Research Article

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Adverse Effects of Consumed *Mangifera* Fruit Studied on Ants as Biological Models

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ABSTRACT

The fruit of the *Mangifera indica* tree is delicious and has much dietetic qualities, containing several healthy elements. It is also known to contain allergens which can cause severe contact dermatitis and erythema in sensitive individuals. However, apart from studies looking at the benefits of mango consumption and those examining some of the potentially harmful consequences, there are no studies looking at the possible adverse effects of mango pulp on consumer's physiology and behavior. Our aim is to examine the latter point, using *Myrmica sabuleti* ants as a biological model. Tested on ants, the ingested mango juice induced a decrease in their general activity and linear speed, leading to a larger sinuosity (angular speed) of movement, less audacity, some decrease of their escaping ability and of their ability to cross a twist and turns path. Only a small physiological adaptation occurred for linear speed after 7 days of mango consumption. Orientation towards a source of pheromone, social relationships, memory and, at the limit of significance, movement speed on a very rough surface, were not impacted by mango consumption. No dependence was observed on mango consumption, what was is in line with the rather lengthy decrease of the sinuosity of the ants' locomotion after mango consumption had ended. This impact of mango consumption on the ants' locomotion ceased from about 33 hours after the start of weaning.

Keywords: Activity, Adaptation, Ants, Dependence, Locomotion, Mango

ABBREVIATIONS

ang.deg. = Angular Degrees; ang.deg./cm = Angular Degrees per cm; mm/s = Millimeter per Second; χ^2= Chi-Square; *vs* = Versus; n° = Number; g = gram; cm = Centimeter; mm = Millimeter; ml = Milliliter; mg = Milligram; s = Second; min = Minute; h = Hour; t = Time; % = Percentage.

INTRODUCTION

The *Mangifera indica* tree is native to Asia and is also cultivated in Africa and Indian Ocean islands, in the USA, Mexico, Brazil and the Caribbean. Its fruit, the mango, is delicious and widely consumed, and is therefore intensively cultivated with care and benefits from modern

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technical support [1,2].

Mangoes have several beneficial qualities for the health. Several internet sites [e.g., 3-5] report that they are rich in antioxidants, protective substances, often help digestion, are excellent for heart and eyes and allow to keep skin as well as hear in good health. They contain minerals, mainly potassium, and vitamins, mainly C and A [2], as well as β-carotene, xanthophylls, polyphenols [6] and are not caloric (60-75 Kcal/100 g). However, these fruits may also have some inconvenient properties that should not be neglected and that consumers should be aware of. It is long known that an urticarial reaction may occur by people having peeled and eaten mangoes [7]. Mango skin, such as the sap of the *Mangifera* tree, contains urushiol, a toxic molecule which is also present in cashew nuts, poison ivy and in poison oak and causes severe contact allergy (contact dermatitis as well as erythema). The fruit being ordinarily peeled before it is eaten, its consumption should in principle not cause any problem. However, the pulp of the mango itself is not without danger because, as in the bark and leaves of the tree and predominantly in the skin of the fruit [8,9], it contains 'mangol' (a mixture of three alkyl-resorcinols) in the first 5 mm under the peel [10]. The presence of mangol in the flesh of the fruit may also cause allergenic reactions, even at the first exposition to mango pulp, due to cross-reactivity when having been previously sensitized to urushiol containing plants, and even when after having been sensitized to various respiratory allergens, including pollen [11]. This hypersensitivity to mango pulp or juice is rare and can develop a burning sensation in the lips, mouth, tongue and throat, but also lead to vomiting, diarrhea and occasionally, anaphylaxis [11,12]. The mango pulp allergens are stable compounds, resisting to technological processing of the fruit pulp [13].

The studies that have been published do not mention whether mango pulp consumption has any effect on consumers' physiological and behavioral traits, such as their moving ability, audacity, sensory perception, social relationships, cognition, learning, memory, possible adaptation to adverse effects, possible dependence, as well as what is the persistence of possible effects after weaning. We here aimed to investigate on this aspect, using ants as biological models in the present experimental work.

Why using ants as models and which traits were examined?

Biological processes (e.g., genetics, nervous influx, muscle contraction, sensory perception, conditioning acquisition [14]) are the same in most animal species. Consequently, they are generally firstly studied on vertebrates or invertebrates, then in humans [15]. Invertebrates are often preferred because they are small, can be maintained in a laboratory at low cost, and present a short reproductive cycle [16]. Hymenoptera (e.g., bees) are often used [17], and ants can thus be used. They can be the more so because several colonies containing hundreds of individuals can be maintained for a long time, at low cost, and very easily. We are accustomed to work on the species *Myrmica sabuleti* Meirnert, 1861. We know rather well its biology. Among others, we have examined their visual perception, navigation, recruitment [18], ontogenesis of some of their skills [19], self-recognition in a mirror [20], distance and size effects [21], Weber's law [22], and their numerosity abilities and related topics [e.g., 23-26]. This species constitutes a comfortable biological model. The ethological and physiological traits we intended to examine were the ants' food intake, locomotion, including that on a rough surface, audacity (exploration tendency), brood caring, social relationships, escaping ability, ability to cross a twist and turns path, learning and memory, adaptation to possible side effects, dependence on consumption, and decrease of the effect after weaning.

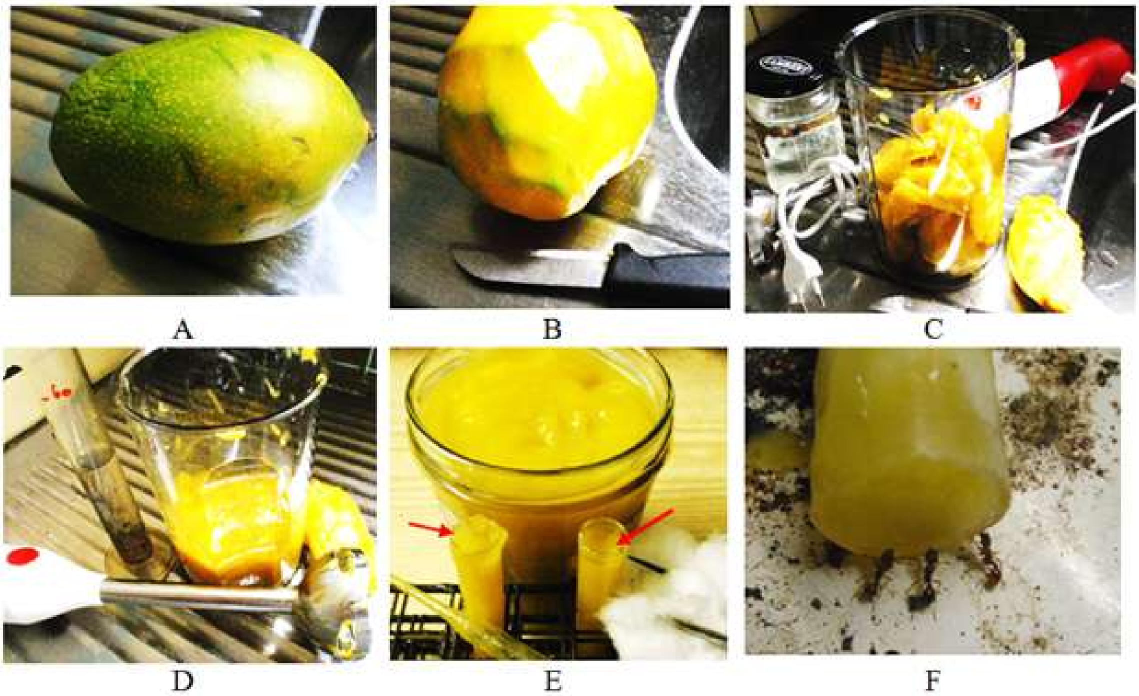

Figure 1. Preparation of the mango solution given to the ants. A: intact mango; B: peeled mango; C: cut and set in an adequate recipient; D: duly mixed; E: the obtained content, ready to be used for filling the cotton plugged tubes intended to be given to the ants (red arrows). F: three ants drinking the provided solution.

MATERIALS AND METHODS

Collection and maintenance of ants

Readers are invited to consult our previous paper on cashew nuts [27] for further details about the two colonies that were used for the study.

Solution of mango pulp given to the ants

The per day amount of consumed mango considered to be large for a human is about 2 ½ fruits (personal evaluation). Humans eating this quantity drink also around one liter of water per day. Insects, and thus ants, due to their anatomy (cuticle) and physiology (excretory apparatus), consume about ten times less water than mammals. To set ants under a mango diet similar to that of humans, they must be provided with a solution of 2 ½ mangoes into 100 ml of water. A solution of 1 ¼ mango into 50 ml of water was thus made. Since 50 ml is more than the quantity required for making all the planned experiments, a stock solution of 1 mango into 40 ml of water, or more exactly into the 15% sugar water commonly given to the ants, was used, and kept at -15 degrees Celsius when not used. For doing such a solution, the content of one mango was carefully mixed into the ants' sugar water using a mix-master, and the resulting solution was provided ad libitum to the ants in their usual cotton plug tube, in the same way that, ad libitum, an only 15% sugar water solution was ordinarily provided to the ants (and served as a control for testing the mango sugar water solution). The cotton plug of the tubes was refreshed every two days, and the entire solution was renewed every 7 days. It was checked each day if the ants duly drank the mango solution, and they did. This is illustrated in Figure 1. Except for the quantification of food consumption and general ant activity, and unless otherwise specified, experiments on the effect of a mango sugar water diet were conducted after one day under this diet.

Meat and sugar water consumption

The ants staying near the meat, at the entrance of the sugar water tube and those found active at any place were punctually counted four times a day during six days. The same counting was made thereafter, after the sugar water tube was replaced by a tube containing the mango sugar water solution. The daily counts under a sugar diet with and without mango were then compared using a Wilcoxon test. The mean of these six daily means was also calculated. (Table 1).

Linear and angular speeds. Orientation to a tied nestmate

As for the previous work on cashew nuts, these traits were quantified on ants moving in their foraging area, the linear and angular speeds without stimulation, and the orientation while presenting them with a nestmate tied to a small piece of paper. Median and quartiles for each of the 40 recorded values were established (Table 2) and the distributions of the values obtained for ants under normal diet and, after one day under mango sugar water diet, compared using the Chi-square test, assuming there was a sufficient turnover of ants between the control and the experimental test. See [27] for further details.

Audacity

This trait was assessed through the ants' tendency to come on a novel apparatus (a paper-made tower) deposited in their foraging area. The ants of the two colonies were counted 20 times in the course of 10 minutes on this apparatus and chronologically added so that a chronological suite of ten paired of numbers, one for normal diet and one for mango diet, was obtained and the effect of these diets compared by using a Wilcoxon test.

Speed on a rough surface

The ants speed of movement was compared when moving on the usual smooth surface of their foraging area and when moving on a n°280 emery paper inserted in a particular device. In the same manner as for walking on the foraging area, the 40 values obtained for linear and angular speed for each two diets were compared using a Chi-square test. Further details in [27].

Brood caring behavior

After five larvae were removed from the nest and placed on the foraging area, the numbers of them being re-entered again inside the nest by the ants were counted after 30 s and then after each of the first 5 min of their deposit. The six numbers of not re-entered larvae of the two colonies were correspondingly added and the sums for ants under normal and mango diet (Table 3) compared using a Wilcoxon test.

Social relationships

The strength of agonistic behavior of ants during five dyadic encounters between workers living under normal and under mango diet was compared using a Chi-square test. Further details on aggressiveness levels are in [27].

Escaping ability

For each colony, the numbers among 6 ants escaping through a hole in the rim of a reversed polyacetate cup, i.e. an enclosure, were counted six times each two minutes after being placed in the enclosure. The six paired numbers obtained for ants under normal and under mango diet (Table 3) were compared using a Wilcoxon test.

Twist and turns test

Fifteen ants were released in front of a twist and turns path and those still in front of this path or having reached the end of the path were counted each two minutes after their release. The six paired sums obtained for the two colonies for ants under normal and under mango diet (Table 3) were compared using the Wilcoxon test.

Visual operant conditioning and memory

The ants of each colony were trained to react to a colored hollow cube set above the entrance of their sugar water tube, with meat being deposited nearby. Ten ants of each colony were then transferred into a tray containing a Y-maze with a novel hollow cube of the same color than that having served for training, set in one of its branches. Paired comparisons were made between ants normally fed and ants under mango diet, using a Wilcoxon test. Table 4 gives the mean proportions of the ants having chosen the right branch calculated after 24 and 48 training hours. Other details are in [27].

Adaptation to side effects

Possible physiological adaptation to a side effect of mango consumption was assessed on the ants' angular speed after one day and seven days of mango consumption. The distributions of the 40 variables obtained on the two colonies when under normal diet, after 1 day of mango diet and after 7 days of mango diet (Table 5), were compared in the usual way, using a Chi-square test.

Dependence

Possible dependence on mango consumption was simply assessed by a choice test comparing the number of ants coming onto and drinking normal sugar water and the mango sugar water solution. A goodness-of-fit Chi-square test was used

Decrease of the effects after the end of consumption

The decrease of the effect of mango sugar water on the ants' angular speed after the ants consumed this died during 12 days was assessed on their foraging area, each 3 hours since weaning. Ten trajectories were recorded for each colony, and the distribution of the twenty variables so obtained for each 3 hours on the two colonies were compared to those recorded at the time of weaning and to that under normal diet (control), by using the Kruskal-Wallis test, assuming there was a sufficient turnover if forager ants between each test. The P values were adjusted for multiple comparisons using the Benjamini-Hochberg procedure with a false discovery rate of 0.05 [28], which is valid in case of positive regression dependency [29]. The polynomial regression equation describing the best the decrease was chosen according to the stepwise procedure described in [30]. Both test and regression were calculated using Statistica v10 software.

RESULTS

Ingested food, activity

Ad libitum consumption of mango impacted these traits (Table 1). Indeed, under such a mango sweet water diet, the ants eat less meat (mean numbers of ants sighted during six days: 0.32 versus 2.13) and were far less active (4.27 versus 19.03) than while living under normal diet. Indeed, under a mango diet, few ants foraged and therefore few reached the food. Also, inside the nest, the ants moved only a little, slowly, doing nearly nothing. However, whatever the diet, the ants drank a similar quantity of sugar water (or were all equally present at this location) which may be explained by the fact that in the presence of a sugared solution, their preferred food, they stayed there longer. The impact of mango diet on the ants' activity may alter other biological parameters (see the following subsections).

Table 1. Effect of consumed mango on ants' food consumption and general activity. The table gives the numbers of ants sighted on the meat food, the sugared water, and being active all around their environment during six days, as well as the mean of these six means.

Days	Under normal diet			Under a diet with mango		
	meat	sugar water	activity	meat	mango sugar water	activity
I	2.00	1.00	14.87	0.38	1.13	5.75
II	2.00	1.50	18.50	0.25	1.25	4.25
III	2.00	1.75	17.50	0.38	1.38	4.75
IV	2.50	1.50	22.00	0.38	1.75	3.00
V	2.50	1.37	20.84	0.25	1.88	3.75
VI	1.75	1.75	20.50	0.25	1.50	4.13
I-VI	2.13	1.47	19.03	0.32	1.48	4.27

Linear and angular speed

The ants' locomotion was impacted under mango consumption (Table 2, lines 1, 2). Their linear speed was statistically much smaller than usually: $\chi2 = 48.00$, df = 1, $P < 0.001$. This decrease of linear speed leaded to an angular speed higher than usual ($\chi2 = 35.73$, df = 1, $P < 0.001$). This result is in agreement with the lesser activity of ants under a mango diet (see the previous observation).

Table 2. Impact of mango diet on five biological traits. The table gives the median (and quartiles) or the mean [and extremes] of the recorded variables. Mango consumption impacted the three first traits, but not so much the ants' tactile perception.

Traits	Under normal diet	Under a diet with mango
Linear speed (mm/s)	6.4 (6.1 – 7.0)	3.6 (3.3 – 3.8)
Angular speed (ang.deg./cm)	105 (85 – 128)	215 (161 – 241)
Orientation (ang.deg.)	27.8 (21.6 – 40.2)	35.3 (28.9 – 42.8)
Audacity (n° of ants)	4.00 [1.- 4]	0.98 [0 – 3]
Speed on a rough surface: Linear speed	2.5 (2.2 – 3.0)	2.9 (2.4 – 3.3)
and Angular speed	341 (298 – 423)	304 (250 – 395)

Orientation

Consuming mango did not affect this trait (Table 2, line 3; Figure 2 A). Ants under such a diet oriented themselves as well as those living under normal diet, a result statistically significant (χ2 = 0.49, df = 1, 0.30 < P < 0.50). They thus well perceived the attractive pheromone emitted by the tied nestmate. Nevertheless, their perception and sensitivity were again evaluated thanks to a following experiment.

Audacity

Under mango consumption, the ants were far less inclined to come onto the, for them, newly seen experimental apparatus (Table 2, line 4; Figure 2 B). Only 0.98 ones were sighted at a time on this apparatus; versus 4.00 under normal diet: N = 10, T = -55, P = 0.001. This was in agreement with their lower activity assessed in the above two first subsections.

Speed on a rough surface

Whatever their diet and as expected, the ants' walking on a rough surface clearly differed from that on a smooth surface like that of their foraging area (compare the first two lines and the last two lines of Table 2). Moreover, since mango consumption already very significatively impacted the ants' velocity on a smooth surface (Table 2, first two lines, and results in subsection 'Linear and angular speed'), we couldn't expect it to impact their speed much more on a rough substrate. We note, however, that under mango diet and on a rough substrate, their linear speed appeared to be slightly faster and their angular speed slightly slower than under normal diet. (Table 2, last two lines). Nevertheless, a Chi-square test comparing their speed distributions did not show a significant difference whether they had consumed a mango diet or a normal diet (linear speed: χ2 = 3.38, df = 2, 0.10 < P < 0.25 and angular speed: χ2 = 4,73, df = 2, 0.05 < P ≤ 0.10). However, a Mann-Whitney ANOVA, which is a more powerful non parametric test, shows results close to the limit of significance: a slight significant difference for linear speed (P = 0.024) and a slight non-significant difference for the angular speed (P = 0.065) (Figure 2 C).

Brood caring

Due to their low activity and their small linear speed, the ants under mango diet dawdled to re-enter the larvae (N = 6, T = +19, P = 0.046). Moreover, they had trouble to hold them correctly when bringing them back into the nest (Table 3, line 1; Figure 2 D). This might imperil the survival of the colony.

Social relationships

Consuming mango did not uttermost affect the ants' social relationships (Table 3, line 2; Figure 2 E). Whatever their diet, the ants behaved in about the same manner in front of a nestmate. Either they did nothing, or made antennal contacts, or seldom and very slightly opened their mandibles. However, this last behavior was more frequent while consuming mango (aggressiveness index 'a' = 0.11 instead of 0.04 under normal diet), but the difference between consuming mango or not was not statistically significant (χ2 = 2,93, df = 2, 0.10 < P ≤ 0.25).

Table 3. Impact of consuming mango on four biological traits. The table gives the numbers of ants or of behaviors observed over time or during 5 minutes. Mango consumption somewhat affected these ants' traits.

Trait	Normal diet	Diet with mango
N° of not re-entered larvae	30'' 1' 2' 3' 4' 5'	30'' 1' 2' 3' 4' 5'
over 5 min	7 5 4 2 0 0	6 6 5 4 3 2
N° of presented levels of	0 1 2 3 4 'a'	0 1 2 3 4 'a'
aggressiveness; variable 'a'	58 32 4 0 0 0.04	59 40 11 0 0 0.10
N° of escaped ants over 12 min	2' 4' 6' 8' 10' 12'	2' 4' 6' 8' 10' 12'
	2 5 6 7 9 12	1 4 4 5 6 8
N° of ants in front (f) and	2' 4' 6' 8' 10' 12'	2' 4' 6' 8' 10' 12'
beyond (b) a twist and	(f) 19 16 13 11 10 9	21 17 15 11 11 12
turns path over 12 min	(b) 1 3 5 8 10 13	0 0 0 1 3 4

Escaping ability

Due to their lower activity and linear speed, the numbers of ants under mango diet which found the exit and could escape during a given time interval were smaller than those observed during the control experiment (Table 3, line 3; Figure 2 F). This was significant: N = 6, T = -21, P = 0.016. However, when under mango diet, the ants obviously seemed not stressed, and simply moved as under a normal diet. Nevertheless, the ants that escape did it slowly, with hesitation.

Twist and turns test

Mango consumption affected the time needed to cross a twist and turns path (Table 3, last lines; Figure 3 A). Being less active and moving slowly, the ants delayed to come into the twists and turns path and, therefore, their number staying still in front of the path was statistically higher than the control number (N = 5, T = 15, P = 0.031). The ants also delayed in crossing the twist and turns path, and were thus less numerous than the control in the area lying beyond this difficult path, a result also and even more significant (N = 6, T = -21, P = 0.016).

Conditioning acquisition, memory

Consumption of mango somewhat impacted the acquisition of conditioning (Table 4). In fact, the ants delayed in becoming conditioned. They finally acquired it, and kept a solid memory of it (Table 4). Photos are shown in Figure 3 B 2a, B 2b.

Table 4. Impact of consumed mango on the ants' conditioning acquisition and on their memory. Mango consumption somewhat affected the acquisition of conditioning, but not the memory.

Elapsed time (hours)	Normal diet (control): conditioning scores (%)	Mango diet: n° of correct *vs* wrong responses of colonies A and B	
		A, B;	overall score (%)
24h	75%	4 *vs* 6, 4 *vs* 6;	40%
48h	85%	8 *vs* 2, 7 *vs* 3;	75%
Cue removal			
24h	80%	8 *vs* 2, 8 *vs* 2;	80%
48h	85%	10 *vs* 0, 8 *vs* 2;	90%

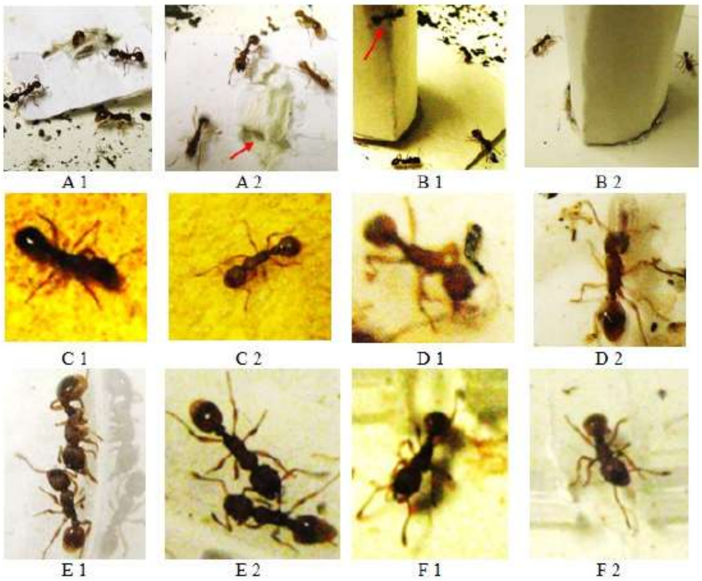

Figure 2. A few photos of the experiments made to know the adverse effects of mango. 1: ants under normal diet; 2: ants consuming mango. A: ants attracted to a tied nestmate (red arrows), whatever their diet. B: ants coming on an unknown apparatus; C: ants moving on a rough substrate; D ants taking care of a larva; E: two nestmates encountering; F: ants escaping from an enclosure.

Adaptation

At first sight, the ants seemed to somewhat adapt themselves to the effect of consumed mango on their locomotion. Indeed, after 7 days their linear speed somewhat, albeit significantly, differed from that measured after one day under this diet: $\chi2 = 15.21$, df = 1, $P < 0.001$ (Table 5, upper part). However, their angular speed did not present such an adaptation, staying similar to that observed after one day: $\chi2 = 0.55$, df = 2, $0.70 < P < 0.80$. The decrease of the effect of consumed mango was thus studied using the angular speed as determinative variable.

Dependence

The ants did not develop dependence on consumed mango (Table 5, lower part). Indeed, from colony A, 34 ants were sighted on the normal sugar solution and 17 others on the mango solution, while from colony B, 44 ants were sighted in front of the normal sugar solution and 11 others on the mango solution. The total equaled thus 78 ants (73.6%) having chosen the normal sugar solution and 28 (26.4%) having preferred the mango solution. These totalized numbers (78, 28) statistically differed from those (53, 53) expected if the ants had randomly chosen the presented solutions ($P < 0.001$). Preferring their normal sugar solution, the ants showed thus no dependence to the consumption of mango. (Figure 3, lower part).

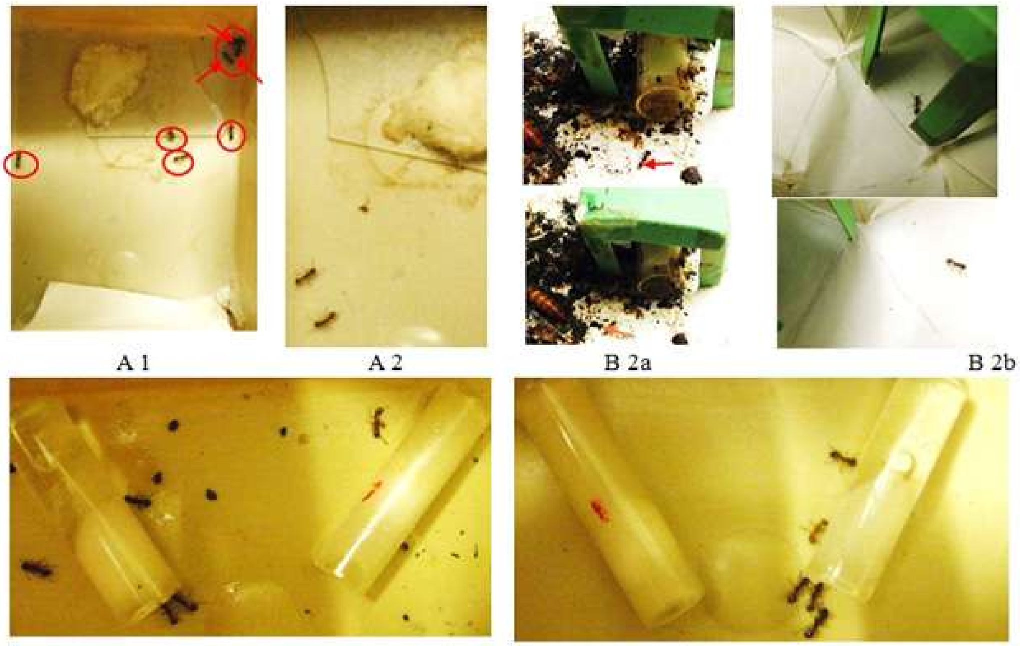

Figure 3. Photos of the effects of normal diet (1) or mango diet (2) on the moving of ants in a twist and turns path (upper photos; A, end part of the path), on their conditioning acquisition (upper photos; B, a: training; b: choice experiment), and dependence (lower photos, tube with mango solution marked with a red dash).

Table 5. Upper part: adaptation to the side effect of consumed mango on the ants' locomotion: the ants somewhat adapted themselves as for their linear speed, but not concerning their sinuosity of movement. Lower part: checking dependence on mango consumption: the ants developed no dependence at all.

Measured trait	Normal diet	+ Mango for 1 day	+ Mango for 7 days
Linear Speed	6.4 (6.1 – 7.0)	3.6 (3.3 – 3.8)	4.2 (3.7 – 4.5)
Angular speed	105 (85 – 128)	215 (161 – 241)	208 (169 – 252)

Lower part of Table

Sugared solution	Number and proportion of ants' visits to each solution			
	colony A	colony B	total number	proportion
Sugar water only	34	44	78	73.58%
+ Mango	17	11	28	26.41%

Table 6. Decrease of the effect of mango consumption on the ants' angular speed after weaning. The effect became statistically different from its initial value 9 hours after weaning and similar to the control situation from about 33 hours after weaning. The slowness of this decrease may account for the absence of dependence on mango consumption. Kruskal-Wallis test with Benjamini-Hochberg adjustment for multiple comparisons.

Time (hours)	Angular speed (ang.deg/cm) Median (quartiles)	Statistics *vs* t = 0 Z	P	*vs* control Z	P
0 h	385 (346 – 443)			8.4023	<0.001
3 h	375 (325 – 395)	0.6327	0.26	7.7697	<0.001
6 h	341 (293 – 375)	0.9939	0.17	7.4084	<0.001
9 h	263 (239 – 318)	2.4272	0.01	5.9752	<0.001
12 h	240 (205 – 265)	3.6642	<0.001	4.7381	<0.001
15 h	225 (192 – 277)	4.1885	<0.001	4.2139	<0.001
18 h	223 (200 – 249)	4.5614	<0.001	3.8409	<0.001
21 h	220 (179 – 244)	4.5458	<0.001	3.8565	<0.001
24 h	205 (194 – 243)	4.4648	<0.001	3.9376	<0.001
27 h	196 (158 – 313)	4.7274	<0.001	3.6749	<0.001
30 h	175 (144 – 202)	6.3237	<0.001	2.0786	0.022
33 h	149 (133 – 194)	6.7699	<0.001	1.6332	0.056
36 h	105 (64 – 127)	8.4267	<0.001	0 .0244	0.49
control	105 (85 – 128)	8.4023	<0.001		

Decrease of the effect after the end of mango consumption

The effect of mango consumption on the ants' sinuosity of movement decreased according to the cubic function:

$y = 408 - 21x + 0.85x^2 - 0.0138x^3$, with y = angular speed (ang.deg./cm) and x = time (hours since weaning)

and ceased to be significant from about 33 hours after weaning (Table 6, Figure 4). It statistically not differed from its initial value up to 6 hours after weaning, then clearly became smaller 9 hours after weaning. Though progressively slowly decreasing in value, the effect became statistically similar to the control value from 33 hours after the start of weaning. This somewhat lengthy decrease may account for the absence of dependence on mango consumption, as it has been often observed for other products used by humans [31-34].

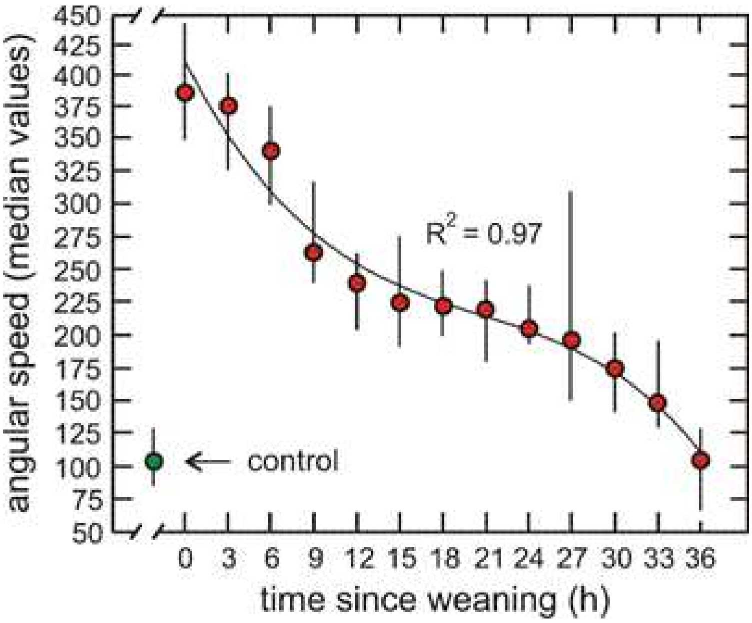

Figure 4. Decrease of the effect of mango on the ants' angular speed after the consumption of this fruit ceased. Polynomial cubic regression based on the angular speed (ang.deg./cm) median values. Interquartile ranges are figured as vertical bars. Numerical and statistical results are given in Table 6.

DISCUSSION AND CONCLUSION

Tested on the ant *Myrmica sabuleti*, mango consumption negatively impacted (1) the quantity of ingested meat, (2) their activity, (3) linear and angular locomotion speeds, (4) audacity, (5) brood caring, (6) escaping ability, (7) time need to cross a twist and turns path, as well as (8) their acquisition of a conditioning. The impact of mango consumption on the first seven of these traits appears to be linked to the impact on the ants' level of motor activity.

The effect of mango consumption on the ants' (9) locomotion speed on a very rough surface appeared to be at the limit of statistical significance.

Traits which do not clearly depend on motor activity such as (10) the orientation towards a source of pheromone, (11) social relationships, and (12) memory were not impacted by mango consumption.

Some slight physiological regulation (i.e. an adaptation at the level of the individual) was observed about the ants' linear speed after they had been on a mango diet for a week.

The ants preferred their usual sugar water diet to one containing mango juice. There was thus no evidence of dependence on mango consumption.

The decrease of the effect of a mango diet on the ants' angular velocity significantly vanished in about 33 hours after its consumption was stopped. This decrease was non-linear, with a conspicuous drop between 6 and 9 hours. Nevertheless, the duration of the decrease is in line with the absence of dependence on mango consumption. Indeed, there is a correspondence between the behavioral dependence on a product and the time taken to decay this behavior after withdrawal [34]. The post-weaning angular velocity decay observed after the end of mango consumption differs from that observed after cashew nuts consumption ceased. The cashew effect ends more rapidly [27], leading to dependence, while the effects of mango last longer, leading to the absence of dependence.

The observation of several behavioral side effects of mango consumption, such as those highlighted by the present work, suggest that the effects of mango on behavioral traits should be investigated in humans.

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CONFLICT OF INTEREST

We declare having no conflict of interest.

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