

The effect of organic and conventional farm management on the allergenic potency and bioactive compounds status of apricots (*Prunus armeniaca* L.)



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ABSTRACT

The present study shows a relationship between the use of organic or conventional practices and the allergenic properties and the bioactive compound content of apricots. The presented results indicate that organic apricots contain significantly more biologically active compounds from polyphenols group 53.75 mg/100 g FW and 31.52 mg/100 g FW and carotenoids 10.90 mg/100 g FW and 8.42 mg/100 g FW in than conventional apricots from polyphenols 16.83 mg/100 g FW and 27.27 mg/100 g FW and carotenoids 4.01 mg/100 g FW and 3.85 mg/100 g FW. Organic fruits are characterized by a higher allergenic potential. The authors of the current research have found a strong relationship between the content of polyphenolic compounds and the content of allergenic proteins for organic apricots $R^2 = 0.9044$ and for conventional apricots $R^2 = 0.8169$. The main conclusion is that some organic apricots, despite their better quality, would not be recommended for consumption by allergy sufferers.

1. Introduction

Many studies have shown that regular consumption of fruits could diminish the risk of serious health problems, such as different kinds of cancer, cardiovascular diseases, hypertension, and overweight (Aune et al., 2017; Alissa & Ferns, 2017; Ganjavi, Faraji, Kamangar, & Tucker, 2017), due to their antioxidant status and bioactive compound content (e.g., carotenoids, polyphenols, vitamin C) (Cheaib et al., 2018; Vlaic et al., 2018; Zeb, Khadim, & Ali, 2017). Organic fruits and vegetables contain more bioactive compounds than conventional fruits. This content is connected with the differences in the corresponding cultivation methods (Ahmadi, Ghasemnezhad, Meighani, & Kavosi, 2016; Hallmann, 2012; Hallmann, Piotrowska, & Świąder, 2016). In organic farming, only natural methods of plant cultivation and plant protection are allowed. For pest management, plants produce natural compounds better known as “natural pesticides”. These compounds are considered polyphenols (Popa, Mitelut, Popa, Stan, & Popa, 2018; Young et al., 2005). Apricots are well known fruits among consumers and are recognized as a tasty and healthy fruit. Many studies have shown that organic farming can increase fruit quality and improve food safety (Barański et al., 2014). However, while the regular consumption of apricots can have positive benefits, the fruits can also cause allergies.

Most people with an allergy to apricots have allergies to other fruits and pollen, particularly to birch pollen (Inman, Groves, McCullough, Quaglia, & Hopley, 2018). In contrast, some reactions to apricots are not allergic in nature but simply represent a food intolerance to apricots (Harbron, 2017; Katelaris, 2010; Inomata et al., 2014; Inomata, Miyakawa, & Aihara, 2017; Vanga, Jain, & Raghaven, 2018). The most effective form of therapy for patients with an apricot allergy is to exclude the fruit from their diet, although this practice may be associated with a reduced quality of life (Jiang, Yin, Mak, & Wen, 2014; Petruláková & Valík, 2015).

Currently, food allergies affect over 4% of the population (4% of adults and 8% of children) (Kiliç & Taşkın, 2015; Markevych, Standl, Lehmann, von Berg, & Heinrich, 2017; Venter et al., 2018). The most common food allergies involve animal products, such as eggs, milk, shellfish, and fish, as well as vegetables, such as wheat, soy, celery and peanuts (Sicherer & Sampson, 2018). An allergic reaction to apricots is a type of cross-allergy. Some food allergens from pome and stone fruits have been identified: homologue Bet v 1 (Pru ar 1, 10 kDa, apricot), Pru p 1 (10 kDa, peach), profilin (Pru p 4, 10 kDa, peach), profilin (Pru p 4, 14 kDa, peach), homologue Bet v 1 (Pru av 1, 18 kDa, cherry), profilin (Pru av 4, 15 kDa, cherry), profilin (Mal d 1, 18 kDa apple), homologue Bet v 1 (18 kDa, Pyr c 1, pear), and profilin (14 kDa, Pyr c 4, pear).

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Fruits that belong to the *Prunus* genus and for which no Bet v 1 homologues have been identified or officially named yet are plums and nectarines (Cantani, 2008; Mothes-Luksch et al., 2017; Volpicella et al., 2015; Wangorsch et al., 2015).

In the current study, we set out to identify and determine the content of bioactive compounds, including polyphenols, carotenoids, vitamins and analogues to the most common panallergens, Bet v 1 and profilin, in selected apricot cultivars from organic and conventional production. There is a lack of information about the allergenic potential of organic apricot cultivars in the literature. In the current experiment, we wanted to prove whether there is a relationship between the content of bioactive compounds and the level of allergens in apricot fruits. The aim of the study was to determine if organic farm management has an impact on the quality and allergenic potential of apricots.

2. Materials and methods

2.1. Origin of fruits

To carry out the experiment evaluating the impact of organic and conventional farm management on the quality and allergenic potential of apricots, three cultivars of the fruit were chosen: 'Harcot', 'Orange Red' and 'Morden 604'. Both organic and conventional apricots were cultivated in two separate orchards from 2012 to 2013. The organic orchard was located in Nowy Dwór-Parcela (Skierniewice), Poland (51°52'N 20°15'E). Apricot trees grafted onto the rootstock of cherry plum (*Prunus cerasifera*) were planted at a spacing of 6 × 5 m and were grown in accordance with the strict rules of organic farming. The protection programme for the apricot trees included 2–3 treatments of copper (Miedzian 50 WP) each year of the experiment.

The conventional orchard was located in Dąbrowice (Skierniewice), Poland (51°56'N 20°06'E). The conventional apricot trees were prepared similarly to the organic ones (rootstock) and were planted at a spacing of 5 × 4 m; all rules of conventional practices were followed in the system. The protection programme for the apricot trees included plant protection against fungal diseases: apricot scab and brown spotted stone fruit (Table 1). Fruits were collected at the fully ripened stage on 28 July 2012 and 30 July 2013. In addition, 500 g of fruit (10 pieces of apricot) was collected from one tree. In total, 2.0 kg of fruit was used for each experimental combination of each year.

2.2. Plant material preparation

The fresh fruits were transported to the laboratory for analysis. The fruits were washed, and the stone was separated from the flesh. Then, each fruit was cut into four parts. Two parts were intended for the freeze-drying process using a LabconCo (2.5) freeze-drier (−40 °C, pressure 0.100 mBa). After freeze-drying, the plant material was ground in a laboratory mill (A-11). The ground samples were poured into

plastic tubes and stored at −80 °C for subsequent analysis. The other two pieces were used for dry matter determination.

2.3. Dry mater

The apricot dry matter content was determined before the fruit was freeze-dried. The apricots were cut into small cubes. Then, 2 g of apricot tissue underwent a drying process with the following stable conditions, drying time 48 h, laboratory equipment Dryer KC-65 with air circulation. After 48 h, all samples were cooled in a desiccator with dry silica indicator balls and weighed. The actual mass was noted. Next, the drying process began again for 24 h. The re-drying process was repeated two more times to achieve a constant weight. The dry matter content of the apricots was calculated in grams per 100 g of fresh weight (FW) as described by Ohene and Maalekuu (2013).

2.4. Carotenoid content

The carotenoids were measured by HPLC method described previously in detail by Hallmann et al. (2017).

2.5. Polyphenol content

The polyphenols were measured by an HPLC method described previously in detail by Hallmann et al. (2017). The procedure of polyphenols extraction was follow: 100 g of freeze-dried apricots tissue was mixed together with 80% of methanol. Next the sample was gently mixed on the vortex. Samples were extracted in ultrasonic bath (10 min, 30 °C, 5.5 kHz). After extraction samples were centrifuged (10 min, 3780 × g, 5 °C). Supernatant was collected to the empty plastic tube and re-centrifuged again (5 min, 31,180 × g, 0 °C). 1 ml of extract was injected to the HPLC-vial and analysed. For polyphenols compounds separation Synergi Fusion-RP 80i column (250 × 4.60 mm) was used. Phenolic compounds were separated under gradient conditions with a flow rate of 1 ml min^{−1}. Two gradient phases 10% (v/v) acetonitrile and ultra-pure water (phase A) and 55% (v/v) acetonitrile and ultra-pure water (phase B), with ortho-phosphoric acid (pH 3.0). Time of the analysis: 38 min. The phases time program was follows: 1.00–22.99 min 95% phase A and 5% phase B, 23.00–27.99 min 50% phase A and 50% phase B, 28.00–28.99 min 80% phase A and 20% phase B, 29.00–38.00 min 95% phase A and 5% phase B. Wavelengths: 250 nm for flavonoids, and 370 nm for phenolic acids.

2.6. Vitamin C content

Vitamin C was measured by an HPLC method. First, 100 mg of the freeze-dried sample was extracted with 5% meta-phosphorus acid. The sample was mixed by a vortex mixer and then incubated in an ultrasonic bath (15 min, 20 °C). The sample was then centrifuged (41,574.4 × g, 10 min, 0 °C). The supernatant was taken from the test tube (without stirring) and transferred to an HPLC vial. The following analysis parameters were used: mobile phase acetic buffer (pH 4.4), Phenomenex Hydro 80-A RP column (250 × 4.6 mm), analysis time 18 min, and detection 255–260 nm, L-Asc and DHA standards from Fluka and Sigma-Aldrich (Warsaw, Poland) with 99% purity were used. Four replicates were analysed for each analytical combination. Five injections of the L-Asc and DHA standards were prepared from the prepared standard solutions, and standard curves for the tested components of vitamin C were determined. The chromatogram was read, and the individual compounds were identified based on the retention time of the standards.

2.7. Allergenic potential analysis

With the aim of assessing the allergenic potential of the apricot samples, the following reagents were used: mouse antibodies against

Table 1

The data about soil and orchards conditions as well fertilization and plant protection in time of apricots cultivation in two years of experiment.

	Organic orchard	Conventional orchard
type of soil	podzolic soil	podzolic soil
% humus content	1.50%	1.30%
soil pH	5.5–6.5	6.2–6.6
groundwater level	up to 150–160 cm	up to 160–180 cm
fertilization	cow manure 40 t/ha	nitrogen 50 kg/ha, phosphorus, 80 kg/ha, potassium 120 kg/ha
number trees per ha	330	500
spacing of trees	6 × 5 m	5 × 4 m
plant protection	Cuprate Copper Max NEW 50 WP 3 kg/ha	Miedzian Extra 350 SC 3 l/ha Switch 62.5 WG 0.75 kg/ha Topsin M SC 1.5 l/ha Calypso 480 SC 0.2 l/ha

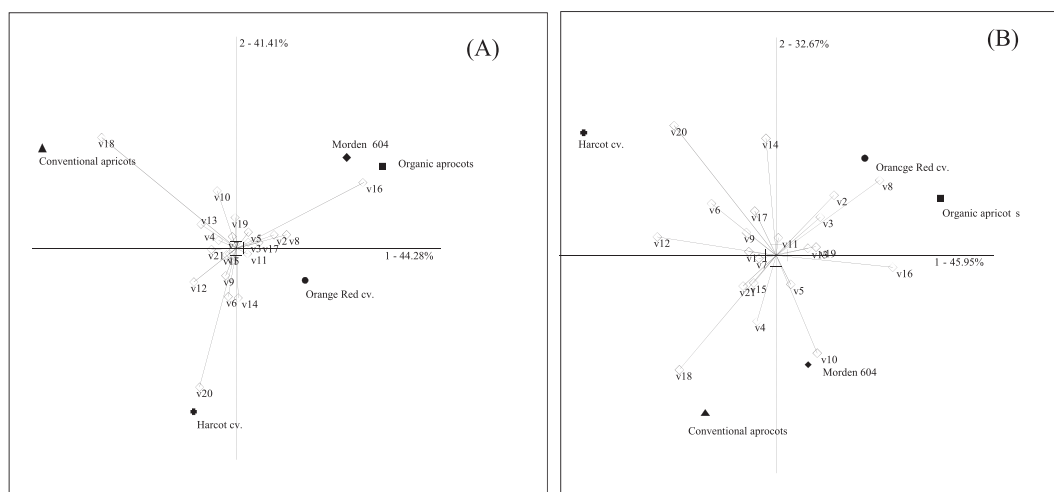


Fig. 1. PCA analysis showing the relationship between the chemical composition of examined apricots cultivars from organic and conventional farm management in 2012 (A) and 2013 (B). (v1) dry matter, (v2) total carotenoids, (v3) lutein, (v4) zeaxanthin, (v5) lycopene, (v6) beta-carotene, (v7) alpha-carotene, (v8) vitamin C, (v9) DHA, (v10) L-Asc, (v11) total polyphenols, (v12) gallic acid, (v13) chlorogenic acid, (v14) caffeic acid, (v15) p-coumaric acid, (v16) quercetin-3-O-glucoside, (v17) myricetin, (v18) luteolin, (v19) kaempferol, (v20) proflin, (v21) Bet v1.

Bet v1 (Dendritics, France), rabbit antibodies against profilin (Dendritics, France), a conjugate of antibodies against mouse immunoglobulins with alkaline phosphatase (Sigma-Aldrich, Poland), antibodies against the rabbit immunoglobulin conjugate with alkaline phosphatase (Sigma, Kraj). For the analysis, 10 μ L of each of the abovementioned factors was suspended in 10 ml of deionized H₂O. In addition, a 3% solution of commercial skim milk (Poland) in deionized H₂O, pNPP (Sigma-Aldrich, Poland) as the substrate for the alkaline phosphatase, and 3 M NaOH (Sigma-Aldrich, Poland) as the stop reagent were used. As a washing agent, PBS with 0.1% Tween 20 (Sigma-Aldrich, Poland) (0.34 g of KH₂PO₄, 5.73 g of Na₂HPO₄, 9 g of NaCl and 1 ml of Tween 20 with distilled H₂O used for the remainder to fill the reach to the 1 l mark) was applied.

The analyses were performed according to [Słowianek, Skorupa, Hallmann, Rembiałkowska, and Leszczyńska \(2016\)](#). To prepare the sample, the Total Protein Extraction Kit for Plant Tissues was used to obtain the fruit extracts. A standard solution was prepared by successive dilutions from the 0.01 mg per 1 ml stock solution of Bet v1 or profilin for the standard curve. The first step was to fill each well of a special microplate (SPL Lifesciences, Korea) with 100 μ L of the standard solution (reference curve) or the samples of the extracts diluted ten times in the carbonate buffer. Then, the plate was kept in a refrigerator (4 °C) for 12 h. The next step was to wash the used wells with 4 $\times$ 350 μ L of the PBS washing buffer. The plate was then incubated for two hours after 400 μ L of 3% skim milk in PBS solution was added to the wells, forming the convex meniscus. The next step was to wash the used wells with 4 $\times$ 350 μ L of the PBS washing buffer. Then, 100 μ L of the antibodies against Bet v1 1000 times diluted or against profilin 1000 times diluted was added and incubated for one hour at room temperature. After one hour, the plate was washed with 4 $\times$ 350 μ L of the washing buffer. Then, 100 μ L of the anti-mouse antibody in the case of analogs od Bet v1 determination (or anti-rabbit in the case of profilin determination) conjugated to alkaline phosphatase (diluted 5000) was added to each well and incubated for one hour. After this time, the plate was washed with 4 $\times$ 350 μ L of the washing buffer, and 100 μ L of the substrate pNPP for enzyme was added. After 30 min, a yellow colour was observed, and the reaction was stopped by adding 100 μ L of the stopping solution, which was NaOH. The plate was read at 405 nm with the use of a Multiscan RC microplate reader (LabSystems, Finland). Then, the results were calculated by the use of a standard curve prepared with the Bet v1 allergen ($y = 0.0242x - 0.0697$ in the range of concentration 0.5–50 ng mL⁻¹. $R^2 = 0.9923$) or profilin ($0.0017x + 0.07415$ in the range of concentration 0.5–100 ng mL⁻¹.

$R^2 = 0.9942$). Limit of detection of Bet v1 is 0.88 ng mL⁻¹, limit of detection of profilin – 1.2 ng mL⁻¹.

2.8. Statistical analysis

The obtained results are expressed as the mean value for the organic and conventional combination, for the three cultivars of ‘Harcot’, ‘Orange Red’ and ‘Morden 604’, and separately for each year of the experiment. The mean value for the organic and conventional apricots was obtained from 12 individual measurements (one orchard, four trees, and three independent samples). The statistical calculations were based on a two-way analysis of variance with the use of Tukey’s test ($p = 0.05$) using Statgraphics 5.1 software (StatPoint Technologies, Inc., Warranton, VA, USA). A lack of statistically significant differences between the examined groups is indicated by the use of the same letters. A standard deviation (SD) and standard error (SE) were given with the mean value. To obtain a clearer picture of the interrelations between the identified biologically active compounds and the allergenic proteins, an analysis of the main component (PCA) was used. A principal component analysis (PCA) is a handy statistical tool that applies an orthogonal transformation to convert a set of data of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. The PCA figures were made using Statistica 10.0 (Statsoft, Tulsa, USA). The PCA was conducted on the basis of the correlation matrix not the covariance matrix, which corresponds to the analysis of standardized data.

3. Results

The current experiment provides information about the impact of farm management on the quality of apricots. The authors have tried to use a holistic “from farm to fork” approach. The obtained results showed not only the nutritional value and the content of the biologically active compounds in apricots but also demonstrated how apricots can affect consumers who suffer from allergy problems. The PCA (principal component analysis) results for apricots showed that the overall degree of variability explained by PC1 and PC2 was 85.69% in 2012 and 78.67% in 2013 ([Fig. 1](#)). This was confirmed by a strong link between the examined chemical compounds and the allergenic proteins. In 2012, the ‘Morden 604’ cultivar was positively correlated with organic apricots. In 2013, another cultivar, ‘Orange Red’, was positively correlated with organic apricots. As shown on the graph in both years of the experiment, the organic and conventional apricots were located in

Table 2

The content of dry matter (g/100 g FW) and carotenoids (mg/100 g FW) and polyphenols (mg/100 g FW) in examined apricots from organic and conventional production in 2012. Mean value $\pm$ standard deviation (n = 12).

parametrs	system		cultivar			p-value	
	Organic apricots	Conventional apricots	Harcot cv.	Orange Red cv.	Morden 604 cv.	system	cultivar
<i>dry matter (g/100 g FW)</i>	19.69 $\pm$ 1.63 ¹ A ²	13.93 $\pm$ 1.43 B	17.05 $\pm$ 4.04 a	17.09 $\pm$ 3.58 a	16.30 $\pm$ 1.57 a	< 0.0001	N.S.
<i>total carotenoids (mg/100 g FW)</i>	10.90 $\pm$ 0.66 A	4.01 $\pm$ 0.42 B	7.62 $\pm$ 3.89 a	7.58 $\pm$ 3.17 a	7.16 $\pm$ 3.35 a	< 0.0001	N.S.
lutein	0.41 $\pm$ 0.03 A	0.29 $\pm$ 0.03 B	0.35 $\pm$ 0.08 a	0.35 $\pm$ 0.07 a	0.34 $\pm$ 0.03 a	< 0.0001	N.S.
zeaxanthin	0.26 $\pm$ 0.02 A	0.19 $\pm$ 0.02 B	0.23 $\pm$ 0.05 a	0.23 $\pm$ 0.05 a	0.22 $\pm$ 0.02 a	< 0.0001	N.S.
lycopene	7.34 $\pm$ 0.57 A	1.51 $\pm$ 0.38 B	4.55 $\pm$ 3.15 a	4.50 $\pm$ 2.52 a	4.23 $\pm$ 3.14 a	< 0.0001	N.S.
beta-carotene	2.47 $\pm$ 0.21 A	1.73 $\pm$ 0.18 B	2.13 $\pm$ 0.53 a	2.13 $\pm$ 0.46 a	2.03 $\pm$ 0.20 a	< 0.0001	N.S.
alpha-carotene	0.42 $\pm$ 0.04 A	0.30 $\pm$ 0.03 B	0.36 $\pm$ 0.09 a	0.36 $\pm$ 0.08 a	0.34 $\pm$ 0.03 a	< 0.0001	N.S.
<i>vitamin C (mg/100 g FW)</i>	13.64 $\pm$ 1.00 A	9.01 $\pm$ 1.04 B	10.71 $\pm$ 2.80 b	12.24 $\pm$ 2.74 a	11.03 $\pm$ 1.61 b	< 0.0001	0.0025
DHA	3.54 $\pm$ 0.41 A	2.43 $\pm$ 0.59 B	2.35 $\pm$ 0.62 b	3.14 $\pm$ 0.72 a	3.46 $\pm$ 0.37 a	< 0.0001	< 0.0001
l-Asc	10.10 $\pm$ 1.01 A	6.58 $\pm$ 0.67 B	8.36 $\pm$ 2.18 ab	9.10 $\pm$ 2.02 a	7.57 $\pm$ 1.25 b	< 0.0001	0.0005
<i>total polyphenols (mg/100 g FW)</i>	53.75 $\pm$ 33.58 A	16.83 $\pm$ 3.49 B	33.50 $\pm$ 2.31 b	16.80 $\pm$ 1.64 c	55.58 $\pm$ 2.66 a	< 0.0001	< 0.0001
gallic	5.32 $\pm$ 2.84 A	2.68 $\pm$ 0.87 B	2.55 $\pm$ 0.85 b	3.54 $\pm$ 0.59 ab	5.92 $\pm$ 3.38 a	< 0.0001	< 0.0001
chlorogenic	23.13 $\pm$ 9.45 A	2.97 $\pm$ 0.62 B	2.56 $\pm$ 1.18 b	3.10 $\pm$ 0.78 b	33.48 $\pm$ 1.27 a	< 0.0001	< 0.0001
caffeic	2.07 $\pm$ 1.67 A	2.07 $\pm$ 0.82 A	1.83 $\pm$ 1.03 b	1.67 $\pm$ 0.73 b	2.72 $\pm$ 1.71 a	N.S.	0.0100
p-coumaric	13.92 $\pm$ 3.44 A	3.74 $\pm$ 2.44 B	19.83 $\pm$ 3.00 a	1.90 $\pm$ 0.91 c	4.75 $\pm$ 1.47 b	< 0.0001	< 0.0001
quercetin-3-O-glucoside	7.57 $\pm$ 2.87 A	3.91 $\pm$ 1.57 B	5.32 $\pm$ 0.49 b	5.29 $\pm$ 0.52 b	6.61 $\pm$ 4.95 a	< 0.0001	0.0072
myricetin	0.69 $\pm$ 0.07 A	0.57 $\pm$ 0.13 B	0.67 $\pm$ 0.11 a	0.55 $\pm$ 0.13 b	0.66 $\pm$ 0.08 a	0.0001	0.0006
luteolin	0.68 $\pm$ 0.42 A	0.66 $\pm$ 0.28 A	0.43 $\pm$ 0.03 a	0.41 $\pm$ 0.07 a	1.16 $\pm$ 0.14 b	N.S.	< 0.0001
kaempferol	0.38 $\pm$ 0.05 A	0.24 $\pm$ 0.02 B	0.31 $\pm$ 0.09 a	0.33 $\pm$ 0.10 a	0.28 $\pm$ 0.03 ab	< 0.0001	0.0012

¹ Data are presented as the mean $\pm$ SD with ANOVA p-value.

² Means in rows followed by the same letter are not significantly different at the 5% level of probability (p < 0.05); N.S. not significant; (n) number of samples (field replications).

completely separate areas. This arrangement suggests a complete chemical dissimilarity between the examined fruits.

The obtained results from the determination of the carotenoid, polyphenol and vitamin C content and the profiles of the identified compounds in the three apricots cultivars from the two farming systems are presented in [Tables 2 and 3](#), separately for the two years of the experiment. For the carotenoid content, only the system of cultivation significantly determined (p < 0.0001) the level of bioactive compounds. We did not observe an effect of cultivar. A similar situation was noticed for the vitamin C (p < 0.0001) content and its profile. Organic

apricots were characterized by a significantly higher level of vitamin C, as well as l-ascorbic (p < 0.0001) and dehydroascorbic acid (p < 0.0001), than conventional apricots in both experimental years ([Tables 2 and 3](#)). 'Orange Red' cv. was one of the best cultivars in terms of vitamin C (p = 0.0025) content but only in 2012. In the next experimental year, only a tendency for a higher level of vitamin C was observed for 'Harcot' cv. (p < 0.0001). For the DHA content only, the obtained results were not statistically significant. The results for the profile and the content of the polyphenols were interesting. In both experimental years, most of the identified polyphenols were higher in

Table 3

The content of dry matter (g/100 g FW) and carotenoids (mg/100 g FW) and polyphenols (mg/100 g FW) in examined apricots from organic and conventional production in 2013. Mean value $\pm$ standard deviation (n = 12).

parametrs	system		cultivar			p-value	
	Organic apricots	Conventional apricots	Harcot cv.	Orange Red cv.	Morden 604 cv.	system	cultivar
<i>dry matter (g/100 g FW)</i>	18.85 $\pm$ 4.02 ¹ A ²	17.44 $\pm$ 1.87 B	21.35 $\pm$ 2.46 a	18.43 $\pm$ 1.03 b	14.65 $\pm$ 1.16 c	0.048	< 0.0001
<i>total carotenoids (mg/100 g FW)</i>	8.42 $\pm$ 0.76 A	3.85 $\pm$ 0.38 B	6.48 $\pm$ 2.89 a	6.18 $\pm$ 1.98 a	5.75 $\pm$ 2.04 b	< 0.0001	0.016
lutein	0.41 $\pm$ 0.03 A	0.29 $\pm$ 0.03 B	0.35 $\pm$ 0.08 a	0.35 $\pm$ 0.07 a	0.34 $\pm$ 0.03 a	< 0.0001	N.S.
zeaxanthin	0.26 $\pm$ 0.02 A	0.19 $\pm$ 0.02 B	0.23 $\pm$ 0.05 a	0.23 $\pm$ 0.05 a	0.22 $\pm$ 0.02 a	< 0.0001	N.S.
lycopene	4.92 $\pm$ 0.58 A	1.37 $\pm$ 0.33 B	3.44 $\pm$ 2.17 a	3.14 $\pm$ 1.36 a	2.84 $\pm$ 1.84 b	< 0.0001	0.015
beta-carotene	2.42 $\pm$ 0.21 A	1.72 $\pm$ 0.18 B	2.10 $\pm$ 0.51 a	2.10 $\pm$ 0.43 a	2.01 $\pm$ 0.19 a	< 0.0001	N.S.
alpha-carotene	0.42 $\pm$ 0.03 A	0.30 $\pm$ 0.03 B	0.36 $\pm$ 0.09 a	0.36 $\pm$ 0.08 a	0.35 $\pm$ 0.03 a	< 0.0001	N.S.
<i>vitamin C (mg/100 g FW)</i>	10.87 $\pm$ 2.26 A	10.05 $\pm$ 1.68 A	11.76 $\pm$ 1.49 a	11.66 $\pm$ 0.63 a	7.96 $\pm$ 0.65 b	N.S.	< 0.0001
DHA	2.78 $\pm$ 0.29 A	2.56 $\pm$ 0.26 B	2.63 $\pm$ 0.44 a	2.72 $\pm$ 0.16 a	2.67 $\pm$ 0.18 a	0.047	N.S.
l-Asc	8.09 $\pm$ 2.10 A	7.49 $\pm$ 1.65 A	9.13 $\pm$ 1.06 a	8.95 $\pm$ 0.50 b	5.29 $\pm$ 0.48 c	N.S.	< 0.0001
<i>total polyphenols (mg/100 g FW)</i>	31.52 $\pm$ 7.91 A	27.27 $\pm$ 4.95 B	30.35 $\pm$ 8.26 a	23.22 $\pm$ 2.49 b	34.62 $\pm$ 1.82 a	0.0008	< 0.0001
gallic	5.69 $\pm$ 1.69 A	5.61 $\pm$ 2.01 A	5.37 $\pm$ 1.13 b	3.77 $\pm$ 0.31 c	7.81 $\pm$ 0.85 a	N.S.	< 0.0001
chlorogenic	8.57 $\pm$ 3.98 A	6.94 $\pm$ 2.54 B	6.70 $\pm$ 1.66 b	4.55 $\pm$ 0.35 c	12.01 $\pm$ 1.74 a	0.0023	< 0.0001
caffeic	2.40 $\pm$ 0.64 B	2.96 $\pm$ 0.78 A	2.17 $\pm$ 0.32 b	2.57 $\pm$ 0.89 b	3.31 $\pm$ 0.45 a	0.00045	0.0003
p-coumaric	9.25 $\pm$ 5.17 A	6.53 $\pm$ 1.78 B	10.78 $\pm$ 5.41 a	8.36 $\pm$ 0.74 b	4.53 $\pm$ 0.83 c	< 0.0001	< 0.0001
quercetin-3-O-glucoside	4.02 $\pm$ 1.88 A	3.81 $\pm$ 1.27 A	3.61 $\pm$ 0.30 ab	2.21 $\pm$ 0.16 b	5.93 $\pm$ 0.77 a	N.S.	< 0.0001
myricetin	0.71 $\pm$ 0.26 A	0.58 $\pm$ 0.09 A	0.74 $\pm$ 0.10 a	0.73 $\pm$ 0.25 a	0.46 $\pm$ 0.04 b	N.S.	0.016
luteolin	0.52 $\pm$ 0.16 A	0.43 $\pm$ 0.09 B	0.58 $\pm$ 0.13 a	0.52 $\pm$ 0.03 a	0.32 $\pm$ 0.03 b	0.0002	< 0.0001
kaempferol	0.35 $\pm$ 0.08 B	0.41 $\pm$ 0.16 A	0.39 $\pm$ 0.06 ab	0.50 $\pm$ 0.13 a	0.25 $\pm$ 0.02 b	0.0055	< 0.0001

¹ Data are presented as the mean $\pm$ SD with ANOVA p-value.

² Means in rows followed by the same letter are not significantly different at the 5% level of probability (p < 0.05); N.S. not significant; (n) number of samples (field replications).

Table 4

The content of profilin and Bet v 1 in examined apricots from organic and conventional production in 2012 and 2013. Mean value $\pm$ standard error (n = 18).

mean value for system	2012		2013	
	profilin (AUg-1)	Bet v1 (AUg-1)	profilin (AUg-1)	Bet v1 (AUg-1)
Organic apricots	311.28 $\pm$ 33.97 ¹ A ²	314.92 $\pm$ 25.75 A	125.37 $\pm$ 23.84 A	342.14 $\pm$ 20.82 A
Conventional apricots	254.35 $\pm$ 31.18 B	347.49 $\pm$ 17.63 A	95.00 $\pm$ 30.85 B	341.96 $\pm$ 26.47 A
<i>mean value for cultivar</i>				
Harcot cv.	308.25 $\pm$ 40.46 a	327.80 $\pm$ 13.05 a	166.73 $\pm$ 23.85 a	339.37 $\pm$ 25.26 a
Orange Red cv.	242.91 $\pm$ 26.55 b	330.52 $\pm$ 18.78 a	105.66 $\pm$ 30.19 b	344.13 $\pm$ 25.02 a
Morden 604 cv.	297.29 $\pm$ 29.62 a	335.29 $\pm$ 7.51 a	58.16 $\pm$ 29.82 c	342.64 $\pm$ 20.52 a
<i>p-value</i>				
system	0.0272	N.S.	0.0038	N.S.
cultivar	0.0345	N.S.	< 0.0001	N.S.

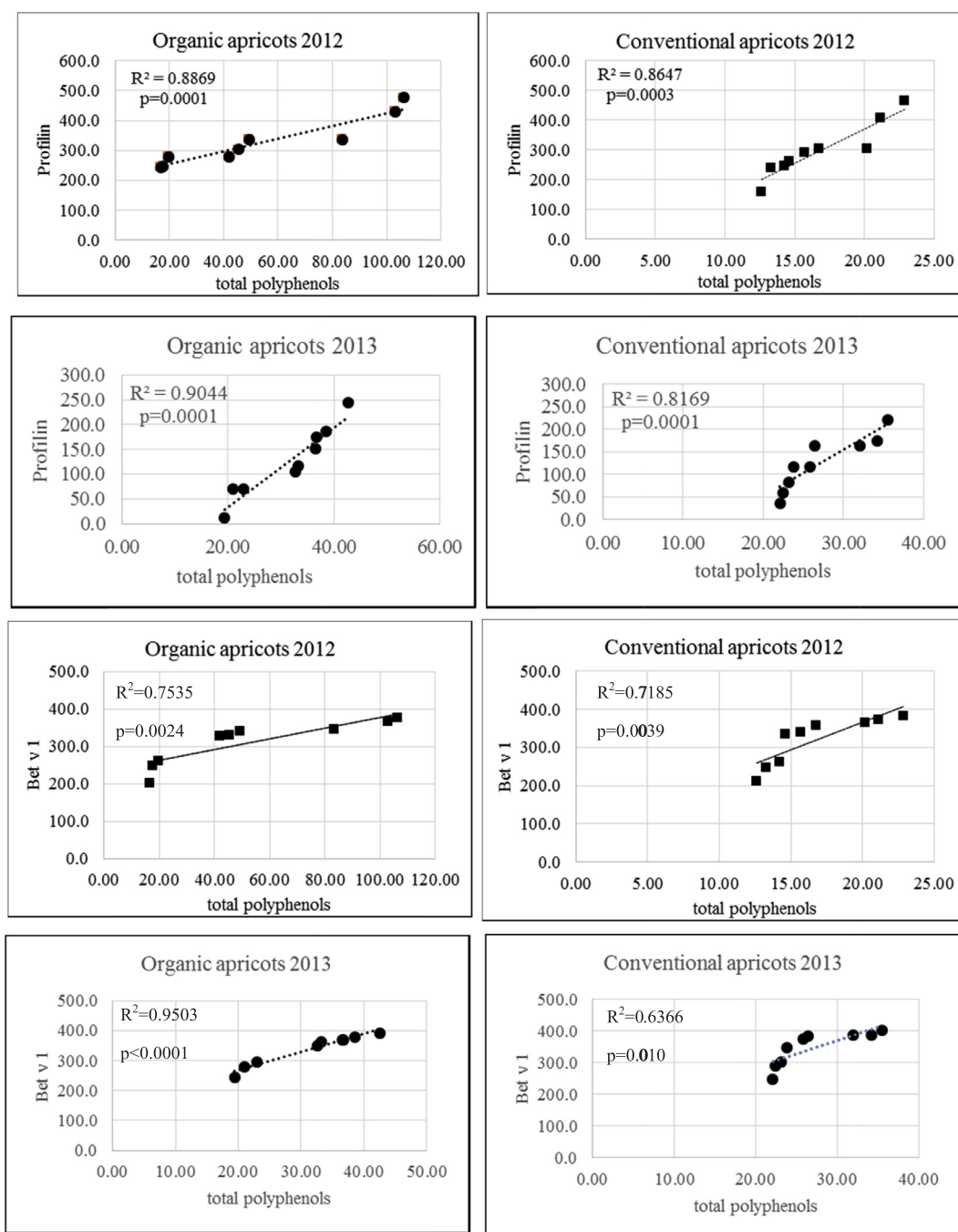


Fig. 2. Linear regression (Pearson's coefficient R^2) between allergenic proteins profilins, Bet v 1 and total polyphenols in apricot fruits.

the organic apricots than in the conventional apricots. No effect of farm management was observed for only a few of the phenolic compounds: caffeic acid ($p = 0.078$) (2012), gallic acid ($p = 0.091$), quercetin-3-O-glucoside ($p = 0.074$) and myricetin ($p = 0.090$) (2013). In both experimental years, a strong significant effect of cultivar was observed for the polyphenol content in the fruits ($p < 0.0001$) (Tables 2 and 3). ‘Morden 604’ cv. contained significantly more phenolic compounds (except for myricetin, luteolin and kaempferol in 2013) than did ‘Harcot’ cv. and ‘Orange Red’ cv.

Profilin analogues in a range from 254.4 to 311.3 in 2012 and from 95.0 to 125.4 in 2013 ng g^{-1} were found in each tested sample for the organic and conventional production (Table 4). The allergenic protein content was significantly different depending on the farm management factor in both experimental years ($p = 0.0027$ and $p = 0.033$). The highest profilin analogue content was found in the ‘Harcot’ cultivar in both experimental years ($p = 0.0345$),

308.3 ng g^{-1} (2012) and 166.7 ng g^{-1} ($p < 0.0001$) (2013). Comparatively, a significantly lower level of profilin was observed in ‘Orange Red’ cv (2012) and in ‘Morden 604’ cv. (2013).

The content of Bet v1 homologues ranged from 314.9 to 347.5 ng g^{-1} in 2012 and from 341.9 to 342.1 ng g^{-1} in 2013. Among the group of examined cultivars, the level of Bet v1 homologues was similar and almost equal in both experimental years. We did not observe an effect of cultivar on the allergenic protein homologues (Table 4). In the group of examined cultivars, a tendency for a higher level of Bet v1 was observed in ‘Morden 604’ fruits.

4. Discussion

Apricot fruits are one of the best sources of different antioxidants, such as carotenoids, polyphenols and vitamin C (Dragovic-Uzelac, Levaj, Mrkic, Bursac, & Boras, 2007; Leong & Oey, 2012; Ugur, Erdogan, Yilmaz, & Basgel, 2018). Apricots are recognized by consumers as tasty and healthy fruits. Organic fruit production is a good alternative for pure and good quality fruit production. The strict rules for organic plant production are thought to allow the production of safe and good quality fruits. Many experiments conducted to compare organic and conventional farm management focus on the theory that organic fruits are more rich in bioactive compounds (Ahmadi et al., 2016; Barański et al., 2014; Hallmann et al., 2016). In the present study, we confirmed that theory, mostly in case of the polyphenol content (Tables 2 and 3). The fact that organic fruits contained more bioactive compounds can be explained by the C/N theory. According to Bloksma, Northolt, Huber, van der Burgt, and van de Vijver (2007), compared with the conventional production process, organic cultivation provides plants and crops with more bioactive compounds. Organic fertilizers (compost and manure) contain less available nitrogen than mineral fertilizers; therefore, the plants in the organic system grow more slowly but contain more bioactive compounds than the plants from conventional systems. On the other hand, the higher level of polyphenols in the plants is a response to biotic and abiotic environmental stress factors. In the case of a pest attack or the occurrence of pathogenic fungi, as well as sun radiation the plants synthesize more polyphenolic compounds (Young et al., 2005). In the current experiment, a similar link was observed (Fig. 2). As pointed Ruiz, Egea, Gil, and Tomas-Barberan (2006) in apricots fruits, the amount of total polyphenols is very variable. In experiment with four apricots cultivars (Colorado cv, Mirlo Anaranjado cv., Mirlo Blanco cv. and Mogador cv.) Melgarejo et al. (2014) showed that the content of total polyphenols was in range from 14.9 mg/100 g FW to 22.2 mg/100 g FW. It is depending on the cultivar as well system of cultivation (organic and conventional). There are exist the new apricots cultivars, they can account also to 160.0 mg/100 g FW of polyphenols. In the experience we presented, the level of polyphenols was slightly lower, but still was satisfied (Tables 2 and 3). As we observed organic apricots, especially in 2012 were characterized by the 3 times higher level of total

polyphenols compare to conventional one. It seems, that not only quantity but as well quality plays an important role in case of polyphenols content in apricots fruits. Phenolic compounds present in apricot primarily comprise gallic acid, chlorogenic acid, caffeic acid, p-coumaric acid, ferulic, acid, and flavonols: quercetin-3-glucoside, quercetin-3-rutinoside, kaempferol-3-rutinoside (Dragovic-Uzelac, Delonga, Levaj, Djakovic, & Pospisil, 2005). Chlorogenic acid and quercetin derivatives are the most abundant phytochemicals found in several apricot varieties (Carbone et al., 2018; Fratianni et al., 2013). As reported Ugur et al. (2018) the level of chlorogenic acid was strongly dependent on the season. Apricots fruits in Turkey in early spring (April) contained much more chlorogenic acid compare to middle-season (July) and late time (November). In three apricots cultivars: Hacıhaililoglu cv., Kabasi cv., and Cekirge cv. always the highest pick of chlorogenic acid was noticed in high-sun exposure time (spring) and was decreased in autumn time. In our experiment we collect the apricots fruits in the middle of polish summer when the sun exposure was the highest. On the other hand the differences between cultivars are the effect of genetic differentiations. Flavonoids having antioxidant abilities and protect plants from various biotic and abiotic stresses. UV radiation causes oxidative stress in plants. As a method of prevention plants start produce secondary metabolic compounds. Therefore, the exposure of apricot fruits to sunlight increases the content of flavonoid compounds. As reported Henry-Kirk et al. (2017) flavonoid biosynthesis is regulated primarily at the transcriptional level. In contrast, flavonols and flavones, which provide UV tolerance are regulated by a distinct subgroup of specifically gens, which are strongly regulated by UV light. However, it should be remembered that the key role in exposure fruits for sun light is tree pruning. It should be emphasized that the presented experiment was carried out in neighboring orchards (organic and conventional and the distance between orchards is 10 km). Both orchards are a very similar under trees pruning, therefore, the pruning method had any effect on the content of flavonoid compounds in apricot fruits. We observed only differences between experimental years. In 2012, the fruits of organic apricots contained more flavonoids, but also vitamin C as well as total carotenoids. These compounds appear in plants in response to solar radiation and high temperature. It is worth to pointed that the weather condition during apricot fruit ripening in 2012 was different than in 2013, especially the number of sunny days, average air temperature and rainfall (Fig. 3). We found a link between forecast weather and bioactive compounds content in apricot fruits (Tables 2 and 3). Many studies have shown the role of light in relation to the regulation of flavonoid biosynthesis and accumulation in fruits. Flavonols levels seem to be especially sensitive to light conditions in peach and nectarines, which are closely related to apricots and belong to this same botanical genus *Prounoideae* and family *Prunus* (Pfeiffer & Hegedus, 2011; Ravaglia et al., 2013). We found a significantly strong linear regression between the profilin content and the total polyphenol content, especially in organic apricots (Fig. 2). This relationship was observed in both years of the experiment. A similar phenomenon was found between the Bet v1 content and the total polyphenol content. However, this relationship was much weaker than the one between the profilin content and the total polyphenol content. A significant linear regression between Bet v1 and polyphenolic compounds was observed for organic apricots in 2013 only.

The plants produced using conventional methods may contain many harmful chemicals and components, and they often have (toxic) allergenic properties, exemplified by a sensitivity to pesticide residues, synthetic food additives, preservatives, etc. (Deshpande & Deshpande, 2017; Linke, Casagrande, & Cardoso, 2018; Yamashita et al., 2017). In the group of dangerous residues, pesticides are the most serious. Pesticides may have carcinogenic, genotoxic, neurodegenerative, endocrine and allergic effects (Kim, Kabir, & Jahan, 2017). The plants produced under organic conditions without toxic (artificial) compounds, genetic modification and all forbidden substances and techniques should be theoretically less allergenic than conventionally produced

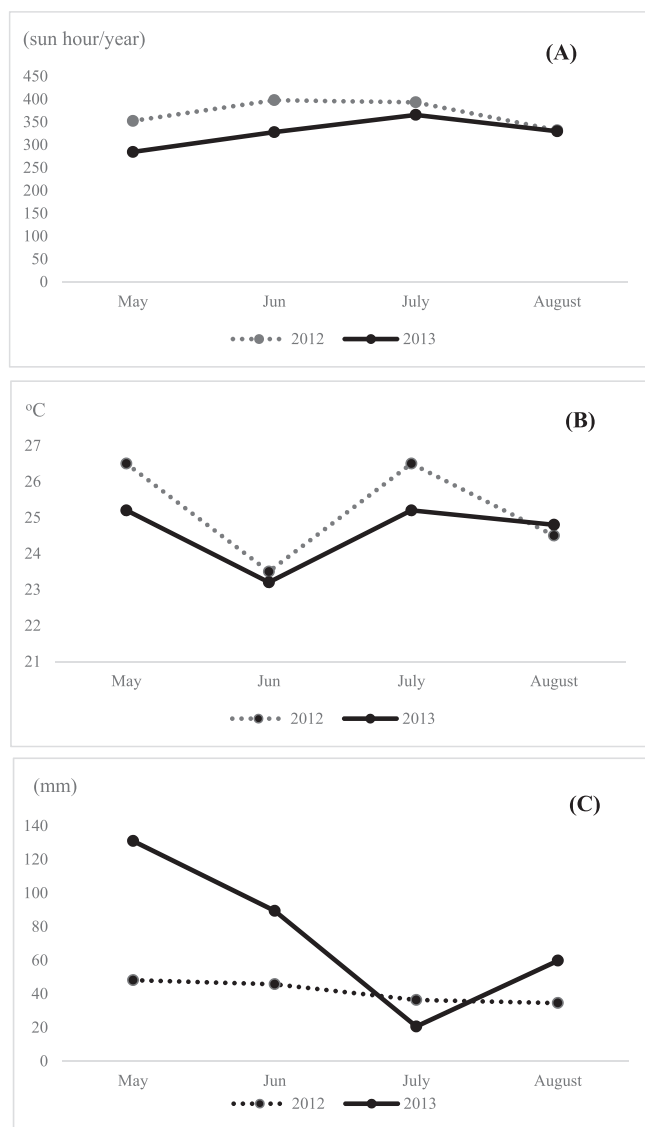


Fig. 3. Weather conditions in experimental orchards (organic and conventional) 2012–2013 in time of apricots fruits development. (A) Sun hours per year, (B) average air temperature, (C) rainfall.

plants. Many consumers believe in that theory and choose organic food for safety. Is their confidence justified? However, our results only partially support the theory that organic apricots contain less allergenic proteins than conventional apricots. A previous study of organic and non-organic crops focused mostly on comparing yield and quality (Barański et al., 2014). Only one of our previous experiments has touched on the problem of the allergenic potential of plant material produced by different farm management practices. As reported by Słowianek et al. (2016), organic tomatoes had more allergenic potential than conventional ones in terms of profilin content. For Bet v1, the authors did not confirm the theory. The organic tomatoes contained a lower level of that allergenic homologue. Similar results were obtained in the present study. Compared to conventional apricots, the organic apricots contained significantly more profilin in the two years of the experiment, with values of 311.3 vs 254.4 ng g⁻¹ (2012) and 125.3 and 95.0 ng g⁻¹ (2013) for organic vs conventional apricots (Table 4). Dölle et al. (2011) found a strong correlation between positive skin allergy tests in tomato-allergic patients and both the origin and maturity level of the tomatoes. When allergic patients consumed an unripe tomato, the skin reactions were much weaker. On the other hand, organic fully ripened red tomatoes produced a stronger allergic reaction compared to

that for cultivars grown by conventional horticulture. In both cases, the skin tests confirmed the higher allergenic potential of organic cultivars, which was also confirmed in most cases by our research with organic and conventional apricots. Pastorello et al. (2000) found that all *Prunoideae* fruits share a cross-reacting, low-molecular-weight protein as the major allergen. In stone fruits (apricots, peach, cherries, plums) this protein corresponds to a 9-kDa lipid transfer protein. LTP was the only allergen recognized by patients allergic to apricots but not allergic to birch pollen (*Betulae*). It seems that the apricot protein LTP is able to sensitize patients who have not been previously sensitized to pollens, probably acting through a gastrointestinal route. Patients who experienced allergy symptoms in response to both apricots and birch pollen showed IgE reactivity to not only the 9-kDa protein but also the 20-kDa and 15-kDa agents, which likely correspond to a Bet v 1 homologue and a profilin homologue of Bet v 2, respectively. In conclusion, our results confirmed that organic apricots contain a higher level of bioactive compounds from polyphenols 53.75 mg/100 g FW and 31.52 mg/100 g FW (respectively in 2012 and 2013) and carotenoids 10.90 mg/100 g FW and 8.42 mg/100 g FW in (respectively in 2012 and 2013) groups than conventional apricots 16.83 mg/100 g FW and 27.27 mg/100 g FW (respectively in 2012 and 2013) and carotenoids 4.01 mg/100 g FW and 3.85 mg/100 g FW in (respectively in 2012 and 2013). On the other hand, we were the first to find a strong link between the allergenic potential of organic fruits and the bioactive compound content (especially in 2013) for organic apricots $R^2 = 0.9044$ and for conventional apricots $R^2 = 0.8169$. The results suggest the new possibility that organic apricots could have adverse effects on allergy patients. To confirm this theory, information about the content of other allergens in apricots grown by organic and conventional production methods is required. Further studies should evaluate the reaction of allergy sufferers by using skin prick tests, a DBPCFC (double blind, placebo-controlled food challenge) or IgE blotting.

Conflict of interest

None.

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