventilation necessary
  - Duration of 18-19,5 hours (in intervals of 30 minutes mushrooms were removed for the sensory test)

2.2 Triangle test: test for similarity

In this test a sensory panel of 42 subjects evaluated the mushrooms by smelling 2 triangles each. One triangle (referred to as Triangle 1) consisted of (two containers of) mushrooms stored with strawberries and one container of mushrooms stored without strawberries, whereas the other triangle (referred to as Triangle 2) consisted of 2 containers of mushrooms

stored without strawberries and one container of mushrooms stored with strawberries. The mushrooms were presented unprepared in identical uncovered blue containers containing approximately 500 grams of product each. Products were removed from the storage room 30 minutes prior to the test and were subjected to room temperature until the time of evaluation. The combination of samples within a triangle was randomised over the subjects, thus AAB, ABA and BAA were equally represented, as were BBA, BAB and ABB. The two triangles were also randomised over the subjects, thus for instance subject 1 received first Triangle 1 then Triangle 2, whereas subject 2 received first Triangle 2, then Triangle 1. Overall, Triangle 1 and Triangle 2 were each presented the same number of times. The subjects were of course not informed about the combination they received. Each subject had to pick the odd one out of the three mushrooms only by smelling. It is a forced choice method, meaning that they had to choose, even when no difference was perceived. Even if they were not certain, it might be that they could indicate the odd one in a forced choice task.

2.3 Data analysis

The test objective is to determine the percentage of consumers that can not detect a difference between the two samples. This means that a Triangle Test for Similarity (Meilgaard et al, 1991) is conducted. One wants to have a high desired level of confidence that the samples are truly not perceivably different. That is, one wants to allow only a small chance that samples that actually are perceivably different are incorrectly declared to be indistinguishable (Meilgaard et al, 1991). In statistical terms: the test for similarity is used to prove that the H_0 assumption that no perceptible difference exists between products must be accepted. With similarity testing the test results state that a certain maximum percentage of the population can distinguish between the samples (given a certain confidence level). In our test statistical conclusions are drawn at the 95% confidence level.

3 Results

3.1 Quality of the product

The quality of both mushrooms and strawberries was very good upon arrival. After storage conditions the quality of the products remained very good. A very small proportion (a few containers) contained some small brown spots after the storage conditions. This appeared in both the control and the treatment samples. These containers were excluded from the sensory test, to ensure that all evaluated products had identical appearance.

3.2 Triangle test – sensory difference

In this experiment 42 persons scored two times each. By chance guessing alone, 33.3% correct responses were to be expected. In table 1 the responses given to the question to pick the odd one out are given.

Tabel 1. Results for the triangle test scores. 'First triangle' is the triangle evaluated first by the panel member, 'second triangle' is the triangle evaluated second. 0 = false, 1 = correct.

Panel member	First triangle	Second triangle	Correctly scored
1	0	1	1
2	0	0	0
3	0	0	0
4	0	0	0
5	0	1	1
6	0	0	0
7	0	0	0
8	1	0	1
9	0	1	1
10	0	1	1
11	0	0	0
12	0	1	1
13	1	1	2
14	0	1	1
15	1	0	1
16	1	0	1
17	0	1	1
18	1	0	1
19	0	1	1
20	1	0	1
21	0	0	0
22	0	0	0
23	1	0	1
24	1	0	1
25	0	1	1
26	0	1	1
27	0	0	0
28	1	1	2
29	0	0	0

30	0	0	0
31	0	1	1
32	1	0	1
33	1	1	2
34	1	0	1
35	0	0	0
36	1	0	1
37	1	1	2
38	1	1	2
39	0	1	1
40	0	0	0
41	0	0	0
42	1	0	1
Total	**16**	**17**	**33**

In total, 33 correct responses were given out of the 84 (39%).

Results are graphically depicted in Figure 1.

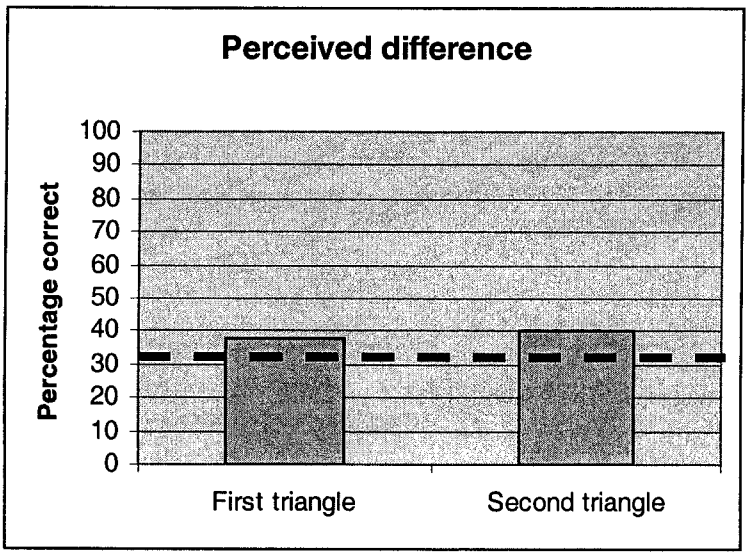

Figure 1. Percentage of correct responses per triangle (- - - = chance level)

Further statistical analyses were conducted on the combined data set of 84 responses, as it was indicated using Smith's test on replicates (Lawless and Heymann, 1998) that the two replicates from each panel member (the first and the second triangle) can be pooled.

The Triangle Test for Similarity was conducted using the mathematical formula given in Meilgaard et al (1991). This will provide a 95% one-tailed confidence interval for the true, the real proportion of 'distinguishers' in the population. The upper end point of the confidence interval is calculated as:

$$P_{max\,(95\%)} = (1.5\,(x/n) - 0.5) + (1.5)\,z_{\beta}\sqrt{((nx - x^2)/n^3)}$$

where x is the observed number of correct responses, n is the number of respondents, and z_{β} is the upper-ß critical value of a standard normal deviate.

The outcome is shown in table 2. With 95% confidence it can be stated that the true proportion of the population that can distinguish the samples is no greater than 22%. In other words: the true proportion of the population that cannot distinguish between the two storage conditions of the mushrooms by smelling is not lower than 78%.

Table 2. True proportion of non-distinguishers

Correct answers	Correct answers expected by chance guessing alone	Total answers	Pmax (95%)	Percentage of the population which cannot detect a difference is not lower than
33	28	84	0.22	78%

The score sheet contained the possibility for the panel members to add comments. Of the 5 panel members that scored correctly in both sessions, two provided comments. This number is too small to provide reliable additional information. No explicit remarks on a strawberry smell were made by any of the panel members, written or verbally.

Additional information is available as panel members each conducted a triangle test twice. The number of panel members that scored correctly in both sessions can be calculated. This can be regarded as a very conservative approach, as it considers only panel members that provided two correct answers to really smell the difference, and to leave out all panel members that scored correctly once. From table 1 can be concluded, that five out of the 42 panel members scored correctly in both sessions (11.9%). By chance guessing alone, 11,1% correct responses were to be expected ($1/3 \times 1/3$). From this perspective, scores do not exceed chance level. This allows the nuance that 78% can be considered as the absolute maximum.

4 Conclusion and discussion

It can be concluded (with 95% confidence) that a maximum of 78% of the population will not be able to smell a difference between mushrooms stored with strawberries and mushrooms stored without strawberries (78% is the lower limit). The Greenery has to decide whether they regard this percentage as an acceptable level.

In deciding on the acceptability, the experimental conditions have to be considered. The regular conditions at the Greenery considering storage and transport were simulated, but whenever variation was reported within these conditions, the worst case scenario was followed. The storage phase at the Greenery includes a part where the products are stored in cooled storage with temperatures of 2-4°C, whereas only the hall storage was simulated, at a temperature of 12°C. Furthermore, the sensory test was conducted 30 minutes after removal of the mushrooms from the storage room. In conditions that do not meet the worst case scenario, or when the time between the physical presence with strawberries and sensory evaluation is longer (e.g. as will be often the case in a buying situation), the percentage of the population that will not smell a difference can be expected to be higher.

Taking abovementioned discussion points into account, in general these results could be considered as acceptable. The ultimate decision on whether this can be regarded as acceptable, however, has to be made by the Greenery, as acceptability largely depends on other factors that have to be taken into account (like specific objectives and strategic considerations). If the Greenery wants to have a higher level of certainty before making a final decision, follow up research can be conducted.

References

Lawless and Heymann (1998). Sensory evaluation of food: principles and practices. New York: Chapman & Hall.

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