NOVEL ACETYLSALICYLIC ACID SALTS

FIELD OF INVENTION

The present invention relates in general to acetylsalicylic acid salts, and in particular to a new and useful water soluble acetylsalicylic acid salts and the method of making the same. Acetylsalicylic acid is a most widely used drug, known chiefly for its analgesic properties. Its range of application is greatly reduced by its low solubility in water (about 0.3%). Besides Li, Na, Mg and Ca salts a number of salts with basic amino acids (US 4,625,888) had been disclosed. Each of these salts has certain advantages and shortcomings, it would therefore be advantageous to have available new salts of acetylsalicylic acid with potentially more advantageous properties.

Since betaine type compounds incorporated in the new salts of acetylsalicylic acid have various pharmacological activities themselves, the new salts of acetylsalicylic acid may have additional beneficial properties to those of acetylsalicylic acid or betaines, including new pharmacological activities.

OBJECT OF THE INVENTION

The object of this invention is the discovery of novel type acetylsalicylic acid salts with certain betaine type compounds. It was unexpected and surprising to discover that acetylsalicylic acid salts with certain betaines that themselves are hygroscopic substances yields stable, water soluble crystalline salts.

Accordingly, an object of the present invention is to provide acetylsalicylic acid salts that are highly soluble in water yet have outstanding stability and shelf life.

A further object of the present invention is to provide a method for making said salts.

Another object of the present invention is to provide meldonium acetylsalicylate salt (3-(trimethylammonioamino)propanoate acetylsalicylate) for use as medicament.

It is an object of the present invention to provide a medicinal product, namely 3-(trimethylammonioamino)propanoate acetylsalicylate (meldonium acetylsalicylate) with antiinflammatory, analgesic, antipyretic, antirheumatic, antihyperlipidemic, antiatherosclerotic, antiaggregative and antithrombotic properties. Another object of the present invention is a method of treating a subject in need of antiinflammatory, analgesic, antipyretic, antirheumatic, antihyperlipidemic, antiatherosclerotic, antiaggregative and antithrombotic therapy. An additional object of the invention is the provision of a pharmaceutical composition comprising MASA for the aforesaid purpose. Further objects of the invention will become apparent hereinafter, and still others will be obvious to one skilled in the art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following are examples of various salts and methods of the present invention and their properties.

Example 1. 4-trimethylammoniobutanoate acetylsalicylate

γ-Butyrobetaine dihydrate (1.81 g, 10 mmol) and acetylsalicylic acid (1.80 g, 10 mmol) were dissolved in ethanol (20 ml). The solution was concentrated *in vacuo* at about 40 °C till syrup consistence that on cooling crystallizes. The crystalline mass was triturated with acetone (50 ml), filtered, washed with acetone and dried *in vacuo* at room temperature. The yield of colorless crystals with m.p. 120-122 °C was 3.04 g (93.5%). The substance is water soluble, stable at ambient conditions.

^{1}H NMR spectrum (D_2O, TMS) δ: 1.93-2.12 (2H, m, $CH_2\underline{CH_2}CH_2$); 2.33 (3H, s, $COCH_3$); 2.40 (2H, t, J = 7.0 Hz, CH_2COO^-); 3.09 (9H, s, Me_3N); 3.24-3.37 (2H, m, CH_2N); 7.16 (1H, dd, J = 1.1 and 8.1 Hz, H-3); 7.38 (1H, ddd, J = 1.1, 7.6 and 7.6 Hz, H-5); 7.56 (1H, ddd, J = 1.8, 7.6 and 8.1 Hz, H-4); 7.79 ppm (1H, dd, J = 1.8 and 7.6 Hz, H-6).

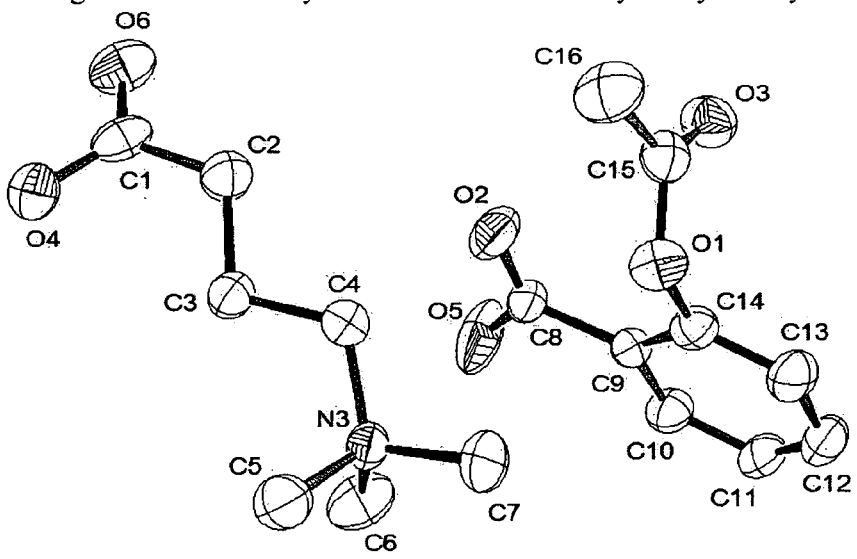
$C_{16}H_{23}NO_6$. Calculated, %: C 59.07; H 7.13; N 4.30.

Found, %: C 59.17; H 7.20; N 4.23.

The new salt is characterized by X-ray powder pattern (Cu K_α – radiation) having peaks at 2Θ-angles 5.10, 13.58, 13.83, 15.02, 15.17, 17.89, 19.33, 19.87, 21.85, 22.05, 23.32, 23.56, 23.92, 24.75, 25.55, 25.80, 27.05, 27.91, 30.25 ± 0.2°.

Structure of the new salt is confirmed by means of X-ray single crystal structure analysis (below). Crystals are monoclinic, cell parameters at experiment temperature T = - 85 °C are: a = 13.2154(6) Å, b = 7.5092(3) Å, c = 17.6451(9) Å, β = 104.728(2), cell volume V = 1693.5(1) Å^3, space group $P2_1/a$.

Fragment of 4-trimethylammoniobutanoate acetylsalicylate crystal structure:



Example 2. *L*-carnitine acetylsalicylate

L-Carnitine (1.61 g, 10 mmol) and acetylsalicylic acid (1.80 g, 10 mmol) were dissolved in ethanol (20 ml) and the solution concentrated *in vacuo* at about 40 °C till syrup consistence that on cooling crystallizes. The crystalline mass was triturated with acetone (50 ml), filtered, washed with acetone and dried *in vacuo* at room temperature. The yield of colorless crystals with m.p. 90-94 °C was 3.17 g (93%). The substance is water soluble, stable at ambient conditions.

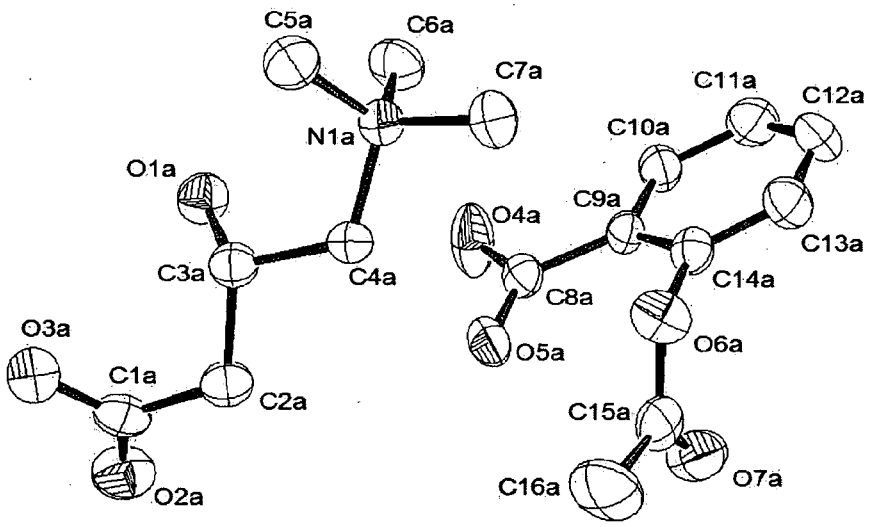
^{1}H NMR spectrum (D_2O, TMS) δ: 2.32 (3H, s, $COCH_3$); 2.53 (2H, d, J = 6.6 Hz, CH_2COO^-); 3.18 (9H, s, Me_3N); 3.38-3.45 (2H, m, CH_2N); 4.59 (1H, quint., J = 6.1 Hz, C<u>H</u>OH); 7.15 (1H, dd, J = 1.1 and 8.1 Hz, H-3); 7.37 (1H, ddd, J = 1.1, 7.6

and 7.6 Hz, H-5); 7.56 (1H, ddd, J = 1.8, 7.8 and 7.8 Hz, H-4); 7.79 ppm (1H, dd, J = 1.8 and 7.8 Hz, H-6).
$C_{16}H_{23}NO_7$. Calculated, %: C 56.30; H 6.79; N 4.10.
Found: %: C 55.67; H 6.85; N 4.12.

The new salt is characterized by X-ray powder pattern (Cu K_α – radiation) having peaks at 2Θ-angles 5.09, 12.62, 13.48, 13.84, 15.04, 17.82, 19.15, 19.77, 21.84, 22.56, 23.33, 23.92, 24.40, 25.17, 25.43, 26.14, 27.24, 29.50, 30.36 ± 0.2°.

Structure of the new salt is confirmed by means of X-ray single crystal structure analysis (below). Crystals are monoclinic, cell parameters at experiment temperature T = - 85 °C are: a = 13.1342(6) Å, b = 7.6396(3) Å, c = 17.737(1) Å, β = 104.535(2), cell volume V = 1722.8(2) $Å^3$, space group $P2_1$.

Fragment of *L*-carnitine acetylsalicylate crystal structure:



Example 3. 3-(trimethylammonioamino)propanoate acetylsalicylate (Meldonium acetylsalicylate)

3-(Trimethylammonioamino)propanoate dihydrate (INN – Meldonium) (3.64 g, 20 mmol) and acetylsalicylic acid (3.60 g, 20 mmol) were dissolved in hot propanol-2 (30 ml) and heated at 50-55 °C for 20 minutes. Heating was discontinued and solution stirred at room temperature for 3 h. The slurry was further stirred at 0 °C for another 3 h, precipitates were filtered off and washed with cold propanol-2 (2x15 ml). Desired salt was recrystallized from propanol-2. Colorless crystals were obtained with m.p. 104-106 °C. Yield 4.12 g (63%).

^{1}H NMR spectrum (D_2O, TMS) δ: 2.34 (3H, s, $COCH_3$); 2.51 (2H, t, J = 6.4 Hz, CH_2COO^-); 3.26 (2H, t, J = 6.4 Hz, CH_2N); 3.33 (9H, s, Me_3N); 7.17 (1H, dd, J = 1.1 and 7.8 Hz, H-3); 7.39 (1H, ddd, J = 1.1, 7.6 and 7.6 Hz, H-5); 7.58 (1H, ddd, J = 1.7, 7.6 and 7.8 Hz, H-4); 7.81 ppm (1H, dd, J = 1.7 and 7.6 Hz, H-6).

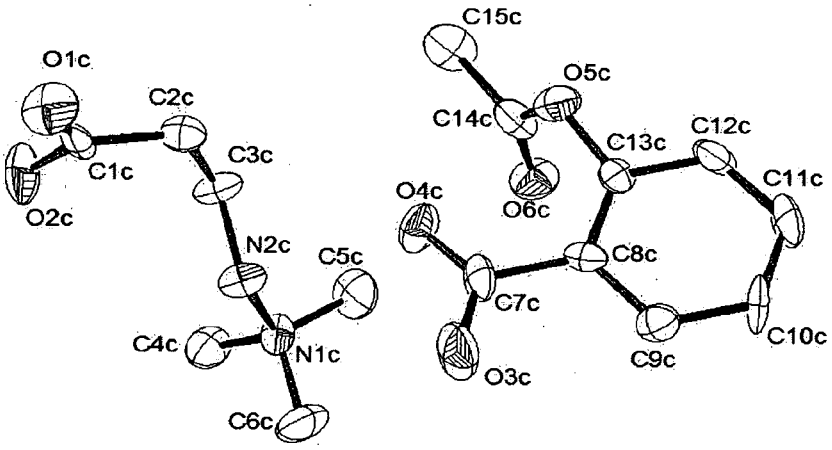
$C_{15}H_{22}N_2O_6$. Calculated, %: C 55.21; H 6.79; N 8.58.
Found, %: C 55.25; H 6.79; N 8.53.

The new salt is characterized by X-ray powder pattern (Cu K_α – radiation) having peaks at 2Θ-angles 5.19,13.22,13.82, 14.20, 14.95, 15.36, 15.93, 18.11,18.97,19.74, 21.02, 22.15, 23.15, 23.65, 24.31, 25.28, 26.18, 26.58, 27.73, 28.36 ± 0.2°.

Structure of the new salt is confirmed by means of X-ray single crystal structure analysis (below). Crystals are monoclinic, cell parameters at experiment temperature

T = - 85 °C are: a = 19.3399(8) Å, b = 7.2400(3) Å, c = 35.237(2) Å, β = 90.758(2), cell volume V = 4933.5(4) $Å^3$, space group $P2_1/n$.

Fragment of 3-(trimethylammonioamino)propanoate acetylsalicylate crystal structure:



Pharmacological properties of 3-(trimethylammonioamino)propanoate acetylsalicylate (meldonium acetylsalicylate).

It is envisaged that the novel substance disclosed in the said application can appear in various polymorphic crystal forms and solvates, preferably hydrates that have similar biological properties and therefore included in this application as variants of the described compound.

We have initially established that meldonium acetylsalicylate delayed and significantly reduced the cutaneous vasodilation caused by niacin. Further experiments demonstrated surprising improved pharmacological activities of meldonium acetylsalicylate.

ABBREVIATIONS USED

The following abbreviations will be used further on in the description for shortness:

AdA – adjuvant arthritis
ASA – acetylsalicylic acid
C - cholesterol
CHD – coronary heart disease
CIC – circulating immune complexes
CL - clopidogrel
CRP – C-reactive protein
DI - dipyridamole
HDL– high density lipoprotein-cholesterol
LA - laropiprant
LDL – low density lipoprotein-cholesterol
MASA – meldonium acetylsalicylate (chemically: 3-(trimethylammonioamino)-propanoate acetylsalycilate

MD – meldonium (INN)
NA – nicotinic acid, niacin
RA – rheumatoid arthritis
TG – triglyceride
TR - Triton WR1339
WBC – white blood cells

Substances. NA (Acros Chemicals), MD (Grindex), ASA (Acros Chemicals), LA (MK 0524, Cayman Chemicals), CL bisulfate for *in vitro* tests (Molcan Corporation), CL for *in vivo* tests as Plavix™ (Sanofi-Aventis), DI (Sigma-Aldrich).

Background. Acetylsalicylic acid is a most widely used drug, best known for its antiinflammatory, analgesic, antipyretic and antirheumatic properties. It is also used in small daily doses as antiplatelet agent for cardiovascular risk patients (Eidelman RS et al, *Arch Intern Med.* 2003;163:2006–2010). Blood platelets play a pivotal role in the development of atherosclerosis and fatal thrombus formation in the course of coronary heart disease. Antiplatelet agents have become paramount in the prevention and management of various diseases involving the cardiovascular, cerebrovascular, and peripheral arterial systems (Meadows TA et al, *Circ Res* 2007;100(9):1261-75). Although known for many years to be an antiplatelet agent, ASA is now becoming more recognized for its anti-inflammatory properties (Ridker PM et al, *N Engl J Med* 1997;336:973–979) in cardiology. Accordingly, clinical measurements of such inflammatory markers as C-reactive protein (CRP) may in part reflect indices of atherosclerosis (Buckley DI et al, *Ann Intern Med 2009;151:483-495).* Present evidence points to that reducing CRP levels prevents CHD events (Ridker PM et al, Lancet 2009;373:1175-82). Ross proposed that atherosclerosis was an inflammatory disease (*Ross R, N Engl J Med* 1999;340:115-126). ASA not only may address the inflammatory aspect of atherosclerosis but also may contribute directly by inducing hypolipidemia (Kourounakis AP et al, *Experimental and Molecular Pathology* 2002, 73:135-138).

NA is an effective lipid-altering agent that prevents atherosclerosis and reduces cardiovascular events. NA has multifarious lipoprotein and anti-atherothrombosis effects that improve endothelial function, reduce inflammation, increase plaque stability, and diminish thrombosis (Rosenson RS, *Atherosclerosis* 2003;171:87-96)

NA almost totally prevented intravascular clotting induced by thromboplastin and pituitrin, showing that it has a thrombolytic effect (Baluda VP, *Kardiologija* 1974;14(11):105-7 (Rus). Anti-thrombotic properties of NA are described by several authors (Shestakov VA, *Probl Gematol Pereliv Krovi*, 1977;22(8):29-35. Chekalina SI, *Sov Med* 1982(5):105-8). Niacin reduces risk of blood clots (Chesney CM et al, *Am Heart J*, 2000;140:631-36).

NA inhibit platelet aggregation (Lakin KM, Farmakol Toksikol, 1980; 43(5):581-5). NA in vitro affects platelet activity by mildly inhibiting aggregation, and stimulating significant prostaglandin release, with mostly intact major platelet receptor expression. The effect of NA is unique, differs from other known antiplatelet agents, and suggests potential opportunities for therapeutic combination (Serebruany VL et al, *Thrombosis and Haemostasis*, 2010 (in press).

NA is an effective lipid-altering agent that prevents atherosclerosis and reduces cardiovascular events (Drexel H, *European Heart Journal Supplements*

2006;Vol 8, Suppl F: F23-F29. Savel'ev AA, Shershevskii MG, *Klin Med (Rus)* 1996;74:48-52).

NA is available in 3 formulations (immediate release, extended release, and long acting). Immediate-release NA is associated with adverse flushing and elevations in blood glucose levels. Long-acting NA is associated with reduced flushing, but also with risk of hepatotoxic effects. Extended-release is associated with less flushing and low hepatotoxic risk (McKenney J, *Arch Intern Med* 2004;164(7):697-705).

The clinical use of NA has been limited by cutaneos flushing. Extended-release niacin can help to control flushing events (Guyton JR et al, *J Clin Lipidol*, 2009;3:101-108). ASA and other NSAIDs have been proposed for control of flushing with different pharmaceutical compositions to ensure advance application of NSAIDs before the dosage of NA (WO9632942, WO9906052, WO2009142731).

Recently a specific antagonist to prostaglandin D2 (Parhofer KG, *Vascular Health and Risk Management* 2009;5:901-908) receptor subtype 1, laropiprant, was proposed as agent for reducing NA-induced flushing (Lai E et al, *Clin Pharm Ther* 2007;81:849-857. Davidson MH, *Am J Cardiol* 2008;101 [suppl]:14B-19B). Although the addition of laropiprant will reduce the frequence of flushing, it will not completely eliminate this side effect. Laropiprant does not change the effect of niacin on lipids or other side effects of niacin. The combination of niacin with laropiprant may therefore enable use of niacin at higher doses and therefore exploit the full potential of the drug (Parhofer KG, *Vascular Health and Risk Management* 2009;5:901-908, Olsson AG, *Expert Opinion on Pharmacotherapy* 2010;11(10):1715-1726).

MD is a medicine with certain beneficial effects on heart and vessels. A certain desirable activity of MD was discovered in animal models of atherosclerosis (Veveris M, Smilsaraja B, *Baltic J Lab Anim Sci* 2000;10,194-199. Veveris M et al., *Baltic J Lab Anim Sci* 2002;12:116-122. Okunevich IV, Ryzhenkov VE, *Patol Fiziol Eksp Ter* 2002;(2):24-7), and observed in clinics (Karpov RS et al, *Ter Arkh* 1991;63(4):90-3). It has been also noticed that MD inhibits platelet aggregation (TsirkinVI, *Ros Kardiol Zh* 2002;1:45-52). Two weeks long therapeutic use of MD peroral administration in rabbits and dogs after experimental arterial thrombosis showed trombolytic effect (Logunova L et al, *Experim Clin Pharmacoter* 1991;19:91-98 (Rus). No data on prophylactic effect of MD on limitation or prevention of thrombosis are known.

Example 4. Determining acute toxicity of MASA

The acute toxicity of MASA was determined on Wistar rats and ICR mice by *p.o.* introduction.

Methods. Male IRC mice with body mass of 20-22 g and Wistar rats with body mass of 200-230 g were used. For determining the acute toxicity each dose was given to 6 animals, each next dose was increased by 500 mg/kg. LD_{50} was calculated after Karber by the method of Akhila JS et al, *Current Sci* 2007;93:917-920 with modification for determining the dose confidence interval (Turner R In *Screening Methods in Pharmacology*, Acad. Press, New York, 1965, 61-63).

LD_{50} was calculated as follows:

LD_{50}=Least dose lethal to all in a group - $\sum(a \times b)/N$

N – number of animals in each group

a – the dose difference

b – the mean mortality (lethality in 2 neighbouring groups/2)

MASA was dissolved *ex tempore* in 0.2% agar-agar and introduced *per os* through catheter into stomach. The volume of liquid thus introduced did not exceed 0.5 ml for mice and 2 ml for rats. Animals were observed till the Day 10 after introduction.

Results. Results for MASA acute toxicty to mice are represented in Table 1 and Table 2.

Table 1

MASA acute toxicity to mice p/o

Group	Dose mg/kg p.o.	Number of animals in group (N)	Lethality (n)	Mean mortality (b)	Probit (a x b)
1	1000	6	0		
2	1500	6	1	0.5	250
3	2000	6	2	1.5	750
4	2500	6	4	3	1500
5	3000	6	6	5	2500

$LD_{50} = 3000 - (5000/6) = 2167$

Factor *f* at P=0.05 for this experiment is 1.32, therefore the confidence interval for LD_{50} is 1642 - 2860 (mg/kg).

After the introduction of MASA the toxic effects appeared within the first hours and a part of animals died within the first 2 days. The toxicity symptoms in surviving animals gradually subsided and after 5-8 days these animals were not different from the controls of the same age. Thus LD_{50} of MASA for mice *p.o.* is found to be 2167 (1642÷2860) mg/kg.

Results for the acute toxicity of MASA in rats *p.o.* are presented in Table 2 and Table 3.

Table 2

Acute toxicity of MASA to rats *p.o.*

Group	Dose mg/kg	Number of animals in group (N)	Letality (n)	Mean mortality (b)	Probit (a x b)
1	1500	6	0		
2	2000	6	2	1	500
3	2500	6	4	3	1500
4	3000	6	6	5	2500

$LD_{50} = 3000 - (4500/6) = 2250$

Factor *f* at P=0.05 for this experiment is 1.308, therefore the confidence interval for LD_{50} is 1720÷ 2944 (mg/kg).

Introduction of MASA to rats *p.o.* in dose 1500 mg/kg caused transient disturbances in feeding habits and movements, but all animals survived. The toxic symptoms started to disappear from day 3 after introduction. Thus LD_{50} of MASA for rats *p.o.* is found to be 2250 (1720÷2944) mg/kg.

Summary. The acute toxicity studies indicated that MASA is a substance of low toxicity (LD_{50} > 2000 mg/kg *p.o.* for mice and rats). Acute toxicity for ASA is given by Boehringer Ingelheim Pharmaceuticals, Inc., Acros Chemicals and Sigma-Aldrich as 250 mg/kg for mice and 200 mg/kg for rats *p.o.*, while Bayer AG gives LD_{50} for rats *p.o.* as >1100 mg/kg and thus MASA is less toxic than ASA.

Table 3

Acute toxicity of MASA for mice and rats; N=6.

Animals	LD50 mg/kg *p.o.*(confidence interval)
Mice	2167 (1642÷2860)
Rats	2250 (1720÷2944)

Example 5. Investigation of analgesic, antipyretic and anti-inflammatory activity of MASA in comparative experiments with ASA and MD

In investigating the analgesic, anti-inflammatory and antipyretic effects of MASA methods widely used in evaluation of NSAIDs were employed. Mongrel white laboratory mice and Wistar rats were used in experiments. Animals were kept in groups of 7-8 in adequate cages in climatized rooms at 22±1 °C, relative humidity 60 ±5% and 12/12 light/darkness cycle with free access to feed and water.

The following groups were formed for comparing the effects of MASA with ASA and MD by oral route:

GROUP	TREATMENT
ASA50	received ASA 50 mg/kg
ASA100	received ASA 100 mg/kg
MD100	received MD 100 mg/kg
MASA75	received MASA 75 mg/kg
MASA150	received MASA 150 mg/kg
MASA300	received MASA 300 mg/kg

Aqueous solutions of test substances were prepared *ex tempore*. In each experimental series a control group was used that received an identical volume of water *p.o.*

Statistics. Data were analyzed by Microsoft Excel 2007 software and results expressed as Mean±SEM. Mean results of different groups were compared using single-factor analysis according to ANOVA with repeated comparison (Tukey's test). $P<0.05$ was considered as significant.

5.1. Investigation of analgesic activity

5.1.1. Evaluation of analgesic activity by mouse writhing test

Method. Nociceptive reaction was evaluated by chemical irritation method – writhing test (Charaborty A et al, *Indian J of Pharmacology* 2004;36(3):148-150). Animals received *i.p.* 0.25 ml of 0.75% aqueous acetic acid solution. After the injection animals were placed separately in special boxes and observed for 10 minutes. The number of abdominal constrictions was registered. Analgesic activity was manifested by reduction of the number of abdominal constrictions in the 10 minutes period. Test substances were introduced 30 min before the irritating agent. The level of analgesia was expressed as analgesic index calculated as follows:

$A = (Cc-Ct)/Cc \cdot 100\%$, where

A – Analgesic index

Cc – number of contractions in control group,

Ct – number of contractions in the test group.

The results are presented in Table 4.

Table 4

Analgesic effect of test substances in writhing test model; N=8; Mean±SEM

Group	Animals with positive reaction/total number	No. of constrictions	Analgesic index
Control	8/8	22.00±1.60	-
MD100	8/8	22.10±1.47	-0.4
ASA50	6/8	5.75±1.32***$^{\$\$\$}$	7.1
MASA75	8/8	12.13±0.61**$^{\$\$}$	4.5
MASA150	7/8	10.63±1.10**$^{\$\$}$	5.2
MASA300	5/8	6.00±1.39***$^{\$\$\$}$	7.3

**P<0.005 *vs* Control - ***P<0.0005 *vs* Control -$^{\$\$}$P<0.005 *vs* MD
$^{\$\$\$}$P<0.0005 *vs* MD

MASA showed dose dependant positive effect. The best results were observed in ASA50 and MASA300 (P<0.0005) groups, while MD was inactive. The analgesic index for MASA300 group was 7.3 (only 5 animals of 8 had pain reaction).

5.1.2. Evaluation of analgesic activity by mouse hot plate test

Method. The hot plate test was conducted on 52 mice with body weight 17 – 26 g as described in literature (Belyakov VA, Solov'ev IK. *Narcotic analgesics*, Nizhny Novgorod, 2001 (Rus). The hot plate test is used to screen centrally acting analgesics (Osterberg A et al, *J Pharmacol Exper Ther* 1958;122:59). Aqueous solutions of test substances were introduced *p.o.* 30 or 60 min. before the testing. The time until the licking of paws was recorded. The criterion of analgesic activity was the delay of response to thermal irritation.

The results are presented in Table 5.

Table 5

Response time in mouse hot plate test; N = 8-10; Mean±SEM

Group	Latent period, s	
	At 30 min after introduction of test substance	At 60 min after introduction of test substance
Control	4.5±0.42	5.0±0.27
MD100	9.5±0.68***$^{\&\&}$	8.3±0.53***
ASA50	5.4±0.46	9.7±1.05**
MASA75	5.4±0.38	4.6±0.26
MASA150	9.5±0.53***$^{\&\&\&}$	7.1±0.55**
MASA300	9.6±1.12**$^{\&}$	8.6±0.60***

**P<0.005 *vs* Control - ***P<0.0005 *vs* Control -$^{\&}$P<0.05 vs ASA (30 min)
$^{\&\&}$P<0.005 vs ASA (30 min) - $^{\&\&\&}$P<0.0005 vs ASA (30 min)

Experimental data indicated that MASA150 and MASA300 as well as MD group manifest significant analgesic effect after 30 and 60 minutes. ASA significantly increased the pain threshold only after 60 minutes indicating a slower onset of effect (Table 5).

6. Comparative evaluation of antipyretic activity of test substances

6.1. Evaluation of the preventive antipyretic activity on rats by injection of pyrogenal

Method. Experiments were conducted on 48 Wistar rats with body mass 165-182 g by intramuscular injection of pyrogenal (*Gamalei State Research Institution*, Moscow, Russia) in 100 μg dose (Shwarz GY, Syubaev RD, *Vedomosti NCEG lekarstvennyh*

sredstv MZ RF 2000;1:44-50 (Rus). Test substances were given *p.o.* one hour before the pyrogenal injection. Rectal temperature was measured by electric thermometer TERMO before injection of pyrogenal (baseline) and for 3 hours after injection. The antipyretic activity was evaluated by the reduction of hyperthermic reaction 2 hours after injection of pyrogenal that correlated well with the published data (10) about the peak of reaction (Table 6). Ambient temperature was kept at 20-21°C.

As follows from the data, the body temperature of the control group animals gradually increased, reached maximum in 2 hours and continued to be over norm for another hour.

Table 6

Changes of rat rectal temperature of control group under the influence of pyrogenal; N=8; Mean±SEM

Group	Baseline (°C)	Rectal temperature (°C)			
		after 30 min	after 60 min	after 120 min	after 180 min
Control	36.16±0.16	36.25±0.21	36.75±0.12$^{\#\#}$	36.90±0.10$^{\#\#\#}$	36.70±0.17$^{\#}$

$^{\#}$P<0.05 *vs* baseline - $^{\#\#}$P<0.005 *vs* baseline - $^{\#\#\#}$P<0.0005 *vs* baseline

The test substances did not substantially influence the normal body temperature of animals but substantially reduced pyrogenal induced hyperthermia (Table 7).

Table 7

Influence of test substances on hyperthermia, induced by intramuscular injection of pyrogenal; N=8; Mean±SEM

Group	Baseline rectal temperature (°C)	Rectal temperature (°C) 120 minutes after injection
Control	36.2±0.12	36.9±0.16$^{\#\#}$
MD100	35.9±0.18	36.2±0.16*
ASA50	35.8±0.17	35.6±0.19***$^{\$}$
MASA75	36.1±0.18	36.3±0.20*
MASA150	35.8±0.15	36±0.21**
MASA300	35.9±0.14	35.8±0.16***$^{\$}$

*P<0.05 *vs* Control - **P<0.005 *vs* Control - ***P<0.0005 *vs* Control
$^{\#\#}$P<0.005 *vs* baseline - $^{\$}$P<0.05 *vs* MD

In the hyperthermia model the increase in body temperature induced by injection of pyrogenal was completely prevented in ASA50 and MASA300 groups (Table 7). In MD100, MASA75 and MASA150 groups the antipyretic effect was less pronounced.

6.2. Evaluation of the preventive antipyretic activity on rats by injection of pyrogenal (curative mode)

Method. The antipyretic effect of test substances in therapeutic (curative) mode was investigated on 48 rats with body mass 182-205 g, with hyperthermia induction by injecting pyrogenal in dose 100 μg (Shwarz GY, Syubaev RD, Vedomosti NCEG lekarstvennyh sredstv MZ RF 2000;1:44-50 (Rus). Test substances were given *p.o.* 2 hours after injection of pyrogenal immediately after the recording of elevated body temperature. Rectal temperature was measured by electric thermometer TERMO before the *i.m.* injection of pyrogenal (baseline temperature), at the peak of hyperthermia (pyrogenal control) and 30 min. after treatment with test substance, i.e., 2½ hours after the injection of pyrogenal. Ambient temperature in laboratory was kept at 20-22 °C.

The results are presented in Table 9.

Table 9

Influence of test substances on hyperthermia, induced by intramuscular injection of pyrogenal (curative mode); N=8; Mean±SEM

Group	Baseline rectal temperature (°C)	Rectal temperature (°C) after injection of pyrogenal (pyrogenal control)	Rectal temperature (°C) at 30 minutes after treatment
Control	36.10±0.15	36.90±0.20$^{\#\#}$	37.00±0.18$^{\#\#}$
MD100	36.41±0.14	37.06±0.13$^{\#\#}$	37.10±0.14$^{\#\#}$
ASA50	36.39±0.13	37.04±0.25$^{\#}$	36.51±0.15*$^{\$}$
MASA75	36.23±0.12	37.01±0.11$^{\#\#}$	36.90±0.07$^{\#\#}$
MASA150	36.25±0.20	36.96±0.15$^{\#}$	36.75±0.09$^{\#\$}$
MASA300	36.11±0.14	36.76±0.11$^{\#\#}$	36.40±0.11*$^{\$\$\%}$

*P<0.05 *vs* Control - $^{\#}$P<0.05 *vs* baseline - $^{\#\#}$P<0.005 *vs* baseline
$^{\%}$P<0.05 *vs* pyrogenal control - $^{\$}$P<0.05 *vs* MD - $^{\$\$}$P<0.005 *vs* MD

Pyrogenal caused significant and similar increase of body temperature to all animals used in the experiment (comp. pyrogenal control vs. baseline, Table 9). The treatment with test substances, except MD, caused the lowering of body temperature vs. baseline and pyrogenal control. The comparatively higher hypothermia was observed in MASA300 and ASA50 groups where the lowering of body temperature was significant *vs* control and MD100. It should be noted that in MASA300 group, contrary to ASA50, the lowering of body temperature was significant also against the pyrogenal control. It indicated considerable and rapid antipyretic effect of MASA that might be valuable in clinic.

7. Comparative evaluation of anti-inflammatory activity of test substances

7.1.The investigation on the acute inflammatory oedema model

Method. Experiments were conducted using carrageneen test (Winter C et al, *Proc Soc Exptl Biol and Med* 1962;III(3):544-547. Wei Jia et al, *Journal of Ethnopharmacology* 2003(89):139-141; Sutharson Lingadurai et al, *African Journal of traditional, complementary and alternative medicines*, 2007, 4(4):411-416) on 42 rats with body mass of 226-274 g. Single injection of carrageneen (Sigma) solution (1%) in saline (0.1 ml) was introduced in rat hind leg paw. Test substances were introduced *p.o.* (through catheter into rat stomach) 30 min. after the injection of carrageneen. The volume of paw was measured by oncometer at baseline and 4 hours after the injection of carrageneen.

The percentage of prevention (inhibition of oedema) was calculated according to formula:

P(%) = (1 – Vo/Vc) x 100, where

P – Prevention in % (inhibition of oedema)

Vo – difference between the paw volume at baseline and at experimental conditions;

Vc – analogical difference in control group.

The results are presented in Table 10.

Table 10

Anti-exudative activity of test substances
in carrageneen inflammation model; N=7, Mean±SEM

Group	Volume of paw (ml) at baseline	Volume of paw (ml) after injection of carrageneen	
		ml	Index, %
Control	1.6±0.30	2.70±0.13	0
MD100	1.5±0.34	2.13±0.12*	43
ASA100	1.6±0.32	1.97±0.10**	66
MASA75	1.6±0.44	2.51±0.11	18
MASA150	1.6±0.31	1.54±0.15***$^{\$\&}$	93
MASA300	1.7±0.25	1.79±0.15**	91

*P<0.05 *vs* Control - **P<0.005 *vs* Control - ***P<0.0005 *vs* Control
$^{\&}$P<0.05 *vs* ASA100 - $^{\$}$P<0.05 *vs* MD

In the acute inflammatory oedema model the volume of affected extremity in control group increased approximately 1.6 times. The most pronounced effect on the inflammatory process was observed in MASA150 group, where the preventive index was 93% *vs* the control group. In the MASA300 group the activity was slightly less – the oedema was reduced by 91%. Reduction of oedema was also observed in MD100 and ASA50 groups.

7.2. Investigation of anti-inflammatory activity of test substances against carrageneen oedema in preventive mode

Method. The carrageneen oedema was investigated by established method (Okunevich IV, Ryzhenkov VE, *Patol Fiziol Eksp Ter*, 2002(2):24-7 (Rus) on 42 rats with body mass of 178-220 g. The test substances were introduced *p.o.* during a 5 day period. On Day 6 immediately after the introduction of test substances rats were given a 0.1 ml injection of 1% carrageneen solution in hind paw. The volume of paw was measured at baseline and 4 hours after the injection of carrageneen. The prevention index was calculated as indicated in previous section. The preventive introduction of test substances for 6 times caused a reduction of oedema compared to untreated animals (Table 11).

Table 11

Preventive anti-exudative action of test substances against
carrageneen oedema; N=7, Mean±SEM

Group	Volume of paw (ml) at baseline	Volume of paw (ml) after injection of carrageneen	
		ml	Reduction in %
Control	1.43±0.12	1.93±0.11	0
MD100	1.33±0.09	1.66±0.10	34
ASA50	1.40±0.06	1.55±0.04*	70
MASA150	1.37±0.11	1.40±0.09**$^{\$}$	94
MASA300	1.34±0.07	1.41±0.04**$^{\$}$	86

*P<0.05 *vs* Control - **P<0.005 *vs* Control - $^{\$}$P<0.05 *vs* MD

In the MASA150 and MASA300 groups a significant preventive activity (94%) was observed, that was higher than that in MD100 (34%) and ASA50 (70%) groups in this inflammatory model (Table 11).

To evaluate the intensity of the inflammation process the CRP levels were determined by standard method on analyzer «INTEGRA 400+» at the end of experiment (5 hours after injection of carrageneen).
Results of determination of CRP in blood are presented in Table 12.

Table 12

The levels of CRP in rat blood at the carrageneen inflammation model for rats; N=7, Mean±SEM

Group	CRP mg/l	CRP increase %
Control	0.17±0.015	0
Carrageneen control	0.23±0.016**	100
MD100	0.22±0.014*	83
ASA100	0.20±0.018	50
MASA150	$0.19\pm0.009^{\#\$}$	33
MASA300	0.21±0.014*	67

*P<0.05 *vs* Control - **P<0.005 *vs* Control - $^{\#}$P<0.05 *vs* Carrageneen control
$^{\$}$P<0.05 *vs* MD

As follows from the data carrageneen caused the increase of CRP in rat blood. In ASA100 group the CRP level increase was reduced by 50% (Table 12). Unexpectedly in MASA150 group the CRC level increase was significantly less pronounced (only 33% to control). It supports the opinion that MASA can have positive effects on inflammatory process in clinic.

Example 8. Investigation of antirheumatic activity of MASA in comparison with ASA and MD

Clinical evidence shows that patients with rheumatoid arthritis (RA) are predisposed to atherosclerosis and cardiovascular disease (Nasonov EL, *Vestn Ross Akad Nauk* 2003(7):6-10). Patients with prolonged RA have more atherosclerosis than patients of the same age with more recent disease onset. Systemic inflammation may amplify the age-related risk of cardiovascular disease (Del Rincon I et al, *Atherosclerosis* 2007;196(2):354-360).

Rheumatoid arthritis holds the top position among the rheumatoid conditions. The most adequate experimental animal model for human rheumatoid arthritis is the model of adjuvant arthritis, induced by injection of Freund's adjuvant in rat hind foot pads. It is widely used in screening of anti-arthritic agents (Wei Jia et al, *Journal of Ethnopharmacology* 2003(89):139-141; Sutharson Lingadurai et al, *African Journal of traditional, complementary and alternative medicines*, 2007, 4(4):411-416).

Methods. Our experiments were scheduled to test the influence of MASA on the progress of adjuvant arthritis in comparison with MD and ASA. Experiments were conducted on Wistar rats with starting body mass of 153-185 g. Rats were kept in climatized rooms at 22±1 °C, relative humidity 60 ±5% and 12/12 light/darkness cycle. Each standard cage housed 7 rats with unlimited access to drinking water and granulated standard feed. All experiments were carried out in accordance with the European Community Council's Directive of 24 November 1986 (86/609/EEC) relative to experimental animal care. All efforts were made to minimize animal suffering and to reduce the number of animals used.

A modified standard procedure for inducting and evaluating the progress of chronic adjuvant arthritis was used (Bellavite P, Ortolani R, Conforti A, *Immunology and Homeopaty. 3. Experimental Studies on Animal Models*, *Advance Access*

Publication 2.05,2006, 171-186). Rats were injected into the hind foot pad 0.1 ml and intraperitonealy with 0.05 ml of complete Freund's adjuvant solution.

The solutions of test substances were prepared *ex tempore*. ASA was used as 0.1% and 1%, MD as 1% and MASA as 0.25%, 1% and 2% aqueous solution. Test solutions were introduced to animal *p.o.* by catheter into the stomach.

The following animal groups were formed (N=7):

GROUP	TREATMENT
Group 1	intact animals, used as controls (Control);
Group 2	animals with induced adjuvant arthritis (AdA);
Group 3	animals receiving ASA in dose 10 mg/kg daily for 28 days after the induction of adjuvant arthritis (ASA10);
Group 4	animals receiving ASA in dose 100 mg/kg daily for 28 days after the induction of adjuvant arthritis (ASA100);
Group 5	animals receiving MD in dose 100 mg/kg daily for 28 days after the induction of adjuvant arthritis (MD100);
Group 6	animals receiving MASA in dose 25 mg/kg daily for 28 days after the induction of adjuvant arthritis (MASA25);
Group 7	animals receiving MASA in dose 100 mg/kg daily for 28 days after the induction of adjuvant arthritis (MASA100);
Group 8	animals receiving MASA in dose 200 mg/kg daily for 28 days after the induction of adjuvant arthritis (MASA200);

Animals of Control group and animals of AdA group instead of test substances received water *p.o.* on the same schedule as test groups.

Statistics. Data were analyzed by Microsoft Excel 2007 software and results expressed as Mean±SEM. Mean results of different groups were compared using single-factor analysis according to ANOVA with repeated comparison (Tukey's test). $P<0.05$ was considered as significant.

Results. Dynamics of clinical manifestation of arthritis was investigated on Day 14 and Day 28. The effects of test substances were evaluated using the following criteria:

1. Evaluation of local manifestation of arthritis – volume of paw and circuit of ankle joint.
2. Evaluation of blood count (WBC).
3. Evaluation of biochemical tests (CRP).
4. Evaluation of immunological indices (levels of CIC).

The oedema, i.e. the volume of hind paw was measured by oncometer. The percentage of prevention (inhibition of oedema) was calculated according to formula:

$P(\%) = (Vc - Vt)/Vc \times 100$, where

Vc – paw volume in control group

Vt – paw volume in test group

P – Prevention in % (inhibition of oedema).

Hematological indices were determined by standard methods on hematological analyzer «PENTRA 120», CRP was determined on «INTEGRA 400+».

Levels of CIC in blood serum were determined spectrometrically, using ethylene glycol.

After injection of Freund's adjuvant all animals of test groups developed chronical inflammation, rats were weary, aggressive on handling, tousled. However the feeding habits in all groups were not different from controls. The increase of body mass in all groups was not substantially different from the control group.

In Tables 13 and 14 the data on local manifestation of arthritis are presented: the volume of paw (characterizing oedema of soft tissue) and circuit/volume of ankle joint (characterizing arthritic type organic damages of joint tissues) on Day 14 and Day 28.

Table 13

Effects on paw volume (ml) by test substances on Day 14 and Day 28 after the injection of Freund's adjuvant; N=7; Mean±SEM

Group	Paw volume on Day 14		Paw volume on Day 28	
	ml	Prevention %	ml	Prevention %
Control	1.03±0.12$^{###}$	-	1.08±0.17$^{###}$	-
AdA	2.42±0.17	0	2.23±0.24	0
ASA10	2.53±0.10	-7	2.08±0.12	7
ASA100	2.35±0.14	3	1.52±0.07$^{#}$	32
MD100	2.60±0.21	-7	1.93±0.13	13
MASA25	2.20±0.21	9	1.32±0.12$^{#\&\&\$}$	41
MASA100	2.07±0.17$^{\&}$	15	1.22±0.08$^{\#\&\&\&@\$}$	45
MASA200	2.13±0.11$^{\&}$	12	1.7±0.09$^{\#\&@}$	24

$^{#}$P<0.05 *vs* AdA - $^{###}$P<0.0005 *vs* AdA - $^{\&}$P<0.05 *vs* ASA10 - $^{\&\&}$P<0.005 *vs* ASA10
$^{\&\&\&}$P<0.0005 *vs* ASA10 - $^{@}$P<0.05 *vs* ASA100 - $^{\$}$P<0.05 *vs* MD

As follows from data of Table 13 on Day 14 all animals of test groups developed pronounced oedema of soft tissues. Treatment during 14 days relatively little influenced the development of oedema. However, animals in groups MASA100 and MASA200 had significantly less pronounced oedema than animals in ASA10 group. MD and ASA10 on Day 14 did not prevent the development of oedema, but had even higher volumes as compared to AdA group (negative protection -7%). MASA in all doses and ASA100 on Day 28 significantly protected from development of oedema (protection %, respectively, 41, 45, 24 and 32 %). It should be noted that MASA100 displayed significantly better protection than ASA10, ASA100 and MD.

Table 14

Effect of test substances on changes in rat ankle joints on Day 14 and Day 28 after injection of Freund's adjuvant. N=7; Mean±SEM

Group	Dimensions of ankle joint on Day 14, mm	Dimensions of ankle joint on Day 28, mm
Control	5.6±0.09$^{##}$	5.8±0.12$^{##}$
AdA	7.2±0.14	7.3±0.16
ASA10	7.2±0.12	6.8±0.14$^{#}$
ASA100	6.9±0.15	7.1±0.16
MD100	7.0±0.13	7.0±0,13
MASA25	7.0±0.14	6.7±0.15$^{#}$
MASA100	7.0±0.13	6.6±0.16$^{\#@\$}$
MASA200	6.8±0.10$^{\#\&}$	6.9±0.11

$^{#}$P<0.05 *vs* AdA - $^{##}$P<0.005 *vs* AdA - $^{\&}$P<0.05 *vs* ASA10 - $^{@}$P<0.05 *vs* ASA100
$^{\$}$P<0.05 *vs* MD

Analysis of ankle joint data (Table 14) shows that on Day 14 only MASA200 had significantly protected against progressing of arthritic damages. On Day 28 significant protection was shown by MASA25, MASA100 and ASA100. Comparatively best protection in this experimental setting was displayed by MASA100. We have established that on Day 28 the level of oedema (Table 13) and arthritic changes in ankle joint (Table 14) were diminished. MASA100 was

significantly more effective than ASA or MD. The evaluation of WBC showed increase (leucocytosis) under the influence of Freund's adjuvant (Table 15). Leucocytosis is a characteristic feature of inflammation process.

Table 15

Changes of WBC in rat blood under the influence of test substances on Day 14 and Day 28 after injection of Freund's adjuvant. N=7; Mean±SEM

Group	Leucocytes $10^3/mm^3$	
	Day 14	Day 28
Control	15.17±0.76$^{\#\#}$	16.50±0.52$^{\#\#}$
AdA	21.48±1.47**	20.32±0.90**
ASA10	15.83±1.23$^{\#}$	16.68±1.22$^{\#}$
ASA10	17.07±1.43	16.91±1.17$^{\#}$
MD100	14.42±1.41$^{\#}$	15.55±1.26$^{\#}$
MASA25	14.72±1.63$^{\#}$	16.77±1.78
MASA100	14.13±0.53$^{\#\#}$	15.52±0.57$^{\#\#}$
MASA200	15.42±1.40$^{\#}$	14.35±0.84$^{\#\#}$

**P<0.005 *vs* Control - $^{\#}$P<0.05 *vs* AdA - $^{\#\#}$P<0.005 *vs* AdA

Use of test substances caused lowering of WBC compared to AdA group indicating the anti-inflammation activity. Although there was no statistically significant difference between the effects of test substances on leucocyte level increase, on Day 14 the comparatively higher activity was displayed by MASA100, but on Day 28 – by MASA200 (Table 15). For evaluation of the development of inflammation process the levels of CRP on Day 14 and Day 28 were determined. The levels of CRP are known to increase during inflammatory process.

Table 16

Changes of CRP levels in rat blood under the influence of test substances on Day 14 and Day 28 after injection of Freund's adjuvant. N=7; Mean±SEM

Group	CRP, mg/l	
	Day 14	Day 28
Control	0.19±0.01$^{\#\#\#}$	0.16±0.02$^{\#\#}$
AdA	0.30±0.02***	0.24±0.02**
ASA10	0.26±0.01**	0.19±0.01#
ASA100	0.29±0.01***	0.18±0.02$^{\#}$
MD100	0.26±0.02**	0.17±0.02$^{\#}$
MASA25	0.29±0.02**	0.15±0.02$^{\#\#\&}$
MASA100	0.29±0.02**	0.16±0.01$^{\#\#\&}$
MASA200	0.25±0.01*#$^{@}$	0.19±0.01$^{\#}$

*P<0.05 *vs* Control - **P<0.005 *vs* Control - ***P<0.0005 *vs* Control
$^{\#}$P<0.05 *vs* AdA - $^{\#\#}$P<0.005 *vs* AdA - $^{\#\#\#}$P<0.0005 *vs* AdA - $^{\&}$P<0.05 *vs* ASA10
$^{@}$P<0.05 *vs* ASA100

As follows from data in Table 16, on Day 14 all test groups showed increased levels of CRP as indication of inflammatory process. In our experimental settings only MASA200 displayed significant protection from increase of CRP on Day 14. It should be noted that MASA200 on Day 14 had substantially better effect than MASA100. On Day 28 the significantly better protection was displayed by MASA25 and MASA100 that were better than ASA10 (Table 16).

CIC levels were determined by standard spectrophotometric method (Baranovskii PV, Rudyk BI, *Laboratornoe delo* 1982;12:35-39 (Rus). Immunological factors were investigated in dynamics on Day 14 and Day 28. Changes in CIC levels are displayed in Table 17.

Table 17

Quantity (units) of CIC on Day 14 and Day 28
after injection of Freund's adjuvant. N=7; Mean±SEM

Group	CIC units, Day 14	CIC units, Day 28
Control	$9.4\pm1.05^{\#\#}$	$7.8\pm0.49^{\#\#}$
AdA	17.4±1.29**	13.4±1.25**
ASA10	$10.8\pm0.74^{\#\#}$	$8.2\pm0.53^{\#}$
ASA100	15.0±1.23*	14.4±1.66*
MD100	11.8±2.22	$8.6\pm0.93^{\#}$
MASA25	$12.6\pm0.68^{\#}$	11.8±1.53
MASA100	20.8±2.99*	$5.8\pm0.74^{\#\#\&@@\$}$
MASA200	21.6±3.26*	$6.2\pm1.02^{\#\#@}$

*P<0.05 *vs* Control - **P<0.005 *vs* Control - $^{\#}$P<0.05 *vs* AdA - $^{\#\#}$P<0.005 *vs* AdA
$^{\$}$P<0.05 *vs* MD - $^{\&}$P>0.05 vs ASA10 - $^{@}$P<0.05 *vs* ASA100 - $^{@@}$P<0.005 *vs* ASA100

On Day 14 and Day 28 the CIC levels in test groups were higher than in Control group. On Day 14 the CIC levels were lower than in AdA group only in ASA10 and MASA25 group. CIC on Day 28 in groups receiving test substances were close to controls, except than ASA100 group.

During the experiment an increase in CIC levels on Day 14 was observed in ASA100 and MASA100 and MASA200 groups. On Day 28 the CIC levels in MASA100 and MASA200 groups the CIC levels had normalised. The increase of CIC levels in blood serum can be observed in various pathological immunity conditions. Substantial increase of CIC is observed in inflammatory processes, including systemic conditions, with CIC levels indicating the intensity of the pathological process (Bier O et al, *Fundamentals of immunology*, New York, Heidelberg, Berlin, p. 442). Prolonged treatment with MASA in various doses lowered the CIC levels to norm. At sufficiently active immunity the main part of CIC is removed by Kupfer's cells and lowering of CIC levels is perceived as positive effect. The fact that use of MASA in MASA100 and MASA200 groups displayed normalising effect on CIC levels on Day 28 indicated that prolonged use of MASA in various doses might be clinically more promising in treatment of arthritis than elevated doses of ASA.

Example 9. Investigation of anti-hyperlipidemic properties

Atherosclerosis is a multifactoral process (Berliner JA et al, *Circulation* 1995;91:2488-2495) with increasing clinical impact along with increasing coronary heart disease symptoms. A substantial role in the atherosclerotic process is played by inflammation and organism's response to it (Ross R, *Am Heart J* 1999;138;S419-S420). Clinical observations indicate that anti-inflammation therapy reduces the manifestations of atherosclerosis (Stoller DK et al, *J Surg Res* 1993;54:7-11). Experimental data confirm the considerable correlation of anti-inflammation activity with hypolipidemic activity at least among COX-1 inhibitors (Kourounakis AP et al, *Exper Mol Pathol* 2002;73:135-138). We compared the hypolipidemic activity of ASA and MASA in equivalent doses.

9.1. Comparative effects of test substances on lipid levels in rat acute hyperlipidemia model

Methods. Male Wistar rats with body mass of 250-270 g were used. Animals were held in groups of 6-8 in climatized rooms at 22 ±1 ^{0}C, relative humidity 60 ±5%, and 12/12 light/dark cycle with free access to water and feed. Acute experimental hyperlipidemia/hypercholesterolemia was induced by Triton WR1339 (TR) as described by Kourounakis AP et al, *Exper Mol Pathol* 2002;73:135-138). Rats after overnight fasting were treated *i.p.* by TR dissolved in isotonic saline in 250 mg/kg dose. The solution of test substances or water was introduced to control and TR group animals *p.o.* one hour before and 20 hours after the introduction of TR as described below.

Blood for biochemical analysis was collected on the next day (24 hours after the injection of TR) by heart punction under ether narcosis. Serum was separated by centrifugation and analyzed for total cholesterol, HDL, LDL and TG levels by commercial kits.

Three series of experiments were conducted.

Statistics. Data were analyzed by Microsoft Excel software and results expressed as mean +/- mean standard error of mean. Mean results of different groups were compared using single-factor analysis according to ANOVA and t-Student's test. $P<0.05$ was considered as significant.

I series – ASA, MD and MASA compared

GROUP	TREATMENT	Number of animals
Control		6
TR	TR 250 mg/kg	8
ASA45	TR 250 mg/kg+ASA 45 mg/mg	6
ASA90	TR 250 mg/kg+ASA 90 mg/mg	8
MD150	TR 250 mg/kg+MD 150 mg/kg	8
MASA75	TR 250 mg/kg+MASA 75 mg/kg	6
MASA150	TR 250 mg/kg+MASA 150 mg/kg	8
MASA300	TR 250 mg/kg+MASA 300 mg/kg	8

Results. Rats that received TR developed pronounced hypercholesterolemia and hyperlipidemia with total cholestorol, LDL and TG levels significantly different from those of control group (total C increase 6-7 times, TG 30 – and more, see Table 18). ASA therapy, especially in dose 90 mg/kg, limited the increase of total C, LDL and TG, but did not significantly change the level of HDL. MD in our experimental setting did not significantly protect from the changes in lipid levels caused by TR. Treatment with MASA caused dose dependant protection from TR-induced hyperlipidemia/hypercholesterolemia. MASA in dose 75 mg/kg does not differ from ASA45, but MASA150 is considerably more efficient than ASA45 and MD150 in protecting from TR effects. MASA300 considerably better than ASA45 and ASA90 lowered the levels of total C, LDL and TG. It indicates that MASA can be useful in preventing and/or treating hypercholesterolemic and hyperlipidemic conditions and considering its anti-inflammation activity can be useful in preventing and/or treating of atherosclerosis and other conditions advanced by disturbances in lipid metabolism and inflammation.

Table 18

Comparative effects of MD, ASA and MASA
on lipid levels in rat hyperlipidemia model; n=6-8; Mean±SEM

Group	C mg/dl	HDL mg/dl	LDL mg/dl	TG mg/dl
Control	80.7±4.7***	56.5±2.8	21.1±2.6***	44.0±6.9***
TR	453.6±40.0	60.3±9.6	386.0±36.5	1399±129.7
ASA45	381.0±30.3	62.8±10.9	307.4±37.8	973±82.7*
ASA90	288.1±23.5*	60.0±7.4	219.1±23.9*	791±73.9**
MD150	345.6±34.1	63.8±9.3	273.9±31.6*	1022±80.7*
MASA75	341.9±16.3*	68.1±8.7	270.1±12.8*	861±105.7*
MASA150	249.6±22.2**$&	58.2±8.1	182.4±19.6**$&	668±104.4**$&
MASA300	219.0±16.7**$#&	56.3±8.6	158.6±19.4**$#&	548±73.2***&$#

*P<0.05 *vs* TR - **P<0.005 *vs* TR - ***P<0.0005 *vs* TR - $P<0.05 *vs* ASA45
# P<0.05 *vs* ASA90 - &P<0.05 *vs* MD150

II series – ASA, MASA, NA and combinations ASA+NA, MASA+NA compared

GROUP	TREATMENT	Number of animals
Control		6
TR	TR 250 mg/kg	8
ASA45	TR 250 mg/kg+ASA 45 mg/mg	6
MASA	TR 250 mg/kg+MASA 150 mg/kg	6
NA	TR 250 mg/kg+NA 50 mg/kg	7
ASA+NA	TR 250 mg/kg+ASA 45 mg/kg+NA 50 mg/mg	7
MASA+NA	TR 250 mg/kg+MASA 150 mg/kg+NA 50 mg/kg	7

Results. In our experimental setting NA provided significant protection against changes in lipid (C, LDL and TG) levels induced by TR (See Table 19). The combination of ASA and NA did not significantly change the effect of NA on lipid levels. Surprisingly the combination of MASA and NA considerably enhanced the effect of NA50 and surpassed the protective effect of MASA on TG levels increase caused by TR (Table 19). The combined use of MASA and NA was also significantly more efficient than normalizing effect of ASA45+NA50 on LDL and TG levels.

Table 19

The effects of MD, ASA and MASA, separately and in combination,
on lipid levels in rat hyperlipidemia model; n=6-8; Mean±SEM

Group	C mg/dl	HDL mg/dl	LDL mg/dl	TG mg/dl
Control	80.7±4.7***	56.5±2.8	21.1±2.6***	44±6.9***
TR		60.3±9.6	386.0±36.5	1399±129.7
ASA45	381.0±30.3	62.8±10.9	307.4±37.8	973±82.7*
MASA150	249.6±22.2**$	58.2±8.1	182.4±19.6**$	668±70.9**$
NA50	327.5±38.4*	66.5±14.6	246.3±32.5*	591±43.3**
ASA45+NA50	316.0±43.1*	57.9±14.3	251.2±33.8*	618±42.8**
MASA150+NA50	226.3±24.9**#$	63.1±10.2	163.2±19.3**$#%	468±34.7**$#%@

*P<0.05 *vs* TR - **<0.005 *vs* TR - ***P<0.0005 *vs* TR - $P<0.05 *vs* ASA45
@P<0.05 *vs* MASA150 - #P<0.05 *vs* NA50 - %P<0.05 *vs* ASA45+NA50

III series – SI, MD, MASA and combinations SI+MD, SI+MASA compared

GROUP	TREATMENT	Number of animals
Control		6
TR	TR 250 mg/kg	8
SI	TR 250 mg/kg+SI 5 mg/kg	7
MD	TR 250 mg/kg+MD 150 mg/kg	6
MASA	TR 250 mg/kg+MASA 150 mg/kg	6
SI+MD	TR 250 mg/kg+SI 5 mg/kg+MD 150 mg/kg	7
SI+MASA	TR 250 mg/kg+SI 5 mg/kg+MASA 150 mg/kg	7

Results. In our experimental setting SI in 5 mg/kg dose provided significant protection against changes in lipid (C, LDL and TG) levels induced by TR (see Table 20). The combination of SI with the test substances increased the normalizing effect on lipid levels. MASA in combination with SI was significantly more efficient than MD+SI in counteracting the increase of LDL and TG levels caused by TR (Table 20). Combination of MD with statins has been proposed in WO2006099244 without any data. Combined use of statins and ASA requires special pharmaceutical composition, since the substances are pharmacologically and chemically incompatible (US 6,235,311), therefore no synergy is possible.

Table 20

The effects of MD, MASA and SI, separately and in combination, on lipid levels in rat hyperlipidemia model; n=6-8; Mean±SEM

Group	C mg/dl	HDL mg/dl	LDL mg/dl	TG mg/dl
Control	80.7±4.7***	56.5±2.8	21.1±2.6***	44±6.9***
TR	453.6±40.0	60.3±9.6	386.0±36.5	1399±129.7
SI	321.3±32.3*	53.7±12.4	259.3±30.1*	826±44.1**
MD	345.6±34.1	63.8±9.3	273.9±31.6*	1022±80.7*
MASA	249.6±22.2**$^{\&}$	58.2±8.1	182.4±19.6**$^{\&}$	668±70.9**$^{\&}$
SI+MD	281.5±31.2**$^{\&}$	59.5±14.9	217.1±26.2*	690±32.6**$^{\&\$}$
SI+MASA	230.7±28.6**$^{\&\$}$	62.8±14.6	153.4±28.0**$^{\&\$\#}$	512±40.2**$^{\&\$\#}$

*P<0.05 *vs* TR - **<0.005 *vs* TR - ***P<0.0005 *vs* TR - $^{\&}$P<0.05 *vs* MD
$^{\$}$P<0.05 *vs* SI - $^{\#}$P<0.05 *vs* MD+SI

Summary. The results indicate the potential of MASA in preventing and/or treating of hypercholesterolemia and hyperlipidemia. Considering the anti-inflammatory activity of MASA it can be more efficient than ASA or MD in preventing and/or treating of atherosclerosis and other conditions advanced by inflammation. The combined use of MASA and NA enhances the positive effects of separate substances on experimentally increased lipid levels better than ASA plus NA. MASA in combination with SI was not only more efficient than SI alone, but was also significantly more efficient than MD+SI in counteracting the increase of LDL and TG levels caused by TR.

9.2. Influence of NA and MASA, separately and in combination, on lipid levels in rat chronic hyperlipidemia model

Methods. Male Wistar rats were used. Animals were held in climatized rooms 22 ±1 ^{0}C with relative humidity 60 ±5%, and 12/12 light/dark cycle with free access to water and feed. Initial weight of animals was 220-240 g. Experimental chronical (subchronical) hyperlipidemia/hypercholesterolemia was induced by TR using the method described by Levine and Saltzman (Levine S, Saltzman A,

J Pharmacol Toxicol Meth 2007;55:224-226). Animals received 250 mg/kg of TR solution via tail vein three times a week for 3 weeks. Solutions of test substances or water for Control and TR group was introduced p.o. once a day one hour before injection of TR solution or taking a blood sample according to the following scheme:

GROUP	TREATMENT	Number of animals
Control		10
TR	TR 250 mg/kg	14
TR+NA	TR 250 mg/kg+NA 50 mg/kg/d	14
TR+MASA	Triton 250 mg/kg+150 mg/kg/d	14
TR+NA+MASA	Triton 250 mg/kg+NA 50 mg/kg+MASA 150 mg/kg/d	14

Blood for biochemical analyses was obtained after 1, 2 and 3 weeks (on the next day after the TR injection) by cardiac punction under ether narcosis. Serum was separated by centrifugation and analyzed for total C, HDL, LDL and TG levels by commercial kits.

Statistics. Data were analyzed by Microsoft Excel software and results expressed as mean +/- mean standard deviation. Mean results of different groups were compared using single-factor analysis according to ANOVA and t-Student's test. $P<0.05$ was considered as significant.

Results. Repeated injections of TR developed pronounced and stable hypercholesterolemia and hyperlipidemia, characterized by significant increase of total C, LDL and TG levels compared to Control (total C increased 6-7 times, TG - 30 and more, see Table 21). NA therapy, especially significantly in the first week, limited the increase of total C, LDL and TG, but significantly increased the HDL levels in 2 and 3 week only. MASA almost equally as NA lowered total C and LDL levels and increased HDL levels, but less than NA prevented from the increase of TG, caused by TR (see Table 21). Unexpectedly the combined use of NA+MASA after 3 weeks substantially better than NA or MASA alone lowered total C, LDL and TG levels and increased HDL levels. Thus the combination NA+MASA is expected to be useful for preventing and/or treating hypercholesterolemia and hyperlipidemia.

Table 21

Influence of NA and MASA, separately and in combination, on lipid levels in rat hyperlipidemia model; n=9-14; Mean±SEM

Group	Total C after 1, 2 and 3 weeks, mg/dl		
	C1	C2	C3
Control	77.6±4.9#	75.1±5.1#	72.7±2.5#
TR	487.6±25.4	501±16.7	513±41.1
TR+NA	345±15.7*	401.1±25.1**	405.5±25.9*
TR+MASA	375.9±25.8*	406.7±19.8**	409±39.4
TR+NA+MASA	331.7±28.4**	379.1±24.7**	375.8±31*

Table 21 cont.

Group	HDL after 1, 2 and 3 weeks, mg/dl		
	HDL1	HDL2	HDL3
Control	54.6±1.9*	54.1±1.3	53.7±1.0*
TR	76.3±6.9	76.2±11.4	77±10.2
TR+NA	111.3±9.1*	144.7±13.5#	127.3±10.9*
TR+MASA	100.1±9.4	113.8±13.1	128.3±18.5*
TR+NA+MASA	112.3±10.9*	129.2±13.1*	154.1±19#

Table 21 cont.

Group	LDL after 1, 2 and 3 weeks, mg/dl		
	LDL1	LDL2	LDL3
Control	18.7±3.8$^{\#}$	19.7±4.4$^{\#}$	16.3±2.0$^{\#}$
TR	388.7±26.7	402.1±19.2	405.1±41.7
TR+NA	216.3±14.0	250.3±20.6$^{\#}$	265.1±18.4*
TR+MASA	263.3±19.4	287.6±18.5$^{\#}$	261.9±12.6**
TR+NA+MASA	205.7±18.5$^{\#\&}$	222.4±16.5$^{\#\&}$	214.4±15.1$^{\$\&\#}$

Table 21 cont.

Group	TG after 1, 2 and 3 weeks, mg/dl		
	TG1	TG2	TG3
Control	38±2.9$^{\#}$	37±3.2$^{\#}$	38±4.4$^{\#}$
TR	1240±80.1	1297±78.3	1234±114.1
TR+NA	734±81.6$^{\#}$	860±73.8**	828±44.7*
TR+MASA	964±94.9*	1079±84	982±72.7
TR+NA+MASA	721.6±52.4$^{\&\#}$	807.6±80.1$^{\&\#}$	714±27.3$^{\&\$\#}$

*P<0.05 *vs* TR - **<0.005 *vs* TR - $^{\#}$<0.0005 *vs* TR - $^{\$}$P<0.05 *vs* NA
$^{\&}$P<0.05 *vs* MASA

The combined use of MASA and NA is significantly more efficient than action of substances alone.

Example 10. Influence of test substances on platelet aggregation and formation of thrombi

10.1. Platelet aggregation

ASA is one of the most widely used prophylactic antiplatelet agents (Miner J et al, *Tex Heart Inst J* 2007;34(2):179-186). ASA has been combined with NA as anti-inflammatory agent (US 3,312,593) and antiplatelet agent (WO 9632942). Many other agents and combinations thereof are known. It has been established that MD normalizes vascular tone, inhibits platelet aggregation and fatty acid oxidation, and optimizes oxygen consumption during myocardial ischemia (Tsirkin VI, *Ros Kardiol Zh* 2002;1:45-52). NA also slightly inhibits platelet aggregation (Lakin KM et al, *Farmakol Toksikol*, 1980,43(5):581-5 (Rus). The typical antiplatelet agent clopidogrel is used alone (US 4,529,596, US 4,847,265, US 5,576328) or in combination with statin (WO9804259) or ASA (WO9729753). Also the antiplatelet agent dipyridamole can be combined with ASA (Halkes PH et al, *Lancet* 2006,367(9523):1665-73). The clinical experience points to higher versatility of various agent combinations.

Method. Platelet aggregation was studied using whole blood impedance aggregometry on Multiplate (Multiple Platelet Function Analyzer, Dynabyte Medical, Germany) (Toth O et al, *Thromb Haemost* 2006;96:781-788. Velik-Salchner C et al, *Anesth Analg* 2008;107:1798-1806). Blood samples for *in vitro* experiment were collected from healthy donor B. (age 37 y.), who had not used ASA or any other antiplatelet agents, into plastic tubes covered with hirudin (Dynabyte Medical, Germany) and used for measurement between 30 min and 4 h after collection. In the *ex vivo* experiment blood was collected into plastic tubes covered with hirudin (Dynabyte Medical, Germany) from narcotized rats that were treated for 3 previous days with test substances *p.o.* The measurements were performed according to modified Dynabyte Medical protocol. Isotonic sodium chloride solution (0.3 ml, or saline with

investigated compound (in final concentration 10^{-4} mmol/ml each of them)) was pre-heated to 37 ^{0}C and pipetted into the test cells and 0.3 ml of whole blood sample anticoagulated with hirudin was added. After 5 min incubation and stirring at 37 ^{0}C, measurements were initiated by adding of the appropriate agonist solution (sourced from Dynabyte Medical, Germany):

1) adenosine diphosphate (ADP) - ADP-Test. ADP stimulates platelet activation by the ADP receptors (P2Y12 and other).

2) arachidonic acid (AA) – ASPI-Test: activation by AA – the substrate of the cyclooxygenase forms tromboxane A2 (TXA2) which is a potent platelet agonist.

3) ADP HS test (prostaglandin E_1 in combination with ADP). The addition of the endogenous inhibitor PGE_1 make ADP HS test more sensitive towards the effects of clopidogrel and related drugs compared to ADP test.

Aggregation curves were recorded for 6 min. and analyzed using Dynabyte Medical software. We calculated the following parameters of platelet aggregation:

1) Amax, the maximal value of platelet aggregation expressed in arbitrary units (AU) of aggregation;

2) AUC, total area under the aggregation curve (AU*min). It is affected by the total height of the aggregation curve as well as by its slope and is best suited to express the overall platelet activity.

Statistics. The results were expressed as the mean and standard error of the mean (Mean ± SEM). To estimate significance of differences, one-way ANOVA was used. If null hypothesis had been rejected, the post-hoc Student-Newman-Keuls test was employed.

Results. As shown in Table 22, MASA in concentration 10^{-4} mol provided significant protection against ADP and especially against platelet aggregation induced by AA and ADP+PGE_1 (significant reduction of AUC un Amax, Table 22). NA (in 10^{-4} mmol/ml group) also reduced aggregation caused by ADP (see Amax, Table 22). The combined action of both substances provided significantly higher and pronounced reduction of platelet aggregation caused by ADP or ADP+PGE_1, manifested both in AUC and Amax data (Table 22).

Table 22

MD, NA and combined influence on ADP, AA and PGE_1+ADP induced platelet aggregation; Mean ± SEM; N= 5-8.

Group	ADP	
	AUC (AU*min)	Amax (AU)
Control	942±43.7	169.3±6.4
MASA 10^{-5}	828±63.5	153.5±8.8
MASA 10^{-4}	798±38.9[1]	140.5±7.2[1]
MD 10^{-4}	869 ±36.3	153.2±6.1
ASA 10^{-4}	883±50.3	151.7±9.3
NA 10^{-4}	859±62.5	148.0±5.2[1]
MD10^{-4}+NA10^{-4}	474± 34.9[3##$$a]	81.0±5.7[4##$$a]
MASA 10^{-4}+NA10^{-4}	403± 37.5[3@a$$&##]	75.3±6.8[2@a$$&##]
ASA+NA	805±47.3[1b]	137±7.1[1b]

Table 22 cont.

Group	AA	
	AUC (AU*min)	Amax (AU)
Control	1023±46.3	178.8±6.9
MASA 10^{-5}	832±54.1[1]	148.4±5.7[1]
MASA 10^{-4}	298±25.3[3#&$]	66.1±6.8[3#&$]
MD 10^{-4}	1050±37.6[&]	179.5±7.3[&]
ASA 10^{-4}	450±24.8[2#@]	103.1±5.9[2#@]
NA 10^{-4}	1010±41.7	161.1±9.4
MD10^{-4}+NA10^{-4}	1106±55.4[a]	173.3±12.1[a]
MASA 10^{-4}+NA10^{-4}	216±18.7[4@ab$$###&]	48.5±6.9[4@ab$$###&]
ASA+NA	463±35.2[2b$#]	99.4±8.2[2b$#]

Table 22 cont.

Group	PGE_1+ADP	
	AUC (AU*min)	Amax (AU)
Control	1005±46.5	175.3±8.9
MASA 10^{-5}	595±45.3[1]	99.3±4.8[2]
MASA 10^{-4}	533±20.3[3]	87.7±4.6[3]
MD 10^{-4}	587±37.4[2]	101.4±2.2[2]
ASA 10^{-4}	-	-
NA 10^{-4}	862±51.9	146.7±8.6
MD10^{-4}+NA10^{-4}	306±35.5[3#$a]	54.5±5.8[3#$a]
MASA 10^{-4}+NA10^{-4}	296±28.7[4@a$#]	50.2±7.3[3@a$$#]
ASA+NA	603±42.5[1$b]	98.0±7.2[2$b]

[1]P<0.05 *vs* Control - [2]P<0.005 *vs* Control - [3]P<0.0005 *vs* Control
[4]P<0.00005 *vs* Control - [&]P<0.05 *vs* ASA - [#]P<0.005 *vs* MD 10^{-4}
[##]P<0.0005 *vs* MD 10^{-4} - [$]P<0.005 *vs* NA 10^{-4} - [$$]P<0.0005 *vs* NA 10^{-4}
[@]P<0.05 *vs* MASA 10^{-4} - [a]P<0.05 *vs* ASA+NA - [b]P<0.05 *vs* MD+NA

MASA significantly better than ASA or MD protected from platelet aggregation induced by AA (Table 22). The combination MASA+NA displayed significantly higher activity against aggregation induced by AA, surpassing that of each substance separately, as well as that of ASA+NA and MD+NA (Table 22).

Parallel experiments were conducted with dipyridamole (DI) and combination of DI with ASA or MASA on ADP or AA caused platelet aggregation (Table 23). DI displays anti-thrombotic and anti-aggregatory activity (Mammen EF, *Thrombosis Research Supplement* 1990 XII, 1-3). Dipyridamole plus aspirin versus aspirin alone is more effective after cerebral ischaemia of arterial origin (Halkes PH et al. Lancet 2006, 367(9523):1665-73).

Table 23

Influence of test substances separately and in combination on platelet aggregation induced by ADP or AA. Mean ± SEM; N= 5-8.

Group	ADP		AA	
	AUC (AU*min)	Amax (AU)	AUC (AU*min)	Amax (AU)
Control	942±43.7	169.3±6.4	1023±46.3	178.8 ±6.9
MASA 10^{-4}	798±38.9[1]	140.5±7.2[1]	298±25.3[3aa&]	66.1±6.8[3aa&]
ASA 10^{-4}	883±50.3	151.7±9.3	450±24.8[3a@]	103.1±5.9[2a@]
DI 3x10^{-4}	665±44.1[2&]	111.1±6.9[2&]	1104±45.5[&@@]	173.9±5.2[&@@]

MASA 10^{-4} +DI $3x10^{-4}$	$465\pm27.0^{3@\$a\&}$	$69.7\pm3.2^{3@\$a\&}$	$116\pm9.8^{4@@\$\$aaa\&}$	$38.5\pm3.6^{4@@\$\$aa\&}$
ASA 10^{-4} +DI $3x10^{-4}$	$667\pm39.4^{2\&}$	$105.2\pm6.7^{2\&@}$	$207.9\pm27.5^{3\&aa}$	$62.8\pm6.8^{2\&aa}$

$^{1}P<0.05$ *vs* Control - $^{2}P<0.005$ *vs* Control - $^{3}P<0.0005$ *vs* Control
$^{4}P<0.00005$ *vs* Control - $^{\&}P<0.05$ *vs* ASA - $^{@}P<0.05$ *vs* MASA
$^{@@}P<0.005$ *vs* MASA - $^{a}P<0.05$ *vs* DI - $^{aa}P<0.005$ *vs* DI - $^{aaa}P<0.0005$ *vs* DI
$^{\$}P<0.05$ *vs* ASA+DI - $^{\$\$}P<0.005$ *vs* ASA+DI

In this series the highest activity was displayed by MASA+DI that was significantly higher than that of ASA+DI (Table 23).

10.2. Thrombosis

Two weeks long therapeutic use of MD peroral administration in rabbits and dogs after experimental arterial thrombosis showed trombolytic effect (Logunova L et al, *Experim Clin Pharmacoter* 1991;19:91-98 (Rus). No data on prophylactic effect of MD on limitation or prevention of thrombosis are known. Through a variety of mechanisms, NA reduces thrombosis (Rosenson RS et al, *Atherosclerosis* 1998;140:271-80).

Method. We chose an experimental thrombosis model based on rat arterial thrombosis induced by $FeCl_3$ (Kurz K et al, *Thromb Res* 1990,60:269-280. Wang X, Xu L, *Thromb Res* 2005,115:95-100). Tissue damage initiated by iron-mediated chemical oxidation predisposes the injured area to platelet adherence and aggregation followed by coagulation activation and fibrin deposition. Male Wistar rats with mass 350-420 g were used in experiments. Animals were kept in groups of 7-8 in adequate cages in climatized room at 22±1 °C, relative humidity 60 ±5% and 12/12 light/darkness cycle with free access to feed and water. All experiments were carried out in accordance with the European Community Council's Directive of 24 November 1986 (86/609/EEC) relative to experimental animal care. All efforts were made to minimize animal suffering and to reduce the number of animals used. Rats were randomly divided into various experimental groups, each consisting of not less than seven animals. The vehicle or test compound MD (25 mg/kg), NA (25 mg/kg), MASA (10 mg/kg), ASA (5 mg/kg) and combination MD+NA (25+25 mg/kg), MASA+NA (10+25 mg/kg) and ASA+NA (5+25 mg/kg) was administered by oral route 2h before the initiation of thrombosis. Parallel experiments were conducted to compare the effects of a single dose of test substance (given 2h before the initiation of thrombosis) and repeated doses (once daily for 3 days). Groups of 7-8 animals received the following substances: MASA (10 mg/kg), clopidogrel (CL) (5 mg/kg), ASA (5 mg/kg) and combination MASA+CL (10+5 mg/kg) or ASA+CL (5+5 mg/kg). Rats were anaesthetized with pentobarbital sodium (50 mg/kg, *i.p.* and 10 mg/kg/h) and were placed on a heat controlled operating table throughout the experiment to maintain a body temperature of 37 °C. One of the carotid arteries was exposed by cervical incision, separated from the adherent tissue, vagus nerve, and a flow probe (electromagnetic blood flow meter MFV 1200, Nicon Kohden, Japan) was placed on the exposed segment of common carotid artery to record the blood flow. After a stabilization period of 15 min, thrombosis was induced by topically applying (in contact with the adventitial surface of vessel) two pieces (2x1 mm) of Whatman filter paper, soaked in 15% solution of $FeCl_3$. Thrombosis time of carotid artery was recorded as time taken for the complete cessation of the blood flow and has been reported as time till occlusion (TTO). If the blood flow did not cease within 90 min in the active treatment group, TTO was recorded as >90 min.

Additionally during the thrombosis experiment rat tail bleeding time was measured. The tail was transected 5 mm from the tip with scalpel and the tail was immediately immersed into 37 ^{0}C warm isotonic saline until termination of bleeding was noted. Termination of bleeding was defined as the time of complete stop of bleeding with no recurrence of bleeding within the next 30 s.

After the thrombosis experiment the narcotized animals who received test substances for 3 days were used for platelet aggregation test *ex vivo*. The abdomen was opened and blood from *vena cava inferior* collected into plastic tubes covered with hirudin (Dynabyte Medical, Germany).

Blood samples were used for measurement between 30 min and 4 h after collection. The measurements were performed according to modified Dynabyte Medical protocol (see above under Platelet aggregation).

Statistics. The results were analyzed by Microsoft Excel 2007 software. Data are presented as means ± SEM. Differences between experimental groups were compared using one-way ANOVA with repeated comparisons (Tukey's test). $P<0.05$ was considered as significant.

Results. The average time for $FeCl_3$ caused vessel thrombosis and the resulting arterial flow arrest in control group was 24.4 min (Table 24).

Table 24

Influence of test substances on $FeCl_3$ induced carotid artery thrombosis.
Mean± SEM; N= 7-8

Group	Time till occlusion		Tail bleeding time	
	min	%	min	%
Control	24.4±1.45	100	8.9±1.28	100
NA (25 mg/kg)	30.3±3.12	124	11.5±1.39	129
MD (25 mg/kg)	29.8±2.29	122	10.5±1.01	118
MD+NA (25+25 mg/kg)	34.0±2.78[1]	139	11.4±1.42	128
MASA (10 mg/kg)	41.7±3.95[2#]	171	12.1±2.20	136
MASA+NA (10+25 mg/kg)	53.1±4.12[2$abc#]	218	13.5±4.19	152
ASA (5 mg/kg)	35.2±3.02[1]	144	13.8±3.27	155
ASA+NA (5+25 mg/kg)	42.5±4.24[2$#]	174	15.2±2.12[1]	171

[1]$P<0.05$ vs Control - [2]$P<0.005$ vs Control - [#]$P<0.05$ vs MD - [$]$P<0.05$ vs NA
[a]$P<0.05$ vs ASA - [b]$P<0.05$ vs ASA+NA - [c]$P<0.05$ vs MD+NA

Prophylactic treatment with MASA provided significant prolongation of TTO ($P<0.005$ *vs* Control), but contrary to ASA was considerably less efficient in bleeding test (136 to 155 %). MASA + NA (10+25 mg/kg) caused comparatively longer delay of thrombosis, surpassing that of MD+NA or ASA+NA (Table 24). It should be noted that using ASA and ASA+NA, the increase of the TTO parallels that of bleeding time, while the increase of TTO using MASA or MASA+NA is considerably higher than that of the bleeding time (Table 24).

In parallel experiments with common control the influence on thrombosis was investigated for ASA, MASA and CL and combinations thereof. The test substances were applied as single dose (2 h before testing) or given once a day for 3 days. ASA or CL, introduced 2 hours before the thrombosis test significantly prolonged TTO *vs* control group that received water (Table 25).

Table 25

Influence of single dose of test substances on TTO and bleeding time in $FeCl_3$ induced carotid artery thrombosis experiment. Mean± SEM; N= 7-8

Group	Time till occlusion		Tail bleeding time	
	min	%	min	%
Control	24.4±1.45	100	8.9±1.28	100
MASA (10 mg/kg)	41.7±3.95[2b]	171	12.1±2.20	136
ASA (5 mg/kg)	35.2±3.02[1]	144	13.8±3.27	155
CL (5 mg/kg)	31.7±2.40[1]	130	11.9±3.62	134
MASA+CL (10+5 mg/kg)	61.5±4.31[3$abc]	252	15.7±3.16	176
ASA+CL (5+5 mg/kg)	45.4±4.80[2ab]	186	16.3±2.25[1]	183

[1]P<0.05 *vs* Control - [2]P<0.005 *vs* Control - [3]P<0.005 *vs* Control
[$]P<0.05 *vs* MASA - [a]P<0.05 *vs* ASA - [b]P<0.05 *vs* CL - [c]P<0.05 *vs* ASA+CL

Single dose of MASA provided more significant increase of TTO than CL. MASA given together with CL significantly increased TTO but only slightly changed the bleeding time (Table 25). It should be noted that combination MASA+CL caused significant increase of TTO compared with that of separate substances and that of combination ASA+CL. The repeated treatment with test substances caused further increase of TTO and bleeding time (Table 26).

Table 26

Influence of repeated treatment by test substances on TTO and bleeding time in $FeCl_3$ induced carotid artery thrombosis experiment. Mean± SEM; N= 7-8

Group	Time till occlusion		Tail bleeding time	
	min	%	min	%
Control	25.3±1.75	100	8.6±1.37	100
MASA (10 mg/kg/d)	48.4±4.35[2]	191	13.1±2.63	152
ASA (5 mg/kg/d)	40.9±3.25[1]	162	17.8±3.17[1]	207
CL (5 mg/kg/d)	49.1±7.75[1]	194	18.3±3.78[1]	213
MASA+CL (10+5 mg/kg/d)	64.6±8.01[2a$]	255	20.7±3.88[1]	241
ASA+CL (5+5 mg/kg/d)	61.0±10.32[2a]	241	27.4±4.98[2$a]	319

[1]P<0.05 *vs* Control - [2]P<0.005 *vs* Control - [$]P<0.05 *vs* MASA - [a]P<0.05 *vs* ASA

Repeated treatment with MASA or CL produced significantly higher influence on TTO than ASA (correspondingly, 191 and 194% against 162%), but MASA contrary to CL or ASA did not increase the bleeding time (Table 26). The repeated treatment with MASA+CL or ASA+CL produced considerable and rather similar increase of TTO, but MASA+CL comparatively less than ASA+CL (241% *vs* 319%) influenced the tail bleeding time (Table 26).

Eksperiments *ex vivo*

After the thrombosis experiment animal blood was collected and aggregation parameters were measured. Three days long treatment by MASA in dose 10 mg/kg caused significant reduction of platelet aggregation by all tested aggregation inducers (Table 27).

Table 27

Influence of MASA, ASA, CL and combinations thereof on platelet aggregation *ex vivo*; Mean ± SEM; N= 4-7.

Group	ADP	
	AUC (AU*min)	Amax (AU)
Control	794±33.5	149.7±9.4
MASA 10 mg/kg/d	528±46.5[1]	75.5±12.8[2]
ASA 5mg/kg/d	768±53.2	150.3±13.5
CL 5mg/kg/d	423±39.4[2&]	68.2±15.1[2&]
MASA+CL (10+5 mg/kg/d)	140±16.8[3@&ab]	35.3±9.4[3@&ab]
ASA+CL (5+5 mg/kg/d)	230±29.8[3&a]	53.3±11.5[2&]

Table 27 cont.

Group	AA	
	AUC (AU*min)	Amax (AU)
Control	935±62.3	167.8±11.6
MASA 10 mg/kg/d	232±44.1[2&a]	48.2±9.7[3&a]
ASA 5mg/kg/d	550±31.3[2]	86.1±6.8[2]
CL 5mg/kg/d	905±53.5[&]	160.7±13.5[&@]
MASA+CL (10+5 mg/kg/d)	187±29.4[3&a]	30.7±9.8[3&a]
ASA+CL (5+5 mg/kg/d)	239±32.7[2&a]	39.8±14.1[2&a]

Table 27 cont.

Group	PGE_1+ADP	
	AUC (AU*min)	Amax (AU)
Control	855±40.5	159.5±12.2
MASA 10 mg/kg/d	195±35.3[3]	41.4±14.8[2]
ASA 5 mg/kg/d	-	-
CL 5 mg/kg/d	259±49.3[2]	49.7±9.9[3]
MASA+CL (10+5 mg/kg/d)	87±15.8[3@ab]	15.5±4.8[3@ab]
ASA+CL (5+5 mg/kg/d)	128±19.4[2@a]	24.6±5.8[3@a]

[1]P<0.05 *vs* Control - [2]P<0.005 *vs* Control - [3]P<0.0005 *vs* Control - [@]P<0.05 *vs* MASA [&]P<0.05 *vs* ASA - [a]P<0.05 *vs* CL - [b]P<0.05 *vs* ASA+CL

Treatment by CL in dose 5 mg/kg/d for 3 days caused considerable protection against the aggregation induced by ADP and PGE_1+ADP, but did not protect from aggregation induced by AA. ASA provided significant protection against induction by AA, but was not effective against ADP (Table 27). The combination of MASA and CL (10+5 mg/kg/d x3) provided comparatively highest prevention from aggregation caused by various agents, significantly better than that provided by ASA+CL in ADP and PGE_1+ADP tests (Table 27).

SUMMARY

MASA considerably better than MD or ASA in similar molar concentrations protects against platelet aggregation induced by AA. Protection by MASA+NA significantly surpasses that of MD, NA and ASA, as well as combination ASA+NA against all inducers of aggregation, as well as that of MD+NA against aggregation induced by AA.

Considering the positive effect of MASA and MASA+NA combination against platelet aggregation and extension of TTO *in vivo*, MASA or MASA+NA

combination can find application for reducing platelet aggregation and thrombosis risk in patients with pronounced atherosclerosis, potential myocardial infarction and insult, as well as disturbances of peripheral circulation. The fact that MASA and MASA+NA combination does not prolong tail bleeding time indicates the possible use of this combination for patients with increased bleeding risk in pre- and postoperation period.

MASA+DI considerably better than ASA+DI protects against aggregation induced by ADP and AA.

MASA+CL. In the thrombosis experiment a single dose of MASA+CL provides better protection against $FeCl_3$ induced thrombosis than ASA+CL. MASA+CL comparatively less than ASA+CL prolongs tail bleeding time. In the *ex vivo* experiment MASA+CL provides considerably more pronounced protection against platelet aggregation than CL, ASA or MASA. MASA+CL better than ASA+CL protects against platelet aggregation induced by ADP and PGE_1+ADP.

These facts indicate that MASA+CL could find application in clinic for immediate protection against increased platelet aggregation risk, imminent or ongoing thrombosis.

Example 11. Comparative investigation of combined application of MASA/NA, MD/NA and LA/NA for reduction of NA induced flushing

Nicotinic acid (niacin, NA) effectively lowers serum cholesterol, LDL and triglycerides, while raising HDL. However a limiting adverse effect in patients receiving immediate-or sustained-release niacin is the rapid development of significant cutaneous warmth and vasodilatation, referred to as "flush" which severely leading to discontinuation (Gupta EK, Ito MK, *Heart Dis* 2002;4:124–137). Laropiprant (MK-0524) (LA) has been proposed as one of the most active and perspective agent for reducing NA flushing (Cheng K et al, *PNAS* 2006;103:6682-6687).

11.1. Antagonism to cutaneous vasodilatation, caused by nicotinic acid

Model. Male Wistar rats were narcotized by sodium pentobarbital (50 mg/kg *i.p.*) and kept under narcosis by additional doses (10 mg/kg) each hour. Blood pressure was measured in left carotid artery, ECG recorded by standard II lead. Blood flow in the right ear artery was measured by laser Doppler flow meter (OXYFLOW 2000, USA). Blood flow, ECG and arterial pressure were registered by AD Instruments PowerLab systems and stored in computer for further processing. After 10 min. long registration of baseline test substances were injected *s.c.* into withers area and registration continued for 30 min. The average blood flow data for each animal were calculated taking into account the average blood pressure and compared with initial and control. Results were calculated from 5 to 8 separate experiments and expressed in % as maximal change in blood flow to baseline (Carballo-Jane E et al, *J Pharmacol Toxicol Methods* 2007;56(3):308-316).

Statistics. The results are presented as means ± SEM for each group. Statistical analysis within groups was performed by Student t-Test. Differences between each experimental group were compared using one-way ANOVA with repeated comparisons (Tukey's test). $P < 0.05$ was considered as significant.

Results. Nicotinic acid (NA) in dose 15 mg/kg caused significant increase in blood flow in ear artery in this animal model (Table 28). MASA, similarly to control (buffered 0.9% NaCl solution), caused non-significant variation in blood flow. NA together with MASA caused delayed (slowly increasing) and statistically significant less pronounced absolute increase in blood flow as compared to NA alone (Table 28).

The potential of MASA to antagonize the peripheral vasodilatation, caused by NA may have beneficial effect in clinic for diminishing the cutaneous effects (flushing) of nicotinic acid and was further investigated in detail as described below.

Table 28

Influence of experimental substances on cutaneous vasodilatation;
Mean ±SEM, N=5-8

Group	Changes in blood flow, %
Control	2.92±2.76
NA (15 mg/kg)	55.75±11.5**
MASA (45 mg/kg)	8.04±2.02$
NA+MASA (15 mg/kg+45 mg/kg)	25.91±9.52*$

*P<0.05 *vs* Control - **P<0.005 *vs* Control - $P<0.05 *vs* NA

Conclusion

We have unexpectedly found that MASA significantly reduces peripheral vasodilatation caused by NA.

The objective of our investigation was comparing the effect of MASA, MD and LA on flushing (changes of skin temperature) caused by NA in experiment.

Methods. Male Wistar rats (280-330 g) were used. Animals were held in groups of 6 in climatized rooms at 22±1 ^{0}C, relative humidity 60±5%, and 12/12 light/dark cycle with free access to drinking water and feed (R3 – Lactamin AB, Sweden). For registration of changes in skin temperature of intact rats contactless temperature recording method was used (Papaliodis D et al, *Br J Pharmacol* 2008;153:1382-1387). Temperature measurements were performed with a hand-held infrared thermometer (Model Proscan 510, TFA-Dostman). Animals were habituated to handling and to the infrared probe for 3 days before use. Temperature readings from the dorsal side of each ear were recorded without anaesthesia at beginning and during experiment. The ear temperature was measured every 5 min. for a period of up to 60 min. The animals were returned to their cages between measurements. NA, MD and MASA were dissolved in saline and pH was corrected immediately before usage. LA (MK 0524, Cayman Chemicals) was first dissolved in DMSO and then freshly diluted with 0.9% NaCl, on each day of the experiment. The rate of NA and LA combination was based on Summary of Product Characteristics for Tredaptive™ (nicotinic acid/laropiprant) 1000 mg/20 mg modified-release tablets.

Statistics. Six ear temperature measurements (three from each ear) were averaged for each time point. Data were analyzed by Microsoft Excel software and results expressed as mean ± standard error of mean (Mean±SEM). Mean results of different groups were compared using single-factor analysis according to ANOVA and t-Student's test. P<0.05 was considered as significant.

11.2. Testing of time and solvent influence on skin temperature

GROUP	TREATMENT	Number of animals
SolvLA	Solvent for LA	6
SolvNA	Solvent for NA, MASA and MD	6
NA	NA 15 mg/kg sc	6

11.3. Investigation of separate test substances on skin temperature at simultaneous [0] or 30 min advance [30] *s.c.* administration

The influence of LA, MD or MASA alone on skin temperature was checked. Each investigated compound was introduced *s.c.* simultaneously with NA as LA+NA [0] or 30 min in advance to NA as LA+NA [30].

GROUP	TREATMENT	Number of animals
Control/solvent		6
NA	NA 15 mg/kg	6
LA	LA 0.3 mg/kg	6
LA+NA	LA 0.3 mg/kg+NA 15 mg/kg	6
MD	MD 45 mg/kg	6
MD+NA	MD 45 mg/kg+NA 15 mg/kg	6
MASA	MASA 45 mg/kg	6
MASA+NA	MASA 45mg/kg+NA 15 mg/kg	6

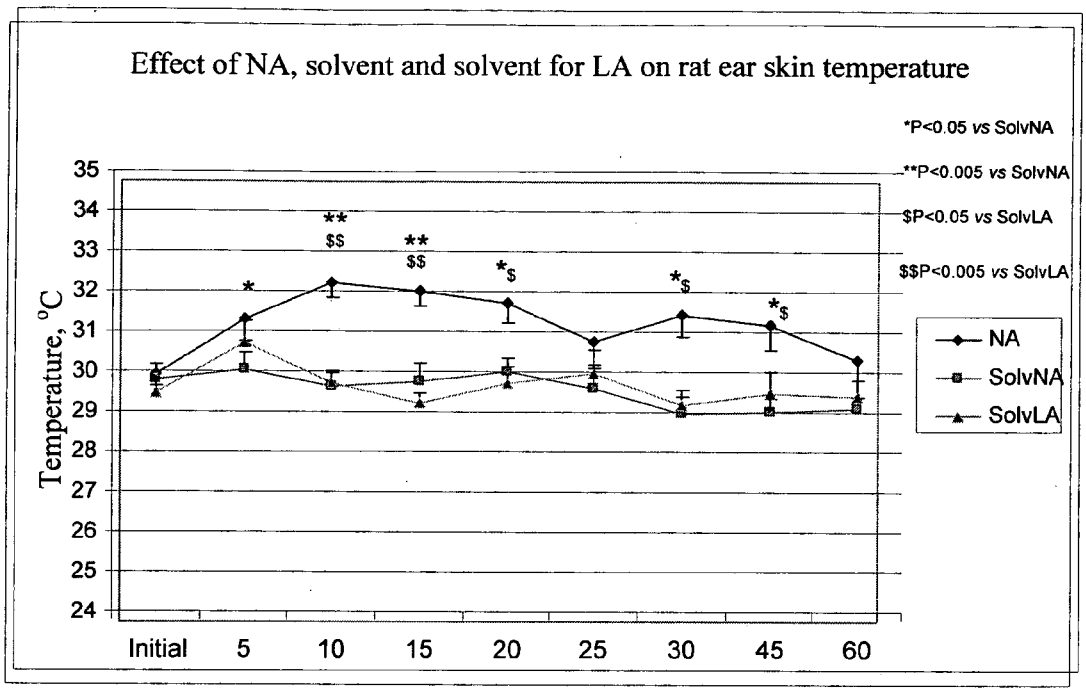
11.4. Investigation of the effect of MASA/NA and MD/NA combination on skin temperature at simultaneous [0] or 45 min advance [45] *p.o.* administration

GROUP	TREATMENT	Number of animals
Control/solvent		6
NA	NA 40 mg/kg	8
MD	MD 100 mg/kg	6
MD+NA	MD 100 mg/kg+NA40 mg/kg	6
MASA150	MASA 150 mg/kg	6
MASA75+NA	MASA 75mg/kg+NA 40 mg/kg	6
MASA150+NA	MASA 150 mg/kg+NA 40 mg/kg	6

RESULTS

R 11.2. Testing of time and solvent influence on skin temperature

The baseline mean ear temperature was 28.4–30.6 ^{0}C recorded at 10 AM to 2 PM. A time response study for NA (15 mg/kg *s.c.*) showed a maximal temperature increase of 2.32±0.37 ^{0}C from baseline and 2.57±0.43 in comparison with Solvent group ($P<0.005$) at 10 min (below). It was established that the effect of the LA solvent on ear temperature was substantially different from that of NA, MASA and MD solvent only in the first 5 min. after injection, therefore only one control group was used in calculation of temperature at 10 min.



R 11.3. Investigation of separate test substances on skin temperature at simultaneous [0] or 30 min advanced [30] *s.c.* administration

Subcutaneous injection of MASA, MD or LA did not cause significant changes in rat ear skin temperature (Table 28). There was no difference on temperature between the MD+NA [0], when MD was added together with NA, and MD+NA [30], when MD was given 30 min in advance of NA.

Table 28

Influence of MASA, LA and MD on rise of skin temperature, caused by NA; N=6, Mean±SEM

Group	Initial temperature ^{0}C	Maximum temperature ^{0}C	Increase, %
Control/solvent	29.5±0.29	29.62±0.25$^{\$\$\$}$	-
NA	29.61±0.40	32.2±0.42***	100
MASA	29.3±0.35	29.2±0.38$^{\$\$\$}$	-
MASA+NA [0]	29.9±0.31	31.5 ±0.40**	62
MASA+NA [30]	29.6±0.32	30.9 ±0.32*$^{\$}$	50
LA	29.43±0.27	29.5±0.35$^{\$\$\$}$	-
LA+NA [0]	29.72±0.31	31.45±0.40**	67
LA+NA [30]	29.51±0.32	30.73±0.34*$^{\$}$	47
MD 45	29.42±0.38	29.6±0.31$^{\$\$\$}$	-
MD+NA [0]	29.53±0.29	31.33±0.48*	69
MD+NA [30]	29.68±0.26	31.40±0.39*	65

*P<0.05 *vs* Control - **P<0.005 *vs* Control - ***P<0.0005 *vs* Control
$^{\$}$P<0.05 *vs* NA - $^{\$\$\$}$P<0.0005 *vs* NA

Simultaneous administration of NA and MASA (NA+MASA [0] group; advance time = 0) caused reduction of NA flushing that was similar to that caused by simultaneous administration of NA and LA or NA and MD. The increase of temperature, caused by NA was reduced, correspondingly from 100% (effect of NA) to 62%, 67 and 69 % (Table 27). In our experiment administration of MASA+NA and

LA+NA (when given *s.c.* 30 min in advance of NA), caused significant and similar protection against the increase of skin temperature, induced by NA (Table 28).

R 11.4. Investigation of the effect of NA/MASA and NA/MD combination on skin temperature at oral administration

Oral (*p.o.*) NA introduction in dose 40 mg/kg caused substantial and prolonged (up to 60 min.) increase of rat ear skin temperature with the maximum between 15 and 45 min. (Table 29).

Table 29

Influence of MASA or MD on NA induced skin hyperthermia by simultaneous [0] or advance [45]
treatment; N=6-8, Mean±SEM

Group	Initial temp. ^{0}C	Temp. 15 min	Temp. 30 min	Temp. 45 min	Max incr. %
Control/solvent	29.9±0.32	30.2±0.48$^{\$\$}$	30.0±0.33$^{\$\$\$}$	30.1±0.37$^{\$\$}$	9
NA	30.0±0.41	32.3±0.46**	33.1±0.41***	32.4±0.48**	100
MASA150	29.7±0.28	29.9±0.33$^{\$\$}$	29.5±0.35$^{\$\$\$}$	29.6±0.39$^{\$\$}$	6
MASA75+NA [0]	29.7±0.33	31.9±0.51*	32.3±0.37**$^{\$}$	32.1±0.46*	84
MASA150+NA [0]	29.8±0.37	30.9±0.47$^{\$}$	32.0±0.42*$^{\$}$	31.95±0.38*	70
MD	29.9±0.35	30.1±0.39$^{\$\$}$	29.8±0.38$^{\$\$\$}$	30.0±0.34$^{\$\$}$	6
MD+NA [0]	29.6±0.26	31.3±0.35*$^{\$}$	32.5±0.42**	32.2±0.40*	96
MD100+NA [45]	29.3±0.35	31.2±0.33*$^{\$}$	32.3±0.41**	32.1±0.44*	95
MASA75+NA [45]	29.4±0.30	31.3±0.53*	31.9±0.45$^{\$}$	31.5±0.42*$^{\$}$	80
MASA150+NA[45]	29.7±0.38	30.7±0.41$^{\$}$	31.2±0.44$^{\$\#}$	30.2±0.38$^{\$\$\#\&@}$	48

*P<0.05 *vs* Control - **P<0.005 *vs* Control - ***P<0.0005 *vs* Control
$^{\$}$P<0.05 *vs* NA - $^{\$\$}$P<0.005 *vs* NA - $^{\$\$\$}$P<0.0005 *vs* NA
$^{\&}$P<0.05 vs MASA150+NA [0] - $^{@}$P<0.05 *vs* MASA75+NA [45]
$^{\#}$P<0.05 *vs* MD+NA [45]

Oral introduction of MASA or MD did not cause substantial changes in skin temperature. Simultaneous introduction *p.o.* of MASA and NA [0] in dose 75 mg/kg caused small, but in dose 150 mg/kg substantial protection from increase of skin temperature induced by NA (Table 29). MD (100 mg/kg) when introduced simultaneously with NA protected from the increase of temperature for 15 min, but did not provide significant protection from the maximal increase of skin temperature, induced by NA (see temperature at 30 min, 45 min, Table 29). Analysis of results show that MASA in dose 150 mg/kg introduced simultaneously NA reduced the increase of skin temperature to 70% that is substantially better than reduction by NA+MD (96%). The increase by NA alone is regarded as 100%. Introducing substances in preventive mode – 45 min before NA, the temperature lowering action of MASA150+NA [45] increased and was significantly better than that of MD+NA [45] or MASA75+NA [45] (Table 29).

MASA when introduced *p.o.* or *s.c.* reduces the increase of skin temperature induced by NA. When introduced *s.c.* MASA similarly to laropiprant reduced the increase of skin temperature induced by NA both at simultaneous and preventive use. The substantial anti-flushing activity of MASA when introduced *p.o.* together with NA or in preventive mode, indicates the potential usefulness of MASA for reducing the undesirable cutaneous effects of NA (flushing).

SUMMARY

Since MASA has anti-inflammatory, antihyperlipidemic and antiplatelet effects it can be considered as a novel therapeutic agent for treating various pathologies induced by platelet aggregation.

MODES OF CARRYING OUT THE INVENTION

The present invention provides a medicinal product comprising MASA for use as antiinflammatory, analgesic, antipyretic, antirheumatic, antihyperlipidemic, antiatherosclerotic, antiaggregative and antithrombotic agent. The medicinal product of the invention may be administered in the form of a pharmaceutical composition. According to this aspect of the invention there is provided a pharmaceutical composition which comprises MASA in admixture with a pharmaceutically acceptable diluent or carrier.

Since the antiinflammatory, analgesic, antipyretic, antirheumatic, antihyperlipidemic, antiatherosclerotic, antiaggregative and antithrombotic use of the medicinal product presumes prolonged use, the most preferable mode of carrying out the invention is provided by a form suitable for oral use, for example as tablets or capsules.

According to a further aspect of the invention there is provided the use of the medicinal product as defined herein before or of the pharmaceutical composition as defined hereinbefore, for the manufacture of a medicament for the treatment of inflammation, pain, fever, rheumatic conditions, hyperlipidemic condition, atherosclerotic condition, platelet aggregation or thrombi formation.

A further aspect of the invention concerns combination medicinal products comprising MASA and another agent selected from the group of NA, statins, CL and DI. These products can be based on pharmaceutical compositions developed for MASA itself.

CLAIMS

1. 4-Trimethylammoniobutanoate acetylsalicylate.

2. 4-Trimethylammoniobutanoate acetylsalicylate of Claim 1, characterized by an X-ray pattern having peaks at 2Θ values 5.10, 13.58, 13.83, 15.02, 15.17, 17.89, 19.33, 19.87, 21.85, 22.05, 23.32, 23.56, 23.92, 24.75, 25.55, 25.80, 27.05, 27.91, 30.25 ± 0.2°.

3. *L*-carnitine acetylsalicylate.

4. *L*-carnitine acetylsalicylate of Claim 3, characterized by an X-ray pattern having peaks at 2Θ values 5.09, 12.62, 13.48, 13.84, 15.04, 17.82, 19.15, 19.77, 21.84, 22.56, 23.33, 23.92, 24.40, 25.17, 25.43, 26.14, 27.24, 29.50, 30.36 ± 0.2°.

5. 3-(Trimethylammonioamino)propanoate (meldonium) acetylsalicylate.

6. 3-(Trimethylammonioamino)propanoate (meldonium) acetylsalicylate of Claim 5, characterized by an X-ray pattern having peaks at 2Θ values 5.19, 13.22, 13.82, 14.20, 14.95, 15.36, 15.93, 18.11,18.97,19.74, 21.02, 22.15, 23.15, 23.65, 24.31, 25.28, 26.18, 26.58, 27.73, 28.36 ± 0.2°.

7. 3-(Trimethylammonioamino)propanoate (meldonium) acetylsalicylate of Claim 5, its solvates or polymorfs for use as medicament.

8. A pharmaceutical composition comprising 3-(trimethylammonioamino)-propanoate (meldonium) acetylsalicylate of Claim 5, and a pharmaceutically acceptable carrier.

9. A pharmaceutical composition of Claim 8 as immediate-release, sustained-release or extended-release formulation.

10. A pharmaceutical composition of Claim 8 adapted for oral administration.

11. A method for preventing and/or treating of inflammation, pain, fever, rheumatic conditions, hyperlipidemic condition, atherosclerotic condition, pathology induced by platelet aggregation or thrombi formation that comprises administering to a patient in need thereof a therapeutically effective amount of the meldonium acetylsalicylate of Claim 5 or the pharmaceutical composition of Claim 8.

12. Use of meldonium acetylsalicylate of Claim 5 or the pharmaceutical composition of Claim 8, in the manufacture of a medicament for the preventing and/or treating inflammation, pain, fever, rheumatic conditions, hyperlipidemic and atherosclerotic condition, pathology induced by platelet aggregation or thrombi formation.

13. The use of meldonium acetylsalicylate of Claim 12, wherein the pathology induced by platelet aggregation includes ischemic events such as myocardial infarction or stroke, or thrombosis and thromboembolism.

14. A combination medicinal product, comprising an effective amount of meldonium acetylsalicylate of Claim 5 and an effective amount of dipyridamole for preventing and/or treating a pathology induced by platelet aggregation.

15. A combination medicinal product, comprising an effective amount of meldonium acetylsalicylate of Claim 5 and an effective amount of clopidogrel or pharmaceutically acceptable salt thereof for preventing and/or treating a pathology induced by platelet aggregation.

16. Use of a combination medicinal product of Claim 15, wherein the pathology induced by platelet aggregation includes ischemic events such as myocardial infarct or stroke, thrombosis or thromboembolism, acute coronary syndrome, sudden cardiac death, and complications after coronary angioplasty or coronary artery bypasses.

17. A combination medicinal product with reduced side effects of peripheral vasodilatation (flushing), comprising an effective amount of meldonium

acetylsalicylate of Claim 5 and an effective amount of nicotinic acid or pharmaceutically acceptable salt thereof.

18. The product of Claim 17, wherein the nicotinic acid or pharmaceutically acceptable salt thereof is in the form of immediate-release, sustained-release or extended-release formulation.

19. The product of Claim 17, wherein meldonium acetylsalicylate is in the form of immediate-release, sustained-release or extended-release formulation.

20. Use of the combination medical product of Claim 17 for the preventing and/or treating of a pathology induced by platelet aggregation.

21. Use of the combination medical product of Claim 20, wherein the pathology induced by platelet aggregation includes ischemic events such as myocardial infarction or stroke, or thrombosis and thromboembolism.

22. Use of the combination medical product of Claim 17 for the preventing and/or treating of metabolic-related disorders.

23. Use of the combination medical product of Claim 22, wherein the disorder is chosen from the group consisting of dyslipidemia, hyperlipidemia, atherosclerosis.

24. A combination medicinal product, comprising an effective amount of meldonium acetylsalicylate of Claim 5 and a statin, selected from the group of atorvastatin, cerivastatin, fluvastatin, lovastatin, mevastatin, pitavastatin, pravastatin, rosuvastatin and simvastatin.

25. Use of the combination medicinal product according Claim 24 for the preventing and/or treating of disorder, selected from the group of dyslipidemia, hyperlipidemia and atherosclerosis.