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(54) Titre : TRAITEMENT DE MALADIE ENTERIQUE INFLAMMATOIRE

(54) Title: TREATMENT OF INFLAMMATORY BOWEL DISEASE

(57) **Abrégé/Abstract:**

The invention relates to the treatment of inflammatory bowel disease, also termed IBD, including ulcerative colitis and Crohn's disease. To this end, the invention proposes clinoptilolite having a particle size between 0.2 and 1 µm for use in the treatment of inflammatory bowel disease, also termed IBD, in mammals and humans. In the case of such use, the clinoptilolite is preferably freed of heavy metals. In one variant, it is administered orally, optionally with pharmaceutically harmless carrier materials and/or diluents.

ABSTRACT

The invention relates to the treatment of inflammatory bowel disease, also termed IBD, including ulcerative colitis and Crohn's disease. To this end, the invention proposes clinoptilolite having a particle size between 0.2 and 1 μm for use in the treatment of inflammatory bowel disease, also termed IBD, in mammals and humans. In the case of such use, the clinoptilolite is preferably freed of heavy metals. In one variant, it is administered orally, optionally with pharmaceutically harmless carrier materials and/or diluents.

TREATMENT OF INFLAMMATORY BOWEL DISEASE

The invention relates to the treatment of inflammatory bowel disease, also termed IBD, including ulcerative colitis and Crohn's disease. In particular, the invention pertains to methods for the treatment of IBD that involve the administration of clinoptilolite.

WO 2010/061355 discloses administering clinoptilolite orally "for treating various medical conditions in humans". In such treatment, a specially pretreated clinoptilolite, termed "potentiated clinoptilolite", is used. The conditions to be treated that are mentioned in the description also include IBS, short for "irritable bowel syndrome", a condition which is completely different from IBD:

IBS is a diagnosis of exclusion, which is not made directly by targeted examinations, but instead comes about *indirectly* by systematic exclusion of other condition causes. It is so to speak a negative intersection of all possible diagnoses; it is an "insignificant", prognostically benign condition of high prevalence, which is neither life-threatening nor life-shortening.

However, IBD relates to two serious symptoms, Crohn's disease and ulcerative colitis, which can be potentially lethal if untreated and, even with adequate treatment, lower life expectancy. Diagnosis generally entails rectosigmoidoscopy, colonoscopy and/or gastroscopy and is often underpinned by histological investigations.

The clinical study presented in the WO document for IBS (in which the presence of IBD was explicitly ruled out by rectosigmoidoscopy) does not in any way predict or give any expectation of efficacy in the case of IBD, simply because medically

completely different symptoms are concerned, which are also treated completely differently in the prior art:

IBS using linaclotide,

IBD using ASA, local glucocorticoids such as budesonide, monoclonal antibodies (for example against TNF such as adalimumab and infliximab or against $\alpha_4\beta_7$ integrin such as vedolizumab).

As stated, customary treatments of IBD occur using derivatives of 5-aminosalicylic acid, using systemically or locally administered glucocorticoids and using immunosuppressants such as azathioprine. However, these medicaments lead to a number of severe, unpleasant side effects, and so they can only be used to a limited extent.

There is therefore a need for a substance or agent, or a medicament, or a cure, which effectively controls such conditions without, or at least with reduced, stress on the patient as a result of side effects.

It is an object of the invention to specify such a medicament or agent or such a cure or treatment.

This is achieved by the administration, preferably oral administration, of clinoptilolite which, preferably, is freed of heavy metals, for example by the method of the applicant as per EP 2 040 837, corresponding to US 8,173,101, and which has a particle size between 0.2 and 1 μm . In other words, inflammatory bowel disease, also termed IBD, is treated by administering, preferably orally, a clinoptilolite which, preferably, is freed of heavy metals, for example by the method of the applicant as per EP 2 040 837, corresponding to US 8,173,101, and which has a particle size between

0.2 and 1 μm . For jurisdictions in which this is possible or required, the invention consists in using clinoptilolite which is preferably free of heavy metals and which has a particle size between 0.2 and 1 μm in order to produce a medicament for treating the condition(s) mentioned at the beginning.

Clinoptilolite is the collective name for a group of minerals from the group of the zeolites within the “tectosilicates” mineral class. The mineral group crystallizes monoclinically and is, in the form of a solid solution series, composed of all variations of the following idealized end members:

- Clinoptilolite-Ca: $\text{Ca}_3(\text{Si}_{30}\text{Al}_6)\text{O}_{72}\cdot 20\text{H}_2\text{O}$
- Clinoptilolite-K: $\text{K}_6(\text{Si}_{30}\text{Al}_6)\text{O}_{72}\cdot 20\text{H}_2\text{O}$
- Clinoptilolite-Na: $\text{Na}_6(\text{Si}_{30}\text{Al}_6)\text{O}_{72}\cdot 20\text{H}_2\text{O}$

Chemically, they are thus “water-containing” aluminosilicates having the cations calcium, potassium or sodium incorporated in the crystal lattice.

Because of their monoclinic nature, clinoptilolites usually develop tabular crystals, but they also occur in the form of bulky mineral aggregates. In pure form, clinoptilolite crystals are colorless and transparent. However, they can also appear white as a result of multiple light refraction owing to lattice defects or polycrystalline formation or assume a yellowish-white to reddish-white color as a result of foreign inclusions, the transparency decreasing accordingly.

Clinoptilolites, which are present in large (or workable) amounts are usually minerals of sedimentary origin and arise from deposits of volcanic origin such as tuffs and volcanic glasses. In addition, clinoptilolite may also be present in cavities of other igneous rocks such as andesite, basalt or rhyolite. Accompanying minerals of

clinoptilolite are further zeolites, halite, quartz, calcite, opal, montmorillonite, hectorite, gaylussite, thenardite and celadonite. Economically profitable deposits can be found in, for example, Cornwall/England; Vogelsberg, Franconia/Germany; Styria/Austria; Andalusia/Spain; Ionian Islands/Greece; east coast of Turkey; Honshu/Japan; southern New Zealand; Chubut/Argentina; South Dakota, Wyoming and also the west coast of the USA and Nova Scotia, Quebec, British Columbia/Canada.

The fact that clinoptilolite is used in pharmaceutical applications is disclosed not only by the printed publication cited at the beginning (see Colella, C: A critical reconsideration of biomedical and veterinary applications of natural zeolites (2011). Clay Minerals 46: 295–309).

The invention will now be more particularly elucidated with reference to the drawings. In this connection,

Fig. 1 shows the change in body weight over days 0–10,

Fig. 2 shows the stool consistency over days 0–10,

Figs. 3 and 4 show the colon length of the individual groups,

Fig. 5 shows histological images,

Fig. 6 shows the damage to the colon,

Fig. 7 shows the overall damage,

Figs. 8 to 10 each show the result of various molecular biology analyses and

Fig. 11 shows the the MPO activity.

The efficacy and the harmlessness of the substance according to the invention are revealed by the analyses and experiments outlined below.

For five groups of **12 mice each** (only 3 mice in the control), the experimental routine procedure frequently used in connection with the treatment of IBD was carried out, in which IBD is induced by administration of dextran sulfate sodium (DSS). This involved administering DSS in drinking water for five days (but not in the control group), and after that the particular test substance was administered orally. On the tenth day, the mice were sacrificed using CO₂ and the colon was removed for examination. The individual groups were as follows:

Group 1: Control group, did not receive any DSS, only 3 mice, in contrast to **12 mice** in each of the other groups.

Group 2: received only DSS.

Group 3: (GHC1) received DSS as described above and, from the sixth day, a clinoptilolite freed of heavy metals which was ground to a mean particle size of 3.5 µm and thus not in accordance with the invention.

Group 4: (GHC2) received, from the sixth day, the substance according to the invention.

Group 5: (5ASA) received, from the sixth day, sulfasalazine, a derivative of mesalazine, also termed 5-ASA.

In summary, the results are as follows: The body weight profile can be seen in Fig. 1. Said figure shows:

Days;

Weight change (g);

Control = control group;

DSS1.5 = group 2;

DSS1.5+GHC1 = group 3;

DSS1.5+GHC2 = (inventive) group 4;

DSS1.5+5ASA = group 5.

The profile clearly shows that the non-DSS-treated control group, especially on the sixth day, exhibited a distinctly greater weight than all the DSS-treated groups.

What is striking is that the treatment with noninertive clinoptilolite (GHC 1, group 3) appears to hinder rather than support the weight gain following administration in the healing phase, whereas this is not the case for the substance according to the invention (GHC 2, group 3). The substance according to the invention performs only slightly worse than the control group with 5-ASA.

A further feature concerning the efficacy of the administered agent is stool consistency, shown in Fig. 2. Said figure shows:

Stool score = stool consistency;

Days;

Loosely shaped pellets;

Moist pellets;

Control = control group;

DSS1.5 = group 2;

DSS1.5+GHC1 = group 3;

DSS1.5+GHC2 = (inventive) group 4;

DSS1.5+5ASA = group 5.

In line with expectations, there was no change in the control group; the groups treated with clinoptilolite (regardless of particle size) and with 5-ASA were completely within the normal range again on the tenth day. Stool consistency is altered by the substance properties of the two test substances (fine powder) in such a way that the score is not 0 but about 1 even after 10 days. However, the profile clearly shows that stool consistency distinctly improves from day 6 (score > 2.0) to day 10 (score 1.0). The substance according to the invention can bind water and the result may therefore be that the feces become altogether softer. However, a value of 1 shows a relatively small change; therefore, a persistence of clinical symptoms cannot really be stated.

The presence of blood in stool is reported in Table I below. Said table shows:

Blood in stool;

Mice group;

Days;

Control = control group;

DSS1.5 = group 2;

DSS1.5+GHC1 = group 3;

DSS1.5+GHC2 = (inventive) group 4;

DSS1.5+5ASA = group 5.

As can be seen, blood in stool was detectable (+) from the sixth to the tenth day only in the DSS-treated group. Blood in stool was exhibited by the two clinoptilolite-treated groups (3 and 4) from the sixth to the eighth day and by the 5-ASA-treated group only on the sixth day.

Table I:

Mice group	Blood in stool					
	Days					
	0	2	4	6	8	10
Control	-	-	-	-	-	-
DSS 1.5	-	-	-	+	+	+
DSS 1.5 + GHC 1	-	-	-	+	+	-
DSS 1.5 + GHC 2	-	-	-	+	+	-
DSS + 5ASA	-	-	-	+	-	-

+ Blood in stool

- No blood in stool

The changes in colon length determined after sacrificing of the animals can be seen qualitatively in the five images of Fig. 3. The figures do not show any distinctive differences between the individual groups. A quantitative evaluation of colon length of the individual groups is shown in Fig. 4 (averaged in each case). Both figures show:

Control = control group;

Colon length (cm);

DSS1.5 = group 2;

DSS1.5+GHC1 = group 3;

DSS1.5+GHC2 = (inventive) group 4;

DSS1.5+5ASA = group 5.

Increasing shortening of the intestine indicates the increasing degree of inflammation. A (statistically insignificant) trend of the substance according to the invention, with respect to all the other groups, of promoting a longer colon can be identified in Fig. 4.

Fig. 5 shows a histological analysis, viz. a representative image of hematoxylin and eosin staining for each test group. Said figure shows:

Control = control group;

DSS1.5 = group 2;

DSS1.5+GHC1 = group 3;

DSS1.5+GHC2 = (inventive) group 4;

DSS1.5+5ASA = group 5.

The images show an undamaged intestinal epithelium for the control group (group 1). In contrast, a widespread inflammation can be seen for group 2 (negative control with DSS). Through the treatment with clinoptilolite (regardless of particle size), it was possible to partially speed up the healing of the intestinal epithelium (groups 3 and 4). The positive control group (group 5) shows a distinctly improved healing of the intestinal epithelium with only sparse signs of epithelial damage and immune cell infiltration.

Fig. 6 shows the colon damage score, a determination of intestinal damage on the basis of histo(patho)logical examinations. The colon damage score is derived from (a) destruction of the epithelium (scale from 0 to 3) (b) extension of crypts (scale from 0

to 3) (c) absence of goblet cells (scale from 0 to 3) (d) infiltration of immune cells (scale from 0 to 3) (e) spreading of inflammatory cells (scale from 0 to 3); said figure shows:

Control = control group;

DSS1.5 = group 2;

DSS1.5+GHC1 = group 3;

DSS1.5+GHC2 = (inventive) group 4;

DSS1.5+5ASA = group 5;

Colon damage score = determination of intestinal damage on the basis of histo(patho)logical examinations;

*** = an extremely significant difference in relation to the control group (control);

= an extremely significant difference in relation to the DDS1.5 group (group 2).

Again, the good convergence of the 5-ASA mice (group 5) and the mice treated with GHC2 according to the invention (group 4) toward the control group can be seen. By contrast, the group which was treated with normal clinoptilolite (GHC1, group 3) cannot be distinguished statistically from the group with no treatment (DSS 1.5, group 1).

Fig. 7 shows the total score, which represents a measure of the overall inflammatory state of the animals. The total score (also termed disease activity index, see Cooper HS, Murthy SN, Shah RS, Sedergran DJ. "Clinicopathologic study of dextran sulfate sodium experimental murine colitis". Lab Invest 1993; 69: 238–249.) is

derived from the results in Figs. 2 to 5 and from the content of Table I. The scale in Fig. 6 is accordingly relative and does not have a fixed unit. Said figure shows:

Total score = the overall inflammatory state;

Control = control group;

DSS1.5 = group 2;

DSS1.5+GHC1 = group 3;

DSS1.5+GHC2 = (inventive) group 4;

DSS1.5+5ASA = group 5.

It can be seen from this figure, which displays increasing damage with increasing value (from 0 to 12), that, apart from the control group with 5-ASA, the smallest changes (subsumed in total score = sum of the parameters stool, colon length and intestinal damage score) compared to the control group with no intestinal damage (control) were only to be found in group 4, which received the substance according to the invention. Group 3, which received normal clinoptilolite, does not show any such improvement compared to the group with no treatment (DSS 1.5).

To objectify and quantify the effects determined from the histological examinations, further analyses of biochemical inflammation markers (TNF- α /IL-6/IL-1 β mRNA by means of RT-PCR, MPO activity) from tissue homogenates of the relevant intestinal segments were carried out. The results for IL-1 β are shown in Fig. 8. Said figure shows:

2exp $\Delta\Delta$ ct = the rise in expression for a particular gene (1 = 1x, 2 = 2x, etc.);

Control = control group;

DSS1.5 = group 2;

DSS1.5+GHC1 = group 3;

DSS1.5+GHC2 = (inventive) group 4;

DSS1.5+5ASA = group 5;

* = a significant difference with respect to the control group (control);

= a significant difference with respect to the DDS1.5 group (group 2).

The novel synthesis of IL-1 β is shown in Fig. 8. IL-1 β is a proinflammatory cytokine, the lowering of which indicates an anti-inflammatory action. Again, better action is detectable in the test group with administration of the substance according to the invention (GHC 2) than in treatment with normal clinoptilolite (GHC 1).

Two further proinflammatory cytokines were examined; the results are shown in Fig. 9 (IL-6) and 10 (TNF- α). Said figures show:

2exp $\Delta\Delta$ ct = the rise in expression for a particular gene (1 = 1x, 2 = 2x, etc.);

Control = control group;

DSS1.5 = group 2;

DSS1.5+GHC1 = group 3;

DSS1.5+GHC2 = (inventive) group 4;

DSS1.5+5ASA = group 5;

** = a very significant difference in relation to the control group (control);

= a significant difference in relation to the DDS1.5 group (group 2);

= a very significant difference in relation to the DDS1.5 group (group 2).

In the case of Il-6 (Fig. 9), again only the substance according to the invention (group 4) shows a stronger action than the treatment with normal clinoptilolite (GHC 1); the former is even better than the control with the standard treatment using 5-ASA.

Fig. 10 shows the results for TNF- α ; in this case, no statistically significant difference between the substance according to the invention and the control with no treatment (+) is detectable. Since the treatment with 5-ASA also does not show a positive effect on TNF- α , the validity of this parameter for assessing the progress of healing must be cast into doubt.

Lastly, measurements were also further made of the MPO activity in intestinal tissue; the results are shown in Fig. 11. Said figure shows:

Control = control group;

DSS1.5 = group 2;

DSS1.5+GHC1 = group 3;

DSS1.5+GHC2 = (inventive) group 4;

DSS1.5+5ASA = group 5;

MPO specific activity [units per ml per mg prot] = specific MPO activity [units per ml, normalized to protein content];

*** = an extremely significant difference in relation to the control group (control);

= a very significant difference in relation to the DDS1.5 group (group 2);

= an extremely significant difference in relation to the DDS1.5 group (group 2).

MPO activity is a customary measurement in IBD studies (Kim JJ, Shajib MS, Manocha MM, Khan WI. "Investigating intestinal inflammation in DSS-induced model of IBD" J Vis Exp. 2012 Feb 1; (60)); it represents the inflammation of the intestine through the quantification of the myeloperoxidase produced by infiltrated neutrophils. The results (Fig. 11) show an action of the substance according to the invention and also of the treatment with normal clinoptilolite (group 3). Clearly, the influence on this parameter is based on a different mechanism of action which the action of the substance according to the invention cannot reproduce correspondingly.

The experiments also show that clinoptilolite, both in the particle size of group 3 and in the finely divided sizes according to the invention (group 4), are well tolerated in the animals and the administration thereof does not cause any problems. There were no cases of death caused by the administration of the two test substances or other signs of toxicity.

The clinoptilolite according to the invention is preferably administered orally, on its own or with carrier substances or fillers that are customary in medicine (lactose, glucose, sucrose, starch, calcium sulfate or microcrystalline cellulose).

"Clinoptilolite having a particle size between 0.2 and 1 μm " is understood to mean that clinoptilolite of said particle size is present in an effective amount. Clinoptilolite having a smaller particle size, which is unavoidably included or present owing to the grinding process and despite careful sieving, as well as clinoptilolite having a larger particle size, if present, is not counted or considered. The clinoptilolite which is usable or used according to the invention is obtained by grinding and sieving. The source of the clinoptilolite does not play an appreciable role.

The fact that the particle size of the clinoptilolite has a distinct influence on its efficacy can be clearly seen from the comparison of the results of group 3 (not according to the invention) with the results of group 4 (according to the invention). The particle size distribution within the limits does not have a significant influence on the efficacy.

Said particle size is determined, for example, by sedimentation or by evaluation of the scattering of laser light, or by digital image processing, as is sufficiently known in the prior art.

The duration of administration is individually adapted to the patient by the attending physician according to the course of remission. The same also applies to the dose to be administered, which varies within the range between 1 to 500 mg/kg, preferably between 5 and 100 mg/kg of body weight.

In the case of oral administration, the clinoptilolite according to the invention is optionally admixed with pharmaceutically acceptable carrier materials and/or diluents. These are for example: lactose, glucose, sucrose, starch, calcium sulfate, microcrystalline cellulose and many other substances known and used in the prior art.

General mathematical remarks relating to the assessment:

Significance in analytical statistics is understood to mean the probability that a feature or a characteristic of a random sample is in agreement with the entire population. Said probability is calculated by means of the p-value. The p-value indicates in what percentage % of all cases the actual final result of the entire population will be beyond the calculated range. Depending on the result of the p-value, these can be additionally classified and interpreted:

“Extremely significant” $p \leq 0.001$ less than 0.1% of all cases of the actual overall result are beyond the considered range.

“Very significant” $p \leq 0.01$ less than 1% of all cases of the actual overall result are beyond the considered range.

“Significant” $p \leq 0.05$ less than 5% of all cases of the actual overall result are beyond the considered range.

CLAIMS:

1. Clinoptilolite having a particle size between 0.2 and 1 μm for the treatment of inflammatory bowel disease (IBD) in a mammalian subject.
2. Clinoptilolite according to Claim 1, characterized in that the mammalian subject is a human.
3. Clinoptilolite according to Claims 1 or 2, characterized in that it is free of heavy metals.
4. Clinoptilolite according to any one of Claims 1 to 3, characterized in that it is for oral administration, optionally with a pharmaceutically acceptable carrier, diluent or a combination thereof.
5. Clinoptilolite according to Claim 4, characterized in that it is for administration at a dose between 1 to 500 mg/kg of body weight of the mammalian subject.
6. Clinoptilolite according to Claim 5, characterized in that it is for administration at a dose between 5 and 100 mg/kg of body weight of the mammalian subject.

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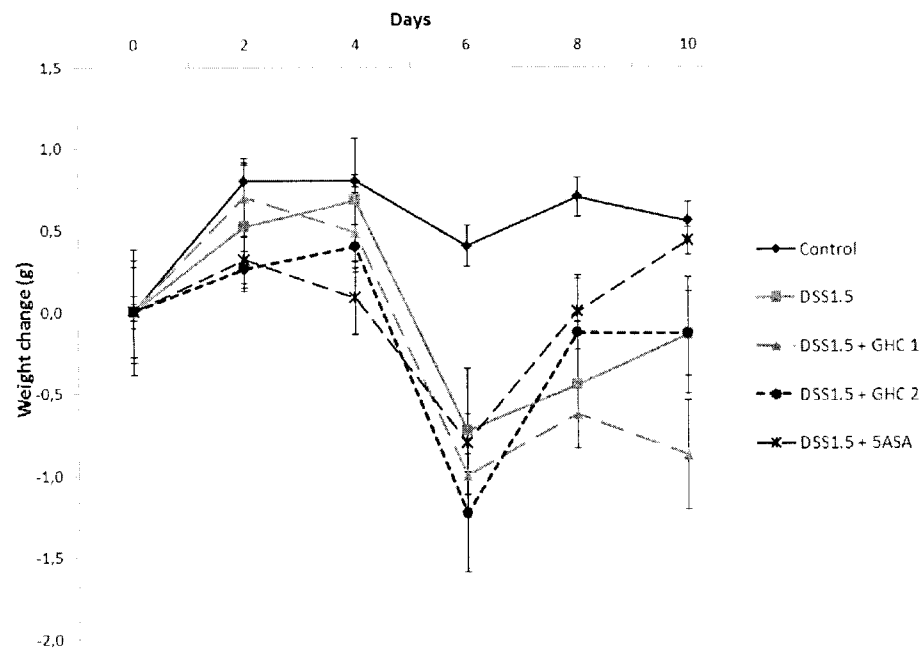


Fig. 1

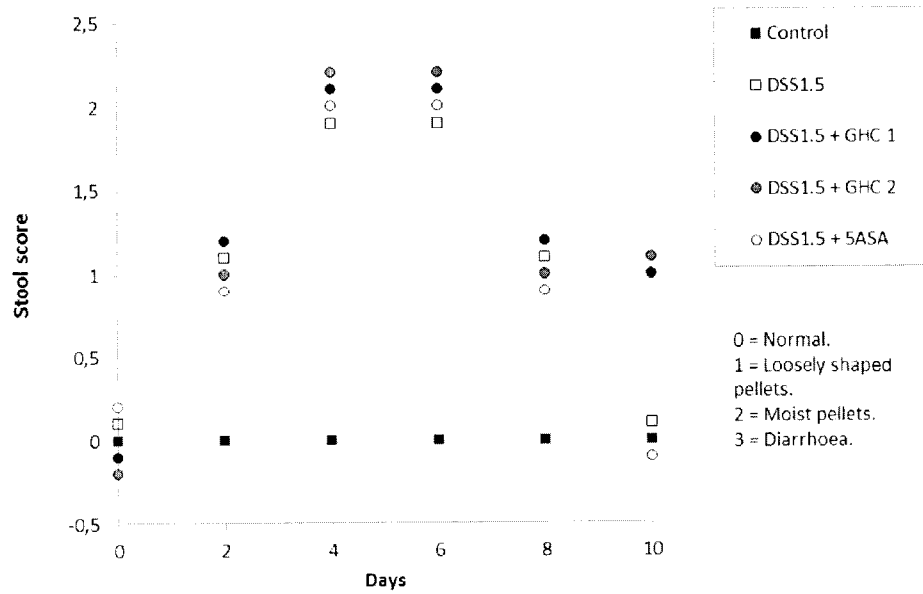


Fig. 2

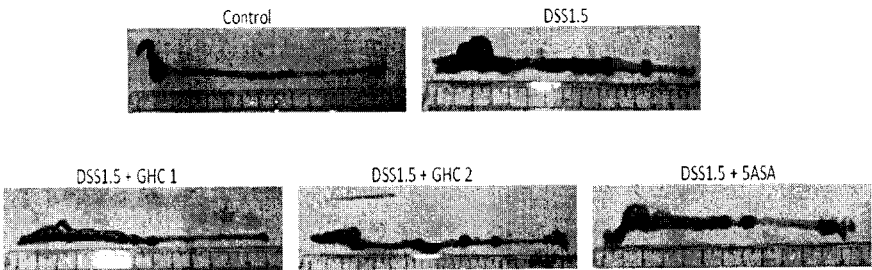


Fig. 3

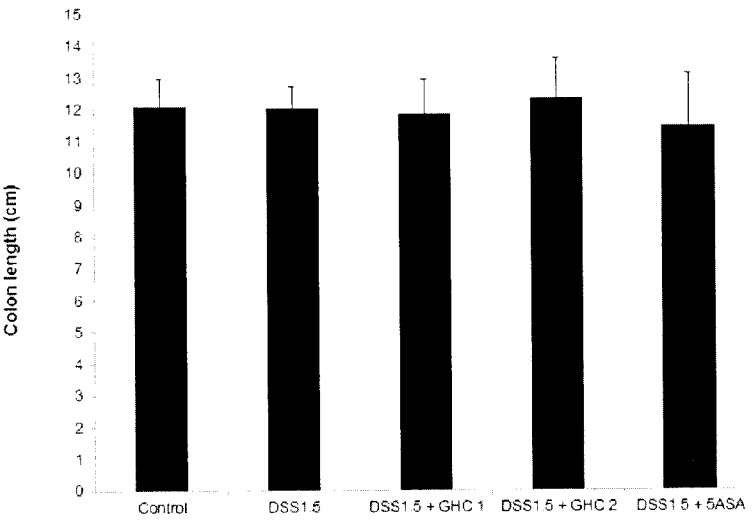


Fig. 4

3/6

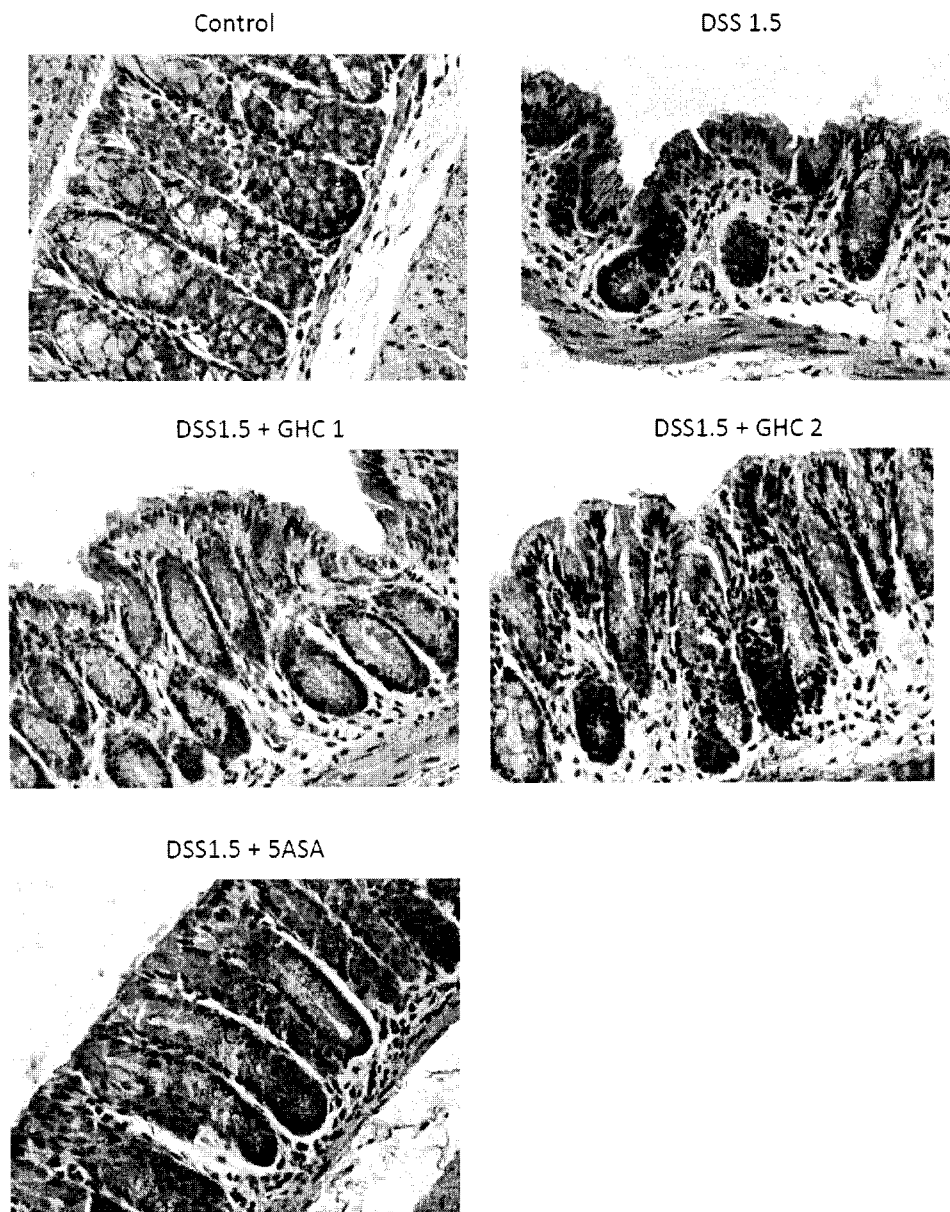


Fig. 5

4/6

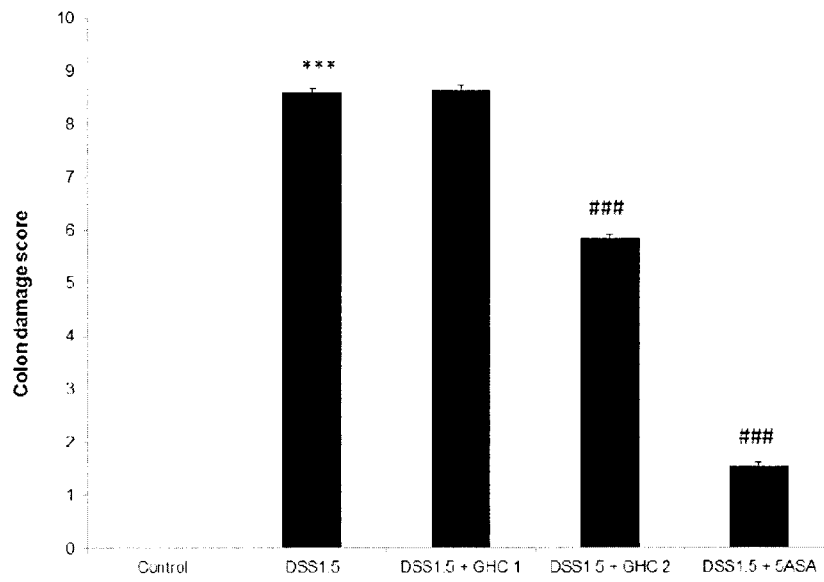


Fig. 6

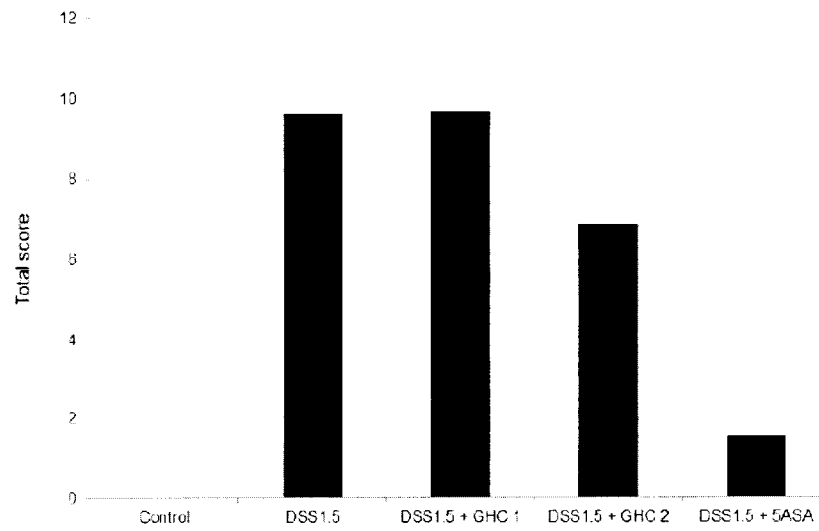


Fig. 7

5/6

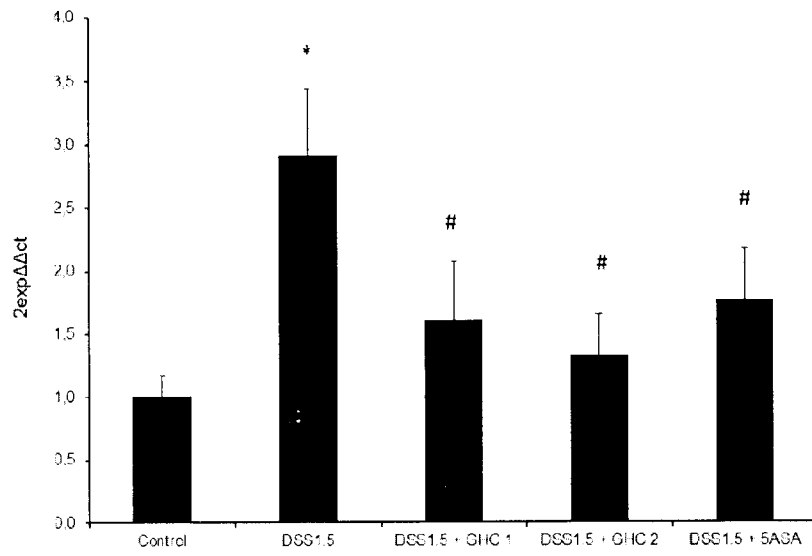


Fig. 8

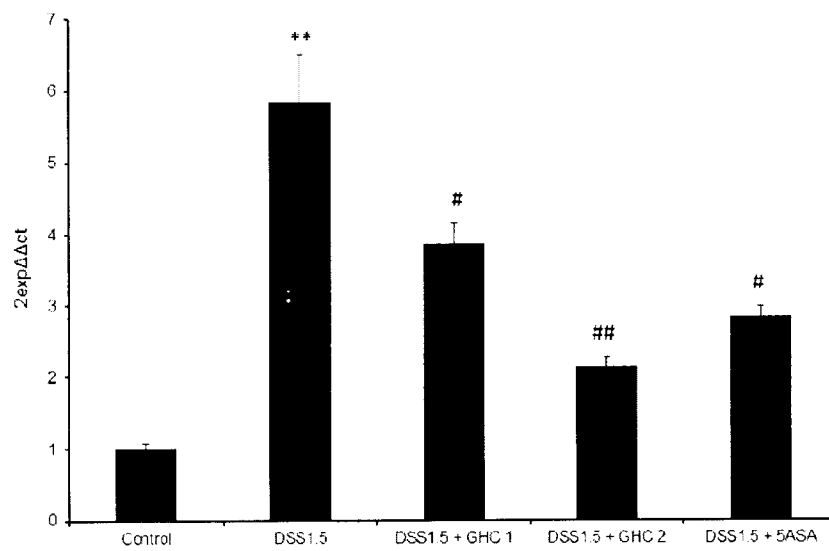


Fig. 9

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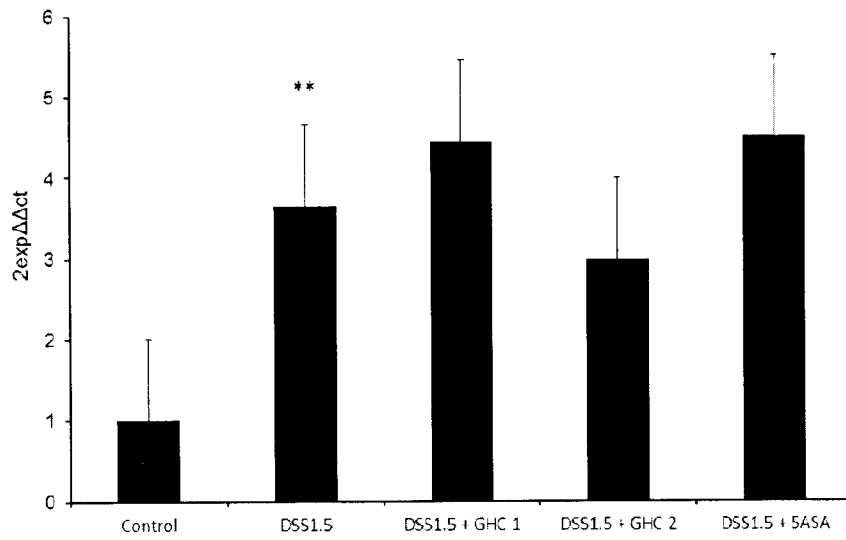


Fig. 10

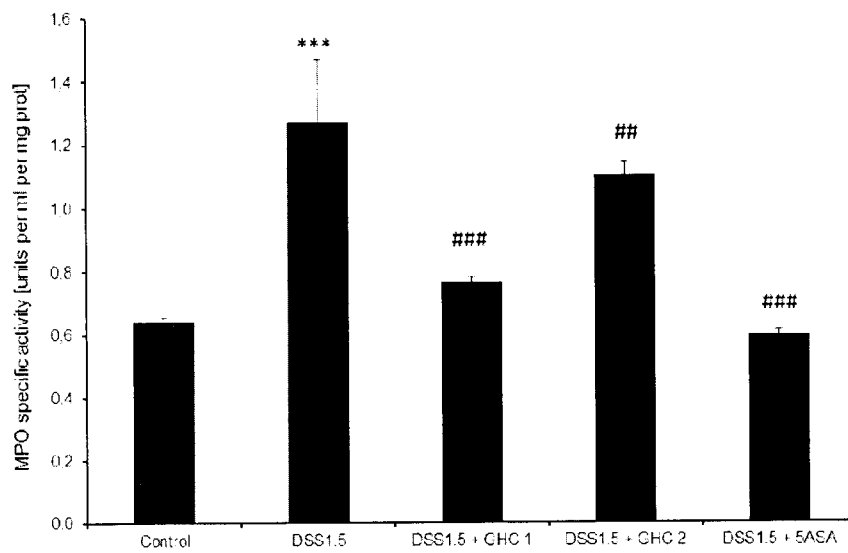


Fig. 11