



**HAL**  
open science

## **Modulation of the $\gamma$ -aminobutric acid (GABA) system by *Passiflora incarnata* L.**

Kurt Appel, Thorsten Rose, Bernd Fiebich, Thomas Kammler, Christine Hoffmann,  
Gabriele Weiss

### **► To cite this version:**

Kurt Appel, Thorsten Rose, Bernd Fiebich, Thomas Kammler, Christine Hoffmann, et al.. Modulation of the  $\gamma$ -aminobutric acid (GABA) system by *Passiflora incarnata* L.. *Phytotherapy Research*, 2010, <10.1002/ptr.3352>. <hal-00599846>

**HAL Id: hal-00599846**

**<https://hal.science/hal-00599846v1>**

Submitted on 11 Jun 2011

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

**Modulation of the  $\gamma$ -aminobutric acid (GABA) system by  
Passiflora incarnata L.**

Journal:	<i>Phytotherapy Research</i>
Manuscript ID:	PTR-10-0961.R1
Wiley - Manuscript type:	Full Paper
Date Submitted by the Author:	11-Oct-2010
Complete List of Authors:	Appel, Kurt; VivaCell Biotechnology GmbH Rose, Thorsten; VivaCell Biotechnology GmbH Fiebich, Bernd; VivaCell Biotechnology GmbH Kammler, Thomas; PASCOE pharmazeutische Präparate GmbH, Medical Science Hoffmann, Christine; PASCOE pharmazeutische Präparate GmbH, Medical Science Weiß, Gabriele; PASCOE pharmazeutische Präparate GmbH, Medical Science
Keyword:	GABA, anxiety, insomnia, passion flower, Passiflora incarnata L., Pascoflair® 425 mg

SCHOLARONE™  
Manuscripts

view

## Modulation of the $\gamma$ -aminobutyric acid (GABA) system by *Passiflora incarnata* L.

Kurt Appel<sup>1</sup>, Thorsten Rose<sup>1</sup>, Bernd Fiebich<sup>1</sup>, Thomas Kammler<sup>2</sup>, Christine Hoffmann<sup>2</sup>, Gabriele Weiss<sup>2</sup>

<sup>1</sup> VivaCell Biotechnology GmbH (Denzlingen, Germany)

<sup>2</sup> PASCOE pharmazeutische Präparate GmbH (Gießen, Germany)

### **Abstract**

*Passiflora incarnata* L. (Passifloraceae) is important in herbal medicine for treating anxiety or nervousness, GAD, symptoms of opiate withdrawal, insomnia, neuralgia, convulsion, spasmodic asthma, ADHD, palpitations, cardiac rhythm abnormalities, hypertension, sexual dysfunction, and menopause. However, the mechanism of action is still under discussion. Despite gaps in our understanding of neurophysiological processes, it is increasingly being recognized that dysfunction of the GABA system is implicated in many neuropsychiatric conditions, including anxiety and depressive disorders. Therefore, we investigated the *in vitro* effects of a dry extract of *Passiflora incarnata* (sole active ingredient in Pascoflair<sup>®</sup> 425mg) on the GABA system. The extract inhibited [<sup>3</sup>H]-GABA uptake into rat cortical synaptosomes but had no effect on GABA release and GABA transaminase activity. *Passiflora incarnata* inhibited concentration dependent the binding of [<sup>3</sup>H]- SR95531 to GABA<sub>A</sub>-receptors and of [<sup>3</sup>H]-CGP 54626 to GABA<sub>B</sub>-receptors. Using the [<sup>35</sup>S]-GTP $\gamma$ S binding assay *Passiflora* could be classified as an antagonist of the GABA<sub>B</sub> receptor. In contrast, the ethanol- and the benzodiazepine-site of the GABA<sub>A</sub>-receptor were not affected by this extract. In conclusion, we show the first evidence that numerous pharmacological effects of *Passiflora incarnata* are mediated via modulation of the GABA system including affinity to GABA<sub>A</sub> and GABA<sub>B</sub> receptors, and effects on GABA uptake.

1  
2  
3  
4  
5  
6  
7 **Keywords**  
8

9 GABA, anxiety, insomnia, passion flower, *Passiflora incarnata* L., Pascoflair®  
10  
11

12  
13  
14 **Corresponding author:**  
15

16 Dr. Gabriele Weiss  
17

18 PASCOE pharmazeutische Präparate GmbH  
19

20 Schiffenberger Weg 55  
21

22 D-35394 Gießen  
23

24 Germany  
25

26 Phone: +49-641-7960-133  
27

28 Email: gabriele.weiss@pascoe.de  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## Introduction

The genus *Passiflora* consists of 500 species that are mostly found in warm and tropical regions. The genus was first discovered by Spanish invaders in 1529. This plant has been used widely in herbal medicine in West India, Mexico, The Netherlands, South America, Italy and Argentina. *Passiflora incarnata* is the official species and monographed in several pharmacopoeias (e.g. *Passiflorae Herba Pharm. Eur.*). *Passiflora incarnata* contains C-glycosyl flavones such as vitexin, isovitexin, schaftoside, isoschaftoside and isovitexin-2-Oglucoside phenols, glycosyl flavonoids and cyanogenic compounds (Wohlmuth et al. 2010).

Only a few human studies are available focusing on its potential role as an anxiolytic (Akhondzadeh et al. 2001, Miyasaka et al. 2007, Movafegh et al. 2008). In some experiments, it has potential effects for treatment of some diseases like anxiety, opiates withdrawal, insomnia, ADHD (attention-deficit hyperactivity disorder) and cancer (Sarris et al. 2001, Dhawan et al. 2004, Patel et al. 2009).

Very few pharmacological studies have been undertaken on the anxiolytic/sedative activity of *Passiflora incarnata*; most of these investigations have been carried out with different *Passiflora* species, such as *P. edulis* (Deng et al. 2010, Barbosa et al. 2008), *P. alata* (Barbosa et al. 2008), *P. coerulea* (Reginatto et al. 2006), or *P. quadrangularis* (de Castro et al. 2007) and with insufficient phytochemical characterization of the extracts.

The anxiolytic activity of an extract from *Passiflora actinia* has been shown to be exerted via the GABA receptor (Lolli et al. 2007), but the much more widely -used *Passiflora incarnata* has not been investigated in this context.

1  
2  
3  
4 Grundmann et al. 2008, who investigated the same dry extract (sole active ingredient in  
5 Pascoflair<sup>®</sup> 425mg) which was used in this study, and Zhong et al. 2008 showed that  
6  
7  
8  
9 *Passiflora incarnata* increased the time mice spent in the open arm of the elevated plus  
10  
11  
12 maze and they postulated that the effects were mediated via GABA receptors.

13  
14 Although there are some reports speculating regarding the effects of *Passiflora*  
15  
16 *incarnata* on the GABA system, investigations concerning the mechanism are still  
17  
18  
19 lacking.

20  
21 Therefore, we hypothesized that the mode of action of the dry extract prepared from the  
22  
23  
24 flowers of *Passiflora incarnata* which is the sole active ingredient of the proprietary  
25  
26  
27 herbal drug Pascoflair<sup>®</sup> 425mg might be modulation via the GABA-system.

28  
29 Overall, we show that this dry extract of *Passiflora incarnata* inhibited the binding of  
30  
31  
32 [3H]- SR95531 to GABA<sub>A</sub>-receptors and of [3H]-CGP 54626 to GABA<sub>B</sub>-receptors in a  
33  
34  
35 concentration dependent manner. Using the [<sup>35</sup>S]-GTP<sub>γ</sub>S binding assay *Passiflora*  
36  
37  
38 *incarnata* could be classified as an antagonist of the GABA<sub>B</sub> receptor. The *Passiflora*  
39  
40  
41 *incarnata* extract inhibited [3H]-GABA uptake into rat cortical synaptosomes and  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60 showed no effect on GABA transaminase and GABA release.

## **Material and Methods**

### **Botanical drug preparation**

*Passiflora incarnata* dry extract (Passiflorae Herba Ph. Eur., DER = 5-7:1, extraction solvent: 50% ethanol (V/V)) was provided by Pascoe pharmazeutische Präparate GmbH (Giessen, Germany). This dry extract is the sole active ingredient of the proprietary herbal drug Pascoflair<sup>®</sup> 425 mg.

Dried extract was used in the pharmacological studies and was dissolved in a measured small amount of dimethylsulfoxide (DMSO) and diluted in the application solution immediately prior to testing. All test doses contained the same quantity of DMSO as did all control test solutions.

### **Chemicals used**

[Butyryl-2,3-<sup>3</sup>H]-SR 95531, [N-Methyl-<sup>3</sup>H]-Ro-15-1788, [7,9-<sup>3</sup>H]-Ro-15-4513 and GTP[ $\gamma$ -<sup>35</sup>S] were from PerkinElmer (Massachusetts, USA). [<sup>3</sup>H]CGP 54626 and SR 95531 hydrobromide were purchased from Biotrend Chemikalien GmbH (Cologne, Germany). Diazepam-ratiopharm<sup>®</sup> was from Ratiopharm GmbH (Ulm, Germany). GABA ( $\gamma$ -amino-n-butyric acid), ( $\pm$ ) Baclofen, GABase were purchased from Sigma-Aldrich Chemie GmbH (Taufkirchen, Germany). Vigabatrin was from Sanofi-Aventis (Frankfurt, Germany).

## ***In vitro* pharmacological experiments**

### **Binding assays**

Male Sprague Dawley rats were sacrificed by decapitation. Rat brain (minus cerebellum and medulla oblongata, i.e. the hippocampus and cerebellum) tissue was homogenized at 4°C in 10 ml 10 mM Tris-HCl pH 7.4, 1 mM EDTA, and centrifuged for 15 min at 25,000xg. The pellet was finally resuspended in 50 mM Tris-HCl pH 7.4, 4 mM MgCl<sub>2</sub> and 1 mM EDTA, frozen in liquid nitrogen and stored at -80°C until usage. Binding experiments (GABA-/Benzodiazepine-/Ethanol-site, GABA<sub>B</sub>-receptor) were performed as described (Heaulme et al. 1987, Mehta and Shank 1995, Asay and Boyd 2006).

The assay was terminated by transfer of the samples on GF/C filter plates, presoaked with 0.1% polyethyleneimine. Filters were washed four times with 200 µl of ice-cold 50 mM Tris-HCl pH 7.4 and filter-bound radioactivity was determined by a microplate reader (Microbeta, Wallac, Finland).

Test compound data are presented specific ligand binding to the receptor. Specific binding is defined as the difference between the total binding and the non-specific binding determined in the presence of reference compound.

The IC<sub>50</sub> values (concentration causing half-maximal inhibition of control specific binding) were determined by non-linear regression analysis of the competitive curves using the algorithm "sigmoidal dose-response" (GraphPadPrism, San Diego, USA). In case of ill-defined curves or algorithm-generated minima below the defined non-specific binding the IC<sub>50</sub> value was determined by graphical extrapolation.



### [<sup>35</sup>S]-GTP $\gamma$ S-binding assays

[<sup>35</sup>S]-GTP $\gamma$ S-binding assays were carried out as described (Bidlack und Parkhill, 2004):

Membranes were preincubated with the respective effectors for 15 min, the incubation was initiated by the addition of 200 pM [<sup>35</sup>S]-GTP $\gamma$ S (60 min incubation at 30°C in a final volume of 100  $\mu$ l assay buffer).

The assay was terminated by transfer of the samples on GF/C filter plates. Filters were washed four times with 200  $\mu$ l of ice-cold 50 mM Tris-HCl pH7.4 and bound radioactivity was determined by a microplate reader (Microbeta, Wallac, Finland).

From every data point the non-specific binding (binding of [<sup>35</sup>S]-GTP $\gamma$ S in the presence of 10  $\mu$ M GTP $\gamma$ S) was subtracted and the value normalized to the respective control signal of the respective plate.

EC<sub>50</sub>- and IC<sub>50</sub> values (concentration causing half-maximal stimulation/inhibition of control specific binding) were determined by non-linear regression analysis of the competitive curves using the algorithm "sigmoidal dose-response" (GraphPadPrism, San Diego, USA). In case of ill-defined curves the IC<sub>50</sub> was determined by graphical exploration of the algorithm-generated curve.

### GABA uptake experiments

Freshly dissected, rat cortex dissected from male Sprague-Dawley rats was immersed immediately in 10 volumes of ice-cold 0.32 M sucrose buffered with 10 mM HEPES pH 7.4 and homogenized. The resulting preparation was centrifuged at 900 x g for 10 minutes at 4 °C. The pellet was discarded and the supernatant was centrifuged again at 4 °C at 10.000 x g. The supernatant was discarded and the pellet was stored with 0.32 M sucrose/HEPES on ice until needed.

Assays were carried out in Farnebo buffer pH 7,4 (121 mM NaCl, 1,8 mM KCl, 1,3 mM CaCl<sub>2</sub>, 1,2 mM MgSO<sub>4</sub>, 25 mM NaHCO<sub>3</sub>, 1,2 mM KH<sub>2</sub>PO<sub>4</sub>, 11 mM glucose, 0,57 mM ascorbic acid, saturated with 95% O<sub>2</sub>/5% CO<sub>2</sub>) containing the GABA transaminase inhibitor aminooxoacetic acid (100 μM). Briefly, 10 μl of drug solution, non-specific ligand or buffer, 180 μl Farnebo buffer and 50 μl of synaptosome preparation were added in each well of a 96 well filtration plate prewetted with Farnebo buffer (Millipore Multiscreen). The incubation proceeded for 10 minutes at room temperature after which 10 μl of [<sup>3</sup>H] GABA (final concentration 100 nM) were added for a total volume of 250 μl. The incubation proceeded for 5 minutes at 37° C. Incubation was terminated by rapid filtration and washing with Farnebo buffer. Radioactivity remaining on the filters was counted with a liquid scintillation counter with an efficiency of about 50%. Specific binding is defined as total binding minus binding in the presence of 50 mM nipecotic acid (GABA uptake inhibitor). The results were statistically analyzed.

### GABA release assays

Rat cortical slices (350 μm) were incubated with 3,3 μM [<sup>3</sup>H]-glutamine in physiological buffer (121 mM NaCl, 1,8 mM KCl, 1,3 mM CaCl<sub>2</sub>, 1,2 mM MgSO<sub>4</sub>, 25

1  
2  
3  
4 mM NaHCO<sub>3</sub>, 1,2 mM KH<sub>2</sub>PO<sub>4</sub>, 11 mM glucose, and 0,57 mM ascorbic acid, saturated  
5  
6 with 95% O<sub>2</sub>/5% CO<sub>2</sub>, pH 7,4) for 45 min at 37° C. The slices were washed several  
7  
8 times with buffer to remove non-specifically bound radioactivity.  
9

10  
11 The slices (n=4) were transferred into nylon mesh baskets and placed in 12 well plates  
12  
13 with 3 ml buffer containing the test compounds and 1 mM nipecotic acid (GABA  
14  
15 uptake inhibitor) per well. The plates were incubated for 10 min at room temperature.  
16  
17

18  
19 These wells were the basal fractions. The slices were than transferred into new plates  
20  
21 with 3 ml stimulation buffer per well (buffer with 50 mM K<sup>+</sup>, corresponding equimolar  
22  
23 reduction of Na<sup>+</sup> to maintain osmolarity) containing the test substances and 1 mM  
24  
25 nipecotic acid and the plates were incubated for 7,5 min. These wells were the  
26  
27 stimulation fractions. The slices were removed and their wet weight was determined.  
28  
29

30  
31 The buffer samples were purified from the tritiated metabolites of [<sup>3</sup>H]-GABA by anion-  
32  
33 exchange chromatography. The pH of the samples was adjusted to 4,0 with acetic acid  
34  
35 and the diluted samples were applied to a DOWEX column equilibrated with sodium  
36  
37 acetate. After washing the columns with 0,1% Triton X-100, GABA was eluted with 0,4  
38  
39 M Tris pH 7,5. GABA containing fractions were used for liquid scintillation counting.  
40  
41  
42  
43  
44

#### 45 **Determination of GABA transaminase (GABA-T) activity**

46  
47 For the determination of GABA transaminase activity the rate of the reaction is  
48  
49 determined by measuring the NADPH production at 340 nm at room temperature for 15  
50  
51 min within the linear range with a spectrophotometer in disposable PMMA cuvettes.  
52  
53 GABase is a mixture of 4-aminobutyrate transaminase (E.C. 2.6.1.19) and succinate  
54  
55 semialdehyde dehydrogenase (E.C. 1.2.1.16) from pseudomonas fluorescens.  
56  
57  
58  
59  
60

1  
2  
3  
4 One unit converts 1.0  $\mu$ mole of  $\gamma$ -aminobutyric acid (GABA) to succinic semialdehyde  
5  
6  
7 and then to succinate per min with a stoichiometric reduction of 1,0  $\mu$ mole of NADP<sup>+</sup> at  
8  
9  
10 pH 8,6 at 25°C.  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

For Peer Review

## Results

### Binding of *Passiflora incarnata* extract to GABA<sub>A</sub> receptor

The specific GABA<sub>A</sub>-receptor antagonist SR95531 competes for the binding of [<sup>3</sup>H]-SR95531 to rat brain membranes in a concentration dependent manner (data not shown). The bound radioactivity in the presence of 100 μM SR95531 was defined as non-specific binding of the radioligand to rat brain membranes.

*Passiflora incarnata* extract competes for the binding of [<sup>3</sup>H]-SR95531 to rat brain membranes in a concentration dependent manner (Fig. 1).

The IC<sub>50</sub> value of *Passiflora incarnata* extract at this site was 101 μg/ml. Therefore, binding to the GABA-site of the GABA<sub>A</sub> receptor is a likely mode of action of *Passiflora incarnata* extract.

**Figure 1: Competitive binding of *Passiflora incarnata* extract at the GABA-site of rat GABA<sub>A</sub> receptors. Competitive binding of *Passiflora incarnata* extract with [<sup>3</sup>H]-SR95531 to rat brain membranes.**

Data represent the mean specific binding ± S:E:M. of one experiment performed in duplicate. The results were confirmed in an independent second experiment.

### Binding of *Passiflora incarnata* extract to GABA<sub>A</sub> receptor/benzodiazepine site

Diazepam competes with the binding of [<sup>3</sup>H]-Ro-15-1788 (Flumazenil) - a highly specific antagonist of the benzodiazepine site of the GABA<sub>A</sub>-receptor to rat brain membranes originating from cerebellum and hippocampus in a concentration-dependent manner. The competitive curve is shifted towards lower concentrations (to the left) in the presence of 10 μM GABA resulting in an about threefold decrease of the IC<sub>50</sub> (data not shown). The bound radioactivity in the presence of 10 μM Diazepam was defined as non-specific binding of the radioligand to the membranes.

The IC<sub>50</sub> values for competitive binding of *Passiflora incarnata* extract at the benzodiazepine site are very high (944 μg/ml). In addition, the binding to this site is not modulated by the presence of GABA as observed for the reference compound (Figure 2). Therefore, it is very unlikely that *Passiflora incarnata* extract acts via this binding site.

**Figure 2: Competitive binding of *Passiflora incarnata* extract to the benzodiazepine site of GABA<sub>A</sub> receptors in rat cerebellum.**

**Competitive binding of *Passiflora incarnata* extract with [<sup>3</sup>H]-Ro-15-1788 binding to rat cerebellum membranes in the absence (■) or presence of 10 μM GABA (▲).**

Data represent the mean specific binding ± S:E:M. of one experiment performed in duplicate. The results were confirmed in an independent second experiment and in two experiments with rat hippocampus membranes.

**Binding of *Passiflora incarnata* extract to GABA<sub>A</sub> receptor/ethanol site**

Ro-15-4513, the reference compound for the ethanol site, competes for the binding of [<sup>3</sup>H]-Ro-15-4513 to rat brain membranes in a concentration-dependent manner. The IC<sub>50</sub> values for competitive binding of *Passiflora incarnata* extract at the ethanol site was 512 µg/ml (data not shown). Therefore, it is very unlikely that *Passiflora incarnata* extract acts via this binding site.

**Binding of *Passiflora incarnata* extract to GABA<sub>B</sub> receptor**

Baclofen - a derivative of GABA that is a specific agonist of GABA<sub>B</sub> receptors - competes with the binding of [<sup>3</sup>H]-CGP 54626 - a selective and potent GABA<sub>B</sub> receptor antagonist- to rat brain and rat hippocampus GABA<sub>B</sub> receptors in a concentration-dependent manner. The bound radioactivity in the presence of 1 mM Baclofen was defined as non-specific binding of the radioligand to the membranes.

*Passiflora incarnata* extract competes with the binding of [<sup>3</sup>H]-CGP 54626 to rat brain and rat hippocampus GABA<sub>B</sub> receptors in a concentration-dependent manner the IC<sub>50</sub> was 120 µg/ml (data not shown).

**Binding of *Passiflora incarnata* extract to GABA<sub>B</sub> receptor ([<sup>35</sup>S]-GTPγS-binding)**

Baclofen - a derivative of GABA that is a specific agonist of GABA<sub>B</sub> receptors - stimulated the [<sup>35</sup>S]-GTPγS binding to rat hippocampal membranes in a concentration-dependent manner (agonist mode). The selective and potent GABA<sub>B</sub> receptor antagonist CGP 54626 reduced the Baclofen-evoked signal in a concentration-dependent manner to the level of the basal signal (no effector added, antagonist mode).

1  
2  
3  
4 *Passiflora incarnata* extract has a lower IC<sub>50</sub> value (31 mg/ml) in the antagonist mode  
5  
6 than in the agonist mode (115 mg/ml). Therefore *Passiflora incarnata* extract is an  
7  
8 antagonist of the GABA<sub>B</sub> receptor (Figure 3).  
9  
10

11  
12  
13  
14  
15  
16 **Figure 3: Effect of *Passiflora incarnata* extract on rat hippocampal GABA<sub>B</sub>-**  
17 **receptors. Concentration dependent effect of *Passiflora incarnata***  
18 **extract on [<sup>35</sup>S]-GTPγS-binding to rat hippocampal membranes.**  
19  
20  
21  
22  
23  
24

25 Data represent the means ± SEM of one experiment carried out in duplicate and are  
26  
27 normalized to 0% change. In the agonist mode (■) 0% change corresponds to the  
28  
29 specific basal signal, in the antagonist mode 0% change corresponds to the maximal  
30  
31 stimulation of the GABA<sub>B</sub> receptors by 100 μM baclofen (□). The results were  
32  
33 confirmed in an independent second experiment.  
34  
35  
36  
37  
38

### 39 **GABA uptake and GABA release experiments**

40  
41 Up to 1000 μg/ml the *Passiflora incarnata* extract investigated in this study had no  
42  
43 effect on potassium-evoked release of [<sup>3</sup>H]-GABA synthesized from [<sup>3</sup>H]-glutamine  
44  
45 from rat cortical slices (data not shown).  
46  
47

48 The extract inhibited [<sup>3</sup>H]-GABA uptake into rat cortical synaptosomes with an EC<sub>50</sub> of  
49  
50 95.7 μg/ml (Figure 4).  
51  
52  
53  
54  
55  
56

57 **Figure 4: Effects of a *Passiflora incarnata* extract on the GABA uptake**  
58  
59  
60



1  
2  
3  
4 Radioactivity accumulated in the filters was normalized to the mean of control  
5  
6 experiments. Raw data were statistically analysed and are expressed in the following  
7  
8 data as mean  $\pm$  CI<sub>95</sub>, n=8.  
9  
10

### 11 12 13 **Effects of *Passiflora incarnata* extract on GABA transaminase activity**

14  
15  
16 The influence of the *Passiflora incarnata* extract on GABA transaminase activity was  
17  
18 determined by measuring the NADPH production at 340 nm with a spectrophotometer.  
19  
20 Vigabatrin ( $\gamma$ -vinyl GABA) an irreversible GABA transaminase inhibitor and effective  
21  
22 antiepileptic was used as positive control. Vigabatrin significantly inhibited GABA  
23  
24 transaminase with an EC<sub>50</sub> of 55.5 mM. Incubation of GABA transaminase with five  
25  
26 different concentrations of the passion flower dry extract (10, 50, 100, 250, 500  $\mu$ g/ml)  
27  
28 showed no effect on GABA transaminase.  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

## Discussion

Extracts from passion flower (*Passiflora incarnata*) have been used to reduce anxiety and insomnia and there are numerous studies in mice and rats which demonstrate a reduced anxiety and stress with passion flower treatment (Dhawan et al. 2001; Miyasaka et al. 2007). In addition there is evidence that extracts from *Passiflora incarnata* may be helpful in the treatment of substance addictions as amphetamine, nicotine, marihuana and alcohol (Capasso und Sorrentino, 2005, Dhawan et al., 2002 and Dhawan and Sharma, 2003).

Although the anxiolytic activity of *Passiflora* species has been repeatedly evaluated in the last years, there is only limited information on the mechanism of action.

This study provides a comprehensive insight into the mode of action of a dry extract prepared from the flowers of *Passiflora incarnata* which is the sole active ingredient of the proprietary herbal drug Pascoflair® 425mg on the GABAergic system.

Preclinical studies have suggested that GABA levels may be decreased in animal models of depression, and clinical studies reported low plasma and CSF GABA levels in mood disorder patients. The *Passiflora incarnata* extract investigated in this study had no effect on potassium-evoked release of [<sup>3</sup>H]-GABA synthesized from [<sup>3</sup>H]-glutamine from rat cortical slices but the extract inhibited [<sup>3</sup>H]-GABA uptake into rat cortical synaptosomes with a EC<sub>50</sub> of 95,7 µg/ml. GABA transaminase (GABA-T), an enzyme target in the therapy of anxiety, epilepsy and related neurological disorders was not affected by *Passiflora incarnata* which is in accordance with already published results (Awad et al. 2007). Because preadministration of Flumazenil (Ro 15-1788), an antagonist of the benzodiazepine binding site of the GABA<sub>A</sub> receptor, attenuates the effects of *Passiflora incarnata in vivo* (Grundmann et al., 2008 and Medina et al., 1990)

1  
2  
3  
4 it was assumed that *Passiflora incarnata* and Diazepam share the same pharmacology.  
5  
6 Our study showed that the IC<sub>50</sub> values for competitive binding of *Passiflora incarnata*  
7  
8 extract at the benzodiazepine site are very high moreover the binding to this site is not  
9  
10 modulated by the presence of GABA so it seems very unlikely that the mode of action  
11  
12 of *Passiflora incarnata* extract includes binding to the benzodiazepine site. Similarly it  
13  
14 is unlikely that it acts via the ethanol site. However, it is very likely that binding to the  
15  
16 GABA-site of the GABA<sub>A</sub> receptor is one of the clinically relevant modes of action of  
17  
18 *Passiflora incarnata* extract.  
19  
20  
21  
22

23 Another possible target might be the binding of *Passiflora incarnata* extract to the  
24  
25 GABA<sub>B</sub> receptor. There is accumulating evidence that modulators of the GABA<sub>B</sub>  
26  
27 receptor (a GPCR – G protein coupled receptor) might act as anxiolytic (Frankowska et  
28  
29 al., 2007) and might be helpful in the treatment of substance addictions (Martin et al.,  
30  
31 2009).  
32  
33  
34

35 The *Passiflora incarnata* extract investigated in this study inhibited the binding of [<sup>3</sup>H]-  
36  
37 CGP 54626 to GABA<sub>B</sub>-receptors in a concentration dependent manner. This could be  
38  
39 verified using the [<sup>35</sup>S]-GTPγS binding assay. It was found that *Passiflora incarnata* has  
40  
41 a lower IC<sub>50</sub> value in the antagonist mode than in the agonist mode. Therefore  
42  
43 *Passiflora incarnata* needs to be classified as antagonist of the GABA<sub>B</sub> receptor. This  
44  
45 opens possibilities for further investigations because GABA<sub>B</sub> antagonists may provide a  
46  
47 pharmacological therapy for cognitive impairment (Helm et al. 2005).  
48  
49  
50

51 Although the compounds responsible for the therapeutic activity of *Passiflora incarnata*  
52  
53 are yet to be identified, this study provides novel evidence of the mechanism of action  
54  
55 of a dry extract of *Passiflora incarnata* with respect to the GABAergic system.  
56  
57  
58  
59  
60

## Conflict of interest

Financial support for the analysis was provided by PASCOE pharmazeutische Präparate GmbH, the manufacturer of PASCOFLAIR® 425 mg. The sponsor had no influence on the conduct of the analysis.

For Peer Review

1  
2  
3  
4 Akhondzadeh S, Naghavi HR, Vazirian M, Shayeganpour A, Rashidi H, Khani M.  
5 2001. Passionflower in the treatment of generalized anxiety: a pilot double-blind  
6 randomized controlled trial with oxazepam. *J Clin Pharm Ther* **26(5)**: 363-7.  
7

8  
9 Akhondzadeh S, Kashani L, Mobaseri M, Hosseini SH, Nikzad S, Khani M. 2001.  
10 Passionflower in the treatment of opiates withdrawal: a double-blind randomized  
11 controlled trial. *J Clin Pharm Ther* **26(5)**: 369-73.  
12

13  
14 Asay MJ, Boyd SK. 2006. Characterization of the binding of [3H]CGP54626 to  
15 GABAB receptors in the male bullfrog (*Rana catesbeiana*). *Brain Res* **1094**: 76-85.  
16

17  
18 Awad R, Levac D, Cybulska P, Merali Z, Trudeau VL, Arnason JT. 2007. Effects of  
19 traditionally used anxiolytic botanicals on enzymes of the gamma-aminobutyric acid  
20 (GABA) system. *Can J Physiol Pharmacol* **85(9)**: 933-42.  
21

22  
23 Barbosa PR, Valvassori SS, Bordignon CL Jr, Kappel VD, Martins MR, Gavioli EC,  
24 Quevedo J, Reginatto FH. 2008. The aqueous extracts of *Passiflora alata* and *Passiflora*  
25 *edulis* reduce anxiety-related behaviors without affecting memory process in rats.  
26 *J Med Food* **11(2)**: 282-8.  
27

28  
29 Bidlack JM, Parkhill AL. 2004. Assay of G protein-coupled receptor activation of G  
30 proteins in native cell membranes using [35S]GTP gamma S binding. *Methods Mol Biol*  
31 **237**: 135-143.  
32

33  
34 Brown E, Hurd NS, McCall S, Ceremuga TE. 2007. Evaluation of the anxiolytic effects  
35 of chrysin: A *Passiflora incarnata* extract, in the laboratory rat. *AANA J* **75**: 333-7.  
36

37  
38 de Castro PC, Hoshino A, da Silva JC, Mendes FR. 2007. Possible anxiolytic effect of  
39 two extracts of *Passiflora quadrangularis* L. in experimental models. *Phytother*  
40 *Res* **21(5)**: 481-4.  
41

42  
43 Deng J, Zhou Y, Bai M, Li H, Li L. 2010. Anxiolytic and sedative activities of  
44 *Passiflora edulis* f. *flavicarpa*. *J Ethnopharmacol* **128(1)**:148-53.  
45

46  
47 Dhawan K, Kumar S, Sharma A. 2001. Anti-anxiety studies on extracts of *Passiflora*  
48 *incarnata* Linneaus. *J Ethnopharmacol* **78**:165-70.  
49

50  
51 Dhawan K, Dhawan S, Sharma A. 2004. *Passiflora*: a review update. *J Ethnopharmacol*  
52 **94(1)**: 1-23.  
53

54  
55 Frankowska M, Filip M, Przegalinski E. 2007. Effects of GABAB receptor ligands in  
56 animal tests of depression and anxiety. *Pharmacol Rep* **59**: 645-655.  
57

58  
59 Grundmann O, Wang J, McGregor GP, Butterweck V. 2008. Anxiolytic activity of a  
60 phytochemically characterized *Passiflora incarnata* extract is mediated via the  
GABAergic system. *Planta Med* **74(15)**: 1769-73.

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

Heaulme M, Chambon JP, Leyris R, Wermuth CG, Biziere K. 1987. Characterization of the binding of [3H]SR 95531, a GABAA antagonist, to rat brain membranes. *J Neurochem* **48** : 1677-1686.

Helm KA, Haberman RP, Dean SL, Hoyt EC, Melcher T, Lund PK, Gallagher M. 2005. GABAB receptor antagonist SGS742 improves spatial memory and reduces protein binding to the cAMP response element (CRE) in the hippocampus. *Neuropharmacology* **48(7)**:956-64.

Lolli LF, Sato CM, Romanini CV, Villas-Boas Lde B, Santos CA, de Oliveira RM. 2007. Possible involvement of GABA A-benzodiazepine receptor in the anxiolytic-like effect induced by Passiflora actinia extracts in mice. *J Ethnopharmacol* **111(2)**:308-14.

Martin IL, Bowery NG, Dunn SM. 2009. GABA Receptors. *Tocris Bioscience Scientific Review Series*: 1-15.

Medina JH, Paladini AC, Wolfman C, Levi de Stein M, Calvo D, Diaz LE, Peña C. 1990. Chrysin (5,7-di-OH-flavone), a naturally-occurring ligand for benzodiazepine receptors, with anticonvulsant properties. *Biochem Pharmacol* **40(10)**: 2227-31.

Mehta AK, Shank RP. 1995. Characterization of a benzodiazepine receptor site with exceptionally high affinity for Ro 15-4513 in the rat CNS. *Brain Res* **704**: 289-297.

Miyasaka LS, Atallah AN, Soares BG. 2007. Passiflora for anxiety disorder. *Cochrane Database Syst Rev* **24;(1)**:CD004518.

Movafegh A, Alizadeh R, Hajimohamadi F. 2008. Preoperative oral Passiflora incarnata reduces anxiety in ambulatory surgery patients: a double-blind, placebo-controlled study. *Anesth Analg* **106(6)**: 1728-32.

Nassiri-Asl M, Zamansoltani F, Shariati-Rad S. 2008. Possible role of GABAA-benzodiazepine receptor in anticonvulsant effects of Pasipay in rats. *Zhong Xi Yi Jie He Xue Bao*. **6(11)**:1170-3.

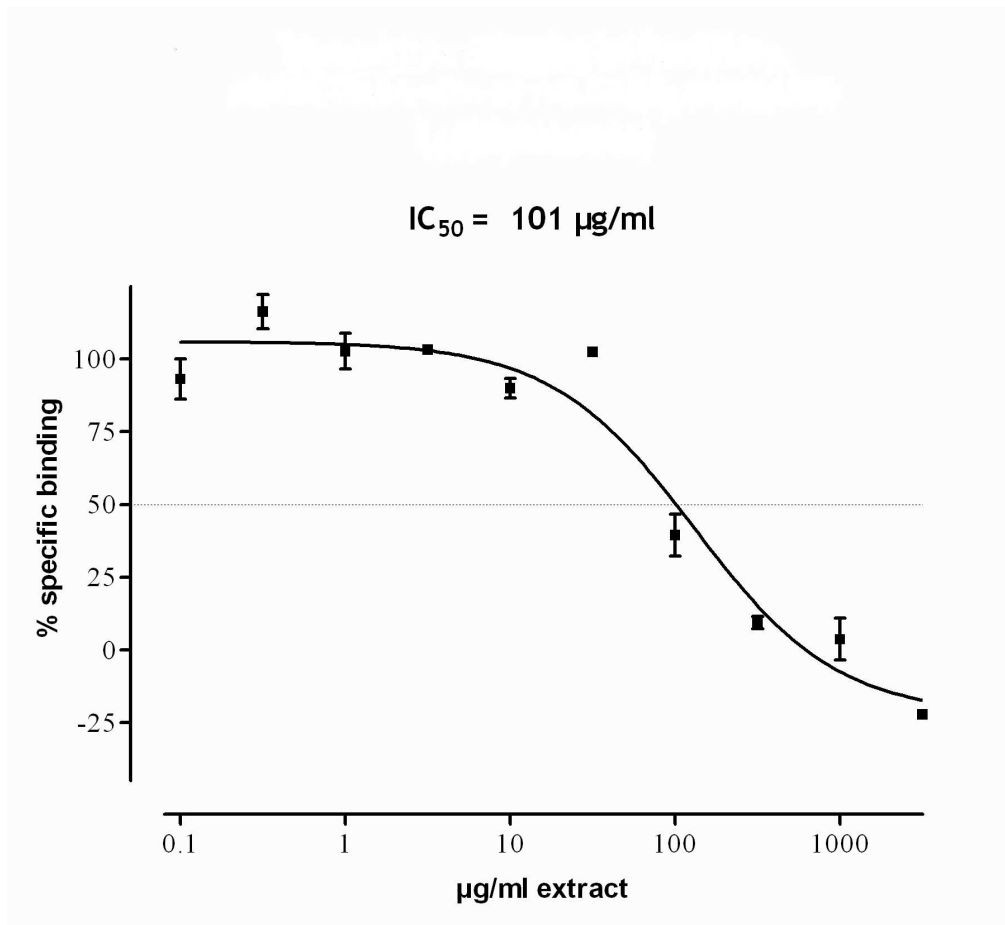
Patel SS, Mohamed Saleem TS, Ravi V, Shrestha B, Verma NK, Gauthaman K. 2009. Passiflora incarnata Linn: A phytopharmacological review. *Int J Green Pharm* **3**: 277-80.

Reginatto FH, De-Paris F, Petry RD, Quevedo J, Ortega GG, Gosmann G. 2006. Evaluation of anxiolytic activity of spray dried powders of two South Brazilian Passiflora species. *Phytother Res* **20**: 348-51.

Sarris J. 2007. Herbal medicines in the treatment of psychiatric disorders: a systematic review. *Phytother Res* **21(8)**:703-16.

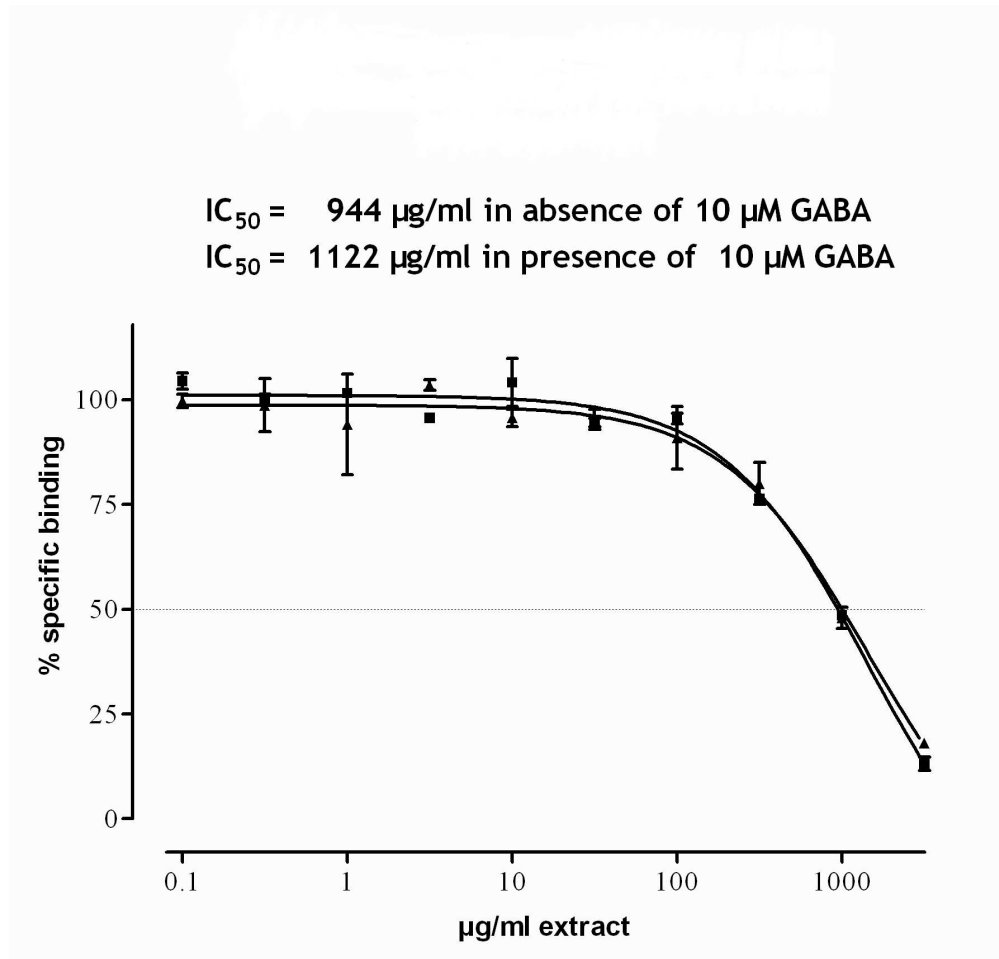
Wohlmuth H, Penman KG, Pearson T, Lehmann RP. 2010. Pharmacognosy and chemotypes of passionflower (Passiflora incarnata L.). *Biol Pharm Bull* **33(6)**:1015-8.

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



378x348mm (120 x 120 DPI)

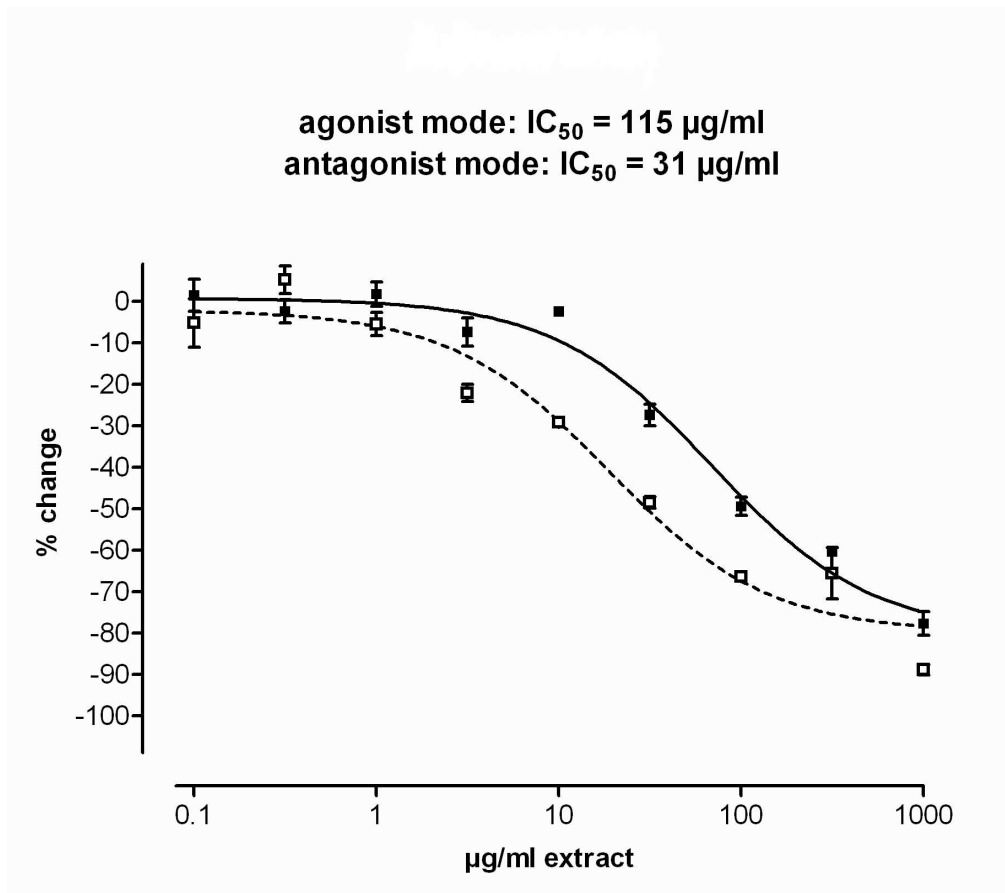
ew

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

378x363mm (120 x 120 DPI)

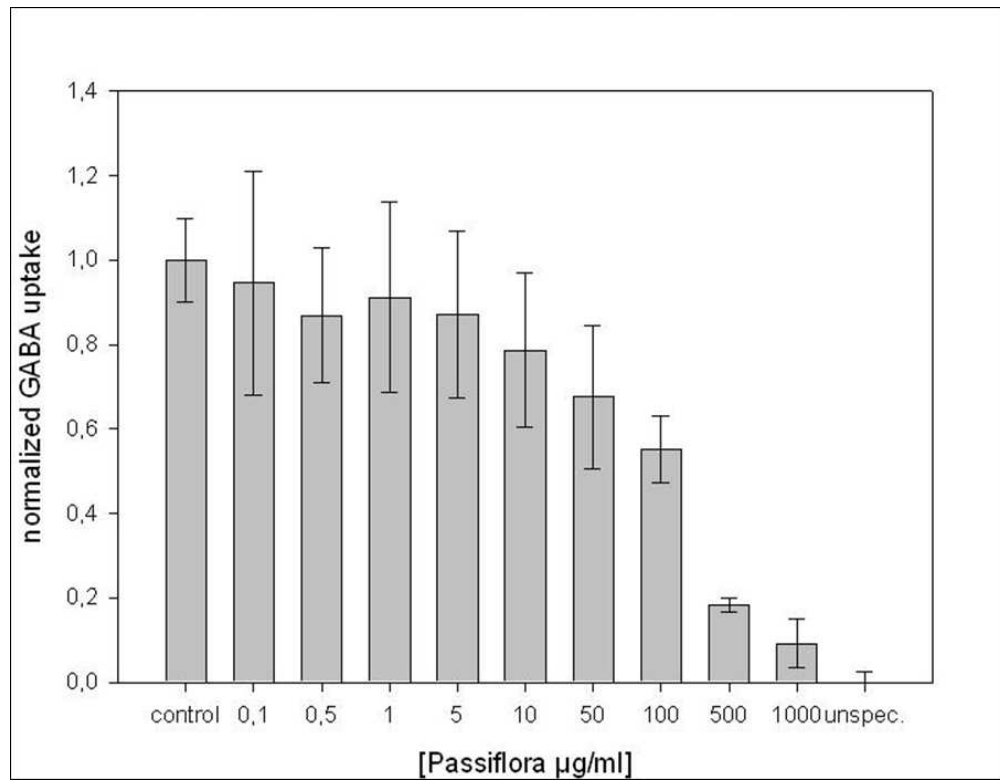


1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60



384x340mm (120 x 120 DPI)





153x118mm (150 x 150 DPI)