5.2 BENTAZONE (172)

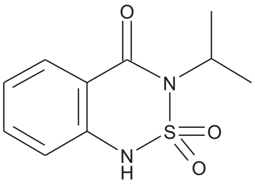
RESIDUE AND ANALYTICAL ASPECTS

Bentazone, a post-emergence herbicide, was originally evaluated by the JMPR in 1991 and re-evaluated for residues and toxicity several times up to 2004. It was reviewed as part of the periodic re-evaluation programme of CCPR on toxicity in 2012 JMPR. Bentazone is a selective herbicide applied as a post emergence treatment to control dicotyledonous weeds in agriculture, horticulture, ornamentals and amenity grasslands. The mode of action is based primarily on an irreversible blockage of photosynthetic electron transport and in further consequence the inhibition of photosynthesis at photosystem II. As a result of this reaction, CO_2 assimilation is suppressed and after a short period of growth stagnation, the plant dies.

At the Forty-third Session of the CCPR (REP 12/PR, Appendix VIII), bentazone was scheduled for periodic review of residues by the 2013 JMPR. The Meeting received information on physical and chemical properties, metabolism, environmental fate, analytical methods and freezer storage stability, national registered use patterns, as well as supervised trials, processing studies and livestock feeding studies.

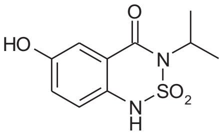
The 2012 JMPR established an ADI for bentazone of 0–0.09 mg/kg bw/day and reaffirmed its previous conclusion that no ARfD is necessary.

Bentazone is 3-isopropyl-1H-2,1,3-benzothiadiazine-4(3H)-one 2,2-dioxide.

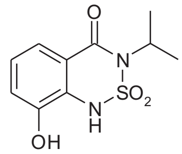


The chemical structures and names of metabolites discussed in this appraisal are:

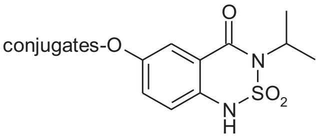
6-OH-bentazone (M351H001) 3-Isopropyl-1H-2,1,3-benzothiadiazine-4(3H)-one-6-hydroxy-2,2-dioxide



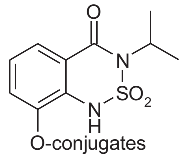
8-OH-bentazone (M351H002) 3-Isopropyl-1H-2,1,3-benzothiadiazine-4(3H)-one-8-hydroxy-2,2-dioxide



Bentazone-6-O-glucoside (M351H013)

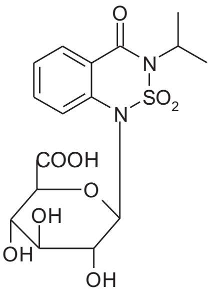


Bentazone-8-O-glucoside (M351H017)

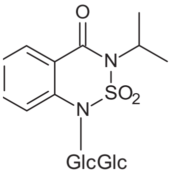


Bentazone-N-glucuronide (Metabolite A, M351H004)

3-isopropyl-1-methyl-2,2-dioxo-2,1,3-benzothiadiazin-4-one



M351H014 and isomers: M351H015-016, -018-019, -022



Animal metabolism

Information was available on metabolism of bentazone in lactating goats and laying hens.

Laboratory animals

Metabolism in laboratory animals was summarized and evaluated by JMPR in 2012. Studies on toxicokinetics showed that elimination was almost exclusively via the urine (approximately 91% within 24 hours). 5 days after dosing, less than 2% was found in faeces and less than 0.02% in expired air. Biliary excretion of radioactivity was minimal. No significant differences were found in absorption and elimination among the different species investigated (rat, rabbit and mouse). Bentazone is minimally metabolized in vivo, with the parent compound being the predominant excretion product. Only small amounts of 6-hydroxybentazone (up to approximately 6% of the dose) and minimal amounts of 8-hydroxybentazone (less than approximately 0.2% of the dose) were detected in urine.

Lactating goats

Lactating goats were administered orally with uniformly ring-labelled [^{14}C]-bentazone for 5 or 8 consecutive days at 3 and 50 mg/kg bw, 97.3% and 99.1% TAR was recovered respectively. Most of administered dose was eliminated in the urine (91.4% and 80.6% TAR). TRR levels in tissues ranged from 0.017 mg eq/kg for muscle to 0.91 mg eq/kg in fat for the low dosed goat and from 1.2 mg eq/kg in muscle to 54 mg eq/kg in kidney for the high dosed goat. The parent bentazone was the major residue component and constituted about 71–96% (0.034 mg/kg and 0.39 mg/kg) of TRR in milk, 71–97% (0.010 mg/kg and 1.2 mg/kg) in muscle, 94–98% (1.6 mg/kg and 2.8 mg/kg) in fat, 91–98% (0.55 mg/kg and 49 mg/kg) in kidney, 83–84% (0.033 mg/kg and 3.1 mg/kg) in liver. The liver in high dosed goat contained bentazone-N-glucuronide (11.1% TRR, 0.40 mg/kg) in addition to the parent compound. Two unidentified minor metabolites at a concentration of 0.002 mg/kg bentazone equivalents were found in milk from the goat dosed at 3 mg/kg bw.

The metabolism studies with [^{14}C]6-hydroxy-bentazone and [^{14}C]8-hydroxy-bentazone were conducted separately at two dose levels of 2 mg/kg bw and 40 me/kg bw for 5 or 6 consecutive days, respectively. Residue were rapidly excreted 70–86% TAR for 6-hydroxy-bentazone and 83–91% TAR for 8-hydroxy-bentazone. The major residue component in edible tissues was unchanged 6-hydroxy-bentazone constituted > 43% TRR and main metabolite was sulphate conjugate of 6-hydroxybentazone (43% of the TRR) in milk. The unchanged 8-hydroxybentazone (29–95% TRR) was the major residue component in the milk and edible tissues. In all three studies unidentified metabolites in milk or edible tissues amounted less than 10% of the TRR.

Laying hens

[^{14}C]bentazone, [^{14}C]6-hydroxybentazone and [^{14}C]8-hydroxybentazone were each administered orally to separate groups of 10 laying hens once daily for 5 days. The doses were 10 mg/hen/day, equivalent to feed containing about 100 ppm. The excretion of radioactivity was rapid. The mean proportions of the total cumulative dose recovered 6 hours after the final dose were 94% from the bentazone group, 90% from the 6-hydroxybentazone group and 93% from the 8-hydroxybentazone group. The mean concentrations of radioactivity were highest in the kidneys in all groups (3.9, 0.66, 1.6 mg eq/kg), followed by muscle (0.39, 0.32, 0.23 mg eq/kg), and liver (1.1, 0.13, 0.23 mg eq/kg). After the administration of bentazone, the parent compound was the major radioactive component in extracts of liver (0.91 mg/kg, 84% TRR) and was exclusively found in muscle (0.29 mg/kg, 100% TRR), fat (0.056 mg/kg, 100% TRR) and eggs (0.13 mg/kg, 100% TRR).

In summary, bentazone is the major residue in the animals tissues, milk and eggs (> 70% TRR).

Plant metabolism

The Meeting received plant metabolism studies with bentazone on soya bean, rice, maize, green beans, potatoes and wheat.

Soya beans were treated with [^{14}C]bentazone once at 2.24 kg ai/ha or twice at 1.68 and 1.12 kg ai/ha. Forage at long and short pre-harvest intervals, hay and bean samples were collected. The residues from single treated forage were 19 mg eq/kg and 7.0 mg eq/kg at 9 DAT and 36 DAT and from the double treated forage were 17 mg eq/kg and 24 mg eq/kg at 9 days after the first treatment and 11 days after the second treatment. In hay, residues for the single treated forage were 21 mg eq/kg at 93 days after treatment and for the double treatment 80 mg eq/kg at 48 days after the second treatment. The residues of bentazone, 6-hydrozy and 8-hydroxy bentazone in the double treated forage, 11days after the second treatment, were 5.0 mg/kg (21% TRR), 1.8 mg/kg (3.3% TRR) and 2.3 mg/kg (9.6% TRR), respectively. The residues in seed were too low for further analysis.

Rice plants were treated by foliar application with 1 kg ai/ha of [^{14}C]bentazone and radioactive residues were determined in whole plants, grain and straw. At day 0, only bentazone (72% TRR) and 6-hydroxy-bentazone (6.5% TRR) were detected. At day 26 bentazone decreased to 24% of the TRR and 6-hydroxy- bentazone in free form increased to 17% of the TRR. At 63 days, 15% bentazone (7.8 mg/kg) and 4.0% 6-hydroxy-bentazone (2.1 mg/kg) were found in straw. In grain samples 63 days after treatment only 6.6% of the TRR was extracted and 93% remained in the insoluble fraction. It was shown that the terminal ^{14}C residue consisted predominantly of recycled fragments of bentazone and 6-hydroxy-bentazone taken up into glucose, polysaccharides and lignin. Minor residues of bentazone were observed in rice grains (1.5% TRR, 0.007 mg/kg) and were below the limit of detection (0.02 mg/kg).

The metabolism of bentazone was investigated in maize grown in outdoor plots and sprayed with an aqueous solution of the sodium salt of [^{14}C]bentazone at a rate equivalent of 1.68 kg ai/ha. In forage only bentazone and 6-hydroxy-bentazone were found in the methanol extract. The levels were 0.12 mg eq/kg and 1.2 mg eq/kg after one week and declined to < 0.05 mg eq/kg and 0.09 mg eq/kg after 9 weeks, respectively. Analysis of the final harvested grain, cobs, husk and stover showed no residues of bentazone or 6-hydroxy- or 8-hydroxy-bentazone (< 0.05mg/kg).

The magnitude of the residues in green beans were determined after one application of [^{14}C]bentazone at 2.24 kg ai/ha or two at 1.68 and 1.12 kg ai/ha. The total radioactive residues in forage (4.1–22% TAR, 5.0–45 mg eq/kq), succulent bean (0.1–0.6% TAR, 0.13–1.9 mg eq/kg) and seed (0.02–0.04% TAR, 0.61–1.3 mg eq/kg) were not further identified.

The metabolism in potato plants was studied after two foliar spray applications of 1.12 kg ai/ha [^{14}C]bentazone. Potato tubers were harvested 41 days after the final treatment. TRR levels found in the whole tuber (0.14 mg eq/kg) were mainly located in the pulp (0.1 mg eq/kg), while the peel contained lower residues (0.037 mg eq/kg). The identified extractable residues were bentazone (3.7% TRR, 0.005 mg/kg) and conjugates of 6-hydroxy-bentazone (about 25% TRR, 0.034 mg/kg). Most of the radioactivity (56% of the TRR) was incorporated into starch.

A wheat metabolism study was performed with [^{14}C]-bentazone. The active substance was applied once at a rate of 1 kg ai/ha. Samples of wheat forage and hay were collected at BBCH 39 (20 days after application) and samples of grain, chaff and straw were sampled at BBCH 89 (83 days after application). The total radioactive residues (TRR) for wheat forage accounted for 4.46 mg eq/kg. Wheat hay showed the highest residue level of all matrices at 31 mg eq/kg, followed by wheat straw with residue levels of 17 mg eq/kg. In wheat chaff the residues amounted to 1.6 mg eq/kg while lowest residue levels were found in wheat grain at 1.1 mg eq/kg. The parent compound was found to be moderately metabolized until harvest. Portions between approximately 39% and 56% of the TRR were still present as unchanged bentazone in forage, hay and straw. The major metabolite in quantitative terms was an O-monosaccharide conjugate of a 6-hydroxylated derivative of parent compound. Other metabolites identified represented less than 4.7% of the TRR each. In the grain the major part of the radioactivity was characterized as carbohydrates (58% of the TRR).

In summary, the metabolism of bentazone in six different crops was similar and considered comparable. The main residue components were parent bentazone and 6-hydroxy-bentazone in soya bean forage and hay, rice hay and straw and grain, maize forage, potato tuber and wheat hay and straw. However, the parent compound was quite low in grains or seeds and confirmed by the supervised trials.

Environmental fate in soil

The Meeting received information on the environmental fate of bentazone in soil, including studies on aerobic soil metabolism, degradation in water/sediment system soil photolysis and crop rotational studies.

Aerobic soil metabolism

The aerobic soil metabolism of bentazone was investigated with [^{14}C-phenyl]-bentazone at a nominal rate of 2.0 and 2.7 mg per kg dry soil. The majority of radioactivity in the extracts was always unchanged compound. At the end of incubation, bentazone was detected in amounts of 2.3–19% TAR. None of metabolites exceeded 5% TAR. Metabolites were formed only in minor amounts of which the most prominent metabolite (max. 2.8% TAR) was identified as N-methyl-bentazone. The half-lives were calculated to be 31 to 45 days. Mineralization to ^{14}C-CO$_2$ reached a total of 9.0% to 21% TAR. No other volatile compounds were detected. In summary, bentazone was not persistent in soil.

Water/sediment dissipation

The degradation of [^{14}C]-bentazone was investigated in two different water/sediment systems (sandy loam/sand) under aerobic conditions over a period of 100 days at 0.34 mg/kg in water. The major residue component was parent bentazone which accounted for more than 60% of the TAR after 100 days. Methyl-bentazone was observed only in the water phase with the maximum concentration less than 13% of the TAR after 100 days. The half-lives in the total system were calculated to be greater than 500 days. Bentazone is stable in the water/sediment system.

Soil Photolysis

The photolytic degradation of ^{14}C-labelled bentazone was investigated on a sandy clay loam soil. The overall results for the material balances in the photolysis and the dark control samples were in the range of 95–100% TAR. Carbon dioxide was the only volatile degradation product trapped (8.1% TAR) after 15 days in the photolysis test and 1.8% TAR in the dark control. The concentration of bentazone decreased to 49% TAR in the course of the photolysis study and to 77% in the dark control samples. No degradation products of $\geq 4\%$ TAR occurred in the photolysis samples or in the dark controls. The half-lives for bentazone in the test systems were calculated to be 13 days under continuous irradiation and 42 days in the dark.

Confined rotational crop

The metabolism of bentazone in succeeding crops was investigated in wheat, radish and lettuce cultivated at three different replant intervals for all crops (30, 120 and 365 DAT). Significant translocation of radioactive residues from soil into the plants was observed for the plant back interval of 30 DAT which decreased rapidly after longer aging periods of 120 and 365 days. The residue concentration in the top soil layer after aging and ploughing decreased slightly with increasing plant back intervals. The total radioactive residues (TRR) in lettuce (immature and mature samples) did not exceed 0.13 mg eq/kg for all plant back intervals. The TRR in white radish tops was 0.17 mg/kg at a plant back interval of 30 DAT, 0.019 mg eq/kg after 120 DAT and to 0.003 mg eq/kg (TRR combusted) after 365 DAT. The total radioactive residues in radish roots of mature crop decreased from 0.13 mg eq/kg (30 DAT), to 0.012 mg eq/kg (120 DAT) and finally to 0.001 mg eq/kg (365 DAT, TRR combusted).In spring wheat, the highest residue levels were measured in hay (declining from 1.6 to 0.07 mg eq/kg, for 30 DAT and 365 DAT, respectively) and straw (declining from 1.1 to 0.049 mg eq/kg, for 30 DAT and 365 DAT, respectively). The total radioactive residues in grain accounted 0.71 to 0.041 mg eq/kg after 30 to 365 days.

Bentazone and/or its soil metabolites were taken up and transformed in the rotational crops primarily into sugars (glucose, fructose and sucrose and further components of similar polarity) which were without exception the most abundant components in all matrices examined. The unchanged parent molecule was found as minor component in samples of immature (30 DAT) and mature lettuce (30 and 120 DAT) in concentrations of < 0.0013 mg/kg and 1.2% TRR only. Additional medium polar degradation products were detected in minor concentrations. The results of this study indicated that potential for uptake of parent bentazone residues from the soil by the succeeding crops is low.

Methods of analysis

The Meeting received descriptions and validation data for analytical methods for residues of bentazone in raw agricultural commodities, feed commodities and animal commodities.

The methods for crop and animal matrices typically use an initial extraction and hydrolysis step, either with acid, base or enzymatic treatment to hydrolyse any sugar conjugates in plant or animal matrices. After a $Ca(OH)_2$-precipitation step to remove acidic plant constituents, a reversed phase C_{18}-column clean-up is performed. The analytes are then methylated with diazomethane and their derivatives are purified using a silica gel-column. The final determination of the residues of bentazone and its OH-metabolites is performed by GC-MS or LC-MS/MS. Bentazone residues can be measured in most matrices to an LOQ of 0.01 mg/kg. All methods are considered sufficiently validated for the determination of bentazone, 6-OH-bentazone and 8-OH-bentazone including conjugates thereof. No multi-residue method was provided.

Stability of residues in stored analytical samples

The Meeting received information on the freezer storage stability of residues of bentazone in plant and animal commodities.

Storage stability studies indicated that the residues are stable over a period of two years maize (green plant, grain and straw), pea (seed), flax (seed) and potato (tuber). Analytical results demonstrated that bentazone and its metabolites 6-OH-bentazone and 8-OH-bentazone as glucoside derivatives, were stable in the different plant matrices over the test period of two years.

No storage stability study on bentazone in animal matrices was provided to the Meeting.

Definition of the residue

The composition of the residue in the metabolism studies, the available residue data in the supervised trials, the toxicological significance of metabolites, the capabilities of enforcement analytical methods and the national residue definitions already operating all influence the decision on residue definitions.

Animal metabolism studies showed that the parent bentazone was a major component of the residue, representing 84–100% of the TRR in poultry matrices and 71–98% of the TRR in goats. No 6-hydroxy and 8-hydroxcy bentazone were found in milk and tissues in goat metabolism studies. Analytical methods are suitable for the determination of bentazone. The Meeting decided that for animal commodities, parent bentazone is the appropriate residue of concern for MRL enforcement and for dietary risk assessment.

The maximum octanol-water partition coefficient of bentazone (log K_{ow} = -0.94 at pH 7) implied that bentazone may not be fat-soluble. Noting that bentazone residues in goat fat were artificial and TRRs in poultry fat were much less than those in muscle the Meeting agreed that bentazone residue is not fat-soluble.

Metabolism studies on plants and supervised trials showed that the main residues in food or feed of plant origin were bentazone and one or both of its conjugated metabolites, 6-hydroxy- and 8-hydroxy-bentazone. However, the two hydroxy-bentazones were less toxic compared with parent bentazone and only existed in feed commodities. Therefore the Meeting decided that for plant commodities, parent bentazone is the appropriate residue of concern for MRL enforcement and for dietary risk assessment.

Definition of the residue (for compliance with the MRL and for estimation of dietary intake for animal and plant commodities): *bentazone*.

The residue is considered to be not fat-soluble.

Results of supervised residue trials on crops

The Meeting received supervised trials data in bulb onion, cucumber, sweet corn, green peas, green beans, dried beans, soya bean, potato, barley, oats, maize, rice, sorghum, wheat, linseed, peanut, herbs, alfalfa, clover, sugar beet and grass.

Onion, bulb

The critical GAP for bentazone on bulb onion was from Turkey (one foliar application at 0.96 kg ai/ha with a PHI of 30 days). Eight trials were available from southern Europe on bulb onion matching Turkish GAP from which residues were < 0.01 (7) and 0.02 mg/kg.

The Meeting estimated an STMR of 0.01 mg/kg and a maximum residue level of 0.04 mg/kg for bulb onion to replace the previous recommendation of 0.1 mg/kg.

Spring onion

The critical GAP for bentazone on spring onion was from the Netherlands (one spray application of 0.72 kg ai/ha, at least 10 cm height). Two trials were available from the Northern Europe on spring onion matching Dutch GAP with residues of < 0.01 and 0.04 mg/kg. Two trials from the Southern Europe were reported at a rate of 0.96 kg ai/ha treated at later growth stage. The residues of bentazone in spring onion from these trials were < 0.01(2) mg/kg.

Noting that the residues from the Northern and Southern Europe's trials were similar, the Meeting agreed to combine Northern and Southern Europe dataset to estimate an STMR 0.01 mg/kg, and a maximum residue level of 0.08 mg/kg for spring onion.

Cucumber

The critical GAP for bentazone on cucumber is from Sweden (one spray application of 1.0 kg ai/ha with a PHI of 42 days). Four trials were available from Canada on cucumber matching Swedish GAP from which residues were < 0.02(4) mg/kg.

Four trials from Canada on cucumber were not considered sufficient for the estimation of a maximum residue level.

Sweet corn (corn-on-the-cob)

The critical GAP for bentazone on sweet corn is from Canada (one spray application of 1.08 kg ai/ha, at 1 to 5-leaf stage) and in France (one spray application of 1.2 kg ai/ha with a PHI of 28 days). Two trials were available from Canada on sweet corn complying with Canadian GAP with residues of < 0.02 (2) mg/kg and one 2× trial treated at a later growth stage with a residue of < 0.02 mg/kg. Two trials were available from France on immature maize matching French GAP with residues of < 0.01(2) mg/kg. Eight trials were available from France on maize cobs w/o husks against French GAP with residues in immature corn of < 0.01(8) mg/kg.

As the residues from the European trials were considered similar, the Meeting decided to combine them and estimated an STMR 0.01 mg/kg, and maximum residue level of 0.01* mg/kg for sweet corn (corn-on-the-cob) respectively.

Peas (pods and succulent = immature seeds)

The critical GAP for bentazone on peas is from the USA (2 applications of 1.12 kg ai/ha with a PHI of 10 days). Ten trials were available from the USA on peas matching US GAP, residues found in peas (pods and succulent immature seeds) were < 0.05(6), 0.05, 0.0.06, 0.46 and 0.74 mg/kg.

The Meeting estimated an STMR 0.05 mg/kg, and maximum residue level of 1.5 mg/kg for peas (pods and succulent immature seeds) and agreed to withdraw the previous recommendation of 0.2 mg/kg for garden pea (young pods)(=succulent, immature seeds).

Beans, except broad bean and soya bean

The critical GAP for bentazone on beans, except broad bean and soya bean was from France (one application at 1.22 kg ai/ha with a PHI of 42 days). From eight trials in Northern Europe and six trials in Southern Europe on green beans with pods matching French GAP at a shorter PHI (35days) residues were < 0.01 (14) mg/kg.

The Meeting estimated an STMR 0.01 mg/kg, and maximum residue level of 0.01* mg/kg for beans, except broad bean and soya bean (green pods and/or immature seeds) and agreed to withdraw the previous recommendations of 0.2 mg/kg for common bean (pods and /or immature seeds) and 0.05 mg/kg for lima bean (pods and /or immature seeds).

Beans, shelled

Five trials from the Northern Europe and seven trials from the Southern Europe on green bean (immature seeds) (green beans without pods) matching French GAP at a shorter PHI (35 days) gave residues of < 0.01 (12) mg/kg.

The Meeting estimated an STMR 0 mg/kg, and maximum residue level of 0.01* mg/kg for beans, shelled (succulent= immature seeds), respectively.

Peas (dry)

The critical GAP for bentazone on peas in the USA, is two applications at 1.12 kg ai/ha with a PHI of 30 days. Two trials were available from the USA on peas matching US GAP resulting in residues of < 0.05(2) mg/kg.

Three trials on peas (dry) were not considered sufficient for the estimation of a maximum residue level. The Meeting agreed to withdraw the previous recommendation of 1 mg/kg for field pea (dry).

Beans (dry)

The critical GAP for bentazone on beans (dry) in Poland, is one application at 1.44 kg ai/ha, at 6–12 cm plant height. From seven southern European trials on beans matching Polish GAP residues were < 0.02(6) and 0.021 mg/kg. Two trials were available from northern Europe on beans matching the GAP of Poland with residues of < 0.02(2) mg/kg.

As residues from the Southern and Northern European trials were similar, the Meeting decided to combine the two datasets and estimated an STMR 0.02 mg/kg, and maximum residue level of 0.04 mg/kg for beans (dry) to replace the previous recommendation of 0.05 mg/kg.

Soya bean (dry)

The critical GAP for bentazone on soya bean (dry) is from Spain (one application of 1.0 kg ai/ha, 1st and 3rd trifoliate leaf); The GAP in Germany is for one application of 0.96 kg ai/ha, emergence to 10 cm height; and the GAP in the USA, two applications of 1.12 kg ai/ha with no PHI. Twelve trials were available from southern Europe on soya bean matching Spanish GAP with some trials treated at later growth stage. Residues found were < 0.01(12) mg/kg. Two trials were available from northern Europe on soya bean matching German GAP with one trail treated at a later growth stage with residues of < 0.01(2) mg/kg. Six trials were available from the USA on soya bean matching US GAP with residues of < 0.05(6) mg/kg. Two exaggerated rate trials from the US resulted in residues of < 0.05(2) mg/kg.

The Meeting estimated an STMR 0.01 mg/kg, and maximum residue level of 0.01* mg/kg for soya bean (dry) on the basis of European dataset replacing its previous recommendation of 0.1 mg/kg.

Potato

The GAP for bentazone on potato in Ireland is for one application of 1.44 kg ai/ha, before shoots exceed 15 cm in height. The GAP in Spain is for one application of 1.0 kg ai/ha, from post-emergence to the fourth leaf growth stage. Eight trials were available from southern Europe on potato matching Spanish GAP from which residues found were < 0.01(4), 0.01, 0.02(2) and 0.06 mg/kg. Twenty five trials were available from northern Europe on potato matching Irish GAP from which residues found were < 0.02(24) and 0.04 mg/kg.

Noting that Southern European trials resulted in higher residue, the Meeting estimated an STMR 0.01 mg/kg, and a maximum residue level of 0.1 mg/kg for potato confirming the previous recommendations.

Cereals grains

Barley, oats and wheat

The GAP for bentazone on cereal grains in Finland is for one application of 1.48 kg ai/ha, 2–3 leaf stage (BBCH 12–13). Five trials were available from southern Europe on barley matching Finnish the application rate but treated at later growth stage. Residues found were < 0.02(5) mg/kg. One trial was available from Canada on barley matching the Finnish application rate and treated at later growth stage with a residue of < 0.02 mg/kg.

The residue found from one trial on oats from Germany, at higher application rate than that of the Finnish GAP and treated at later growth stage, was below the LOQ (0.05 mg/kg).

Three trials were available from southern Europe on wheat matching the Finnish application rate and treated at later growth stage with residues of < 0.02 (3) mg/kg.

Maize

The GAP for bentazone on cereal grains in Italy is one application of 1.48 kg ai/ha with no PHI; the GAP in the Netherlands is for one application of 1.44 kg/ha, at 5-leaf stage. Thirteen trials were available from southern Europe on maize matching the Italian application rate with some trials treated at later growth stages. Residues found were < 0.01(5) and < 0.02(8) mg/kg. Seven trials were available from northern Europe on maize matching the Dutch application rate with some trials treated at later growth stages. Residues found were < 0.01(5) and < 0.02(2) mg/kg.

The ranked order of concentrations of parent compound, median underlined, was < 0.01(10) and < 0.02(10) mg/kg.

Rice

The GAP for bentazone on rice in China is one application of 1.44 kg ai/ha, no PHI; the GAP in Greece is one application of 1.44 kg ai/ha, BBCH 12-21; the GAP in Japan is one application of 2.8 kg ai/ha, applied up to 60 days before harvest.

Two trials were available from China on rice matching Chinese GAP with residues of < 0.02(2) mg/kg. Two trials were available from China on rice at about 1.5× maximum Chinese GAP rate with residues of < 0.02(2) mg/kg.

Two trials were available from Japan on rice matching Japanese GAP with residues of < 0.01(2) mg/kg. Two trials were available from Japan on rice at about 1.5× maximum Japanese GAP rate with residues of < 0.01(2) mg/kg.

Two trials were available from Portugal on rice matching Greek GAP with two trials treated at later growth stage with residues of < 0.02(2) mg/kg.

One trial was available from France on rice against about 1.3× maximum Greek GAP with residues of < 0.02 mg/kg.

All nine trials in Asia and Europe were treated at maximum rate or 1.3–1.6× the maximum rate and resulted in non-detectable residues in rice or brown rice.

Sorghum

The critical GAP for bentazone on sorghum is from Luxembourg (one application of 1.2 kg ai/ha, from emergence to 6-leaf stage (BBCH 16)). Six trials were available from France on sorghum matching the GAP of Luxembourg with residues of < 0.05(6) mg/kg.

The Meeting noted that no residues above LOQ (0.01–0.05 mg/kg) were observed in the samples of barley, oats, wheat, maize, rice and sorghum from 45 supervised trials in various countries following treatment at early growth stages. The Meeting agreed to estimate a maximum residue level 0.01 mg/kg and an STMR 0.01 mg/kg for cereal grains and to withdraw the previous recommendations of 0.1 mg/kg for barley, oat, rice, rye, sorghum and wheat and 0.2 mg/kg for maize.

Oilseeds

Linseed

The critical GAP for bentazone on linseed in France is for one application of 1.2 kg ai/ha with a PHI of 70 days. Three trials were available from France on linseed matching the French application rate at shorter PHIs. Residues found were < 0.02(3) mg/kg. Three trials were available from Canada on linseed matching French GAP showed residues of < 0.02(3) mg/kg.

Considering residues from the French and Canadian trials were similar, the Meeting decided to combine the two dataset and estimated an STMR of 0.02 mg/kg, and maximum residue level of 0.02* mg/kg for linseed, respectively.

Peanut

The critical GAP for bentazone on peanut in the USA is for two application of 1.12 kg ai/ha, up to 28 days after ground crack stage for the second application. Six trials were available from USA on peanut matching the application rate of the US GAP with residues of < 0.05(6) mg/kg. Two trials were available from USA on peanuts with exaggerated application rates resulting in residues of < 0.05(2) mg/kg.

The Meeting estimated a maximum residue level and an STMR value for peanut of 0.05* and 0 mg/kg and replaced the previous maximum residue level recommendation of 0.05 mg/kg.

Herbs

The GAP for bentazone on herbs in Germany is for one application of 0.96 kg ai/ha with a PHI of 42 days; in France the GAP consists of one application at 1.13 kg ai/ha with a PHI of 28 days. Two trials were available from Germany on peppermint matching German GAP with residues of < 0.05(2) mg/kg. Two trials were available from France on melissa (lemon balm) matching French GAP with residues of < 0.02 and 0.037 mg/kg.

As the residues from the European trials were considered similar, the Meeting decided to combine the data and estimated a maximum residue level and an STMR value for herbs, except dry hops, of 0.1 and 0.0435 mg/kg, respectively.

Sugar beet

One trial from USA on sugar beet was received however as no associated GAP was provided the Meeting could not estimate a maximum residue level.

Animal feedstuffs

Pea vines (green)

The critical GAP for bentazone on peas in USA is 2 applications of 1.12 kg ai/ha with a PHI of 10 days. Ten trials were available from USA on peas matching US GAP from which residues found, median underlined, were: 0.11, 0.12, 0.17, 0.19, <u>0.22</u>(2), 0.31, 1.05, 7.05 and 13.1 mg/kg.

The Meeting estimated a median and highest residue for bentazone in pea vines (green) of 0.22 and 13.1 mg/kg.

Pea hay

The critical GAP for bentazone on peas in USA is for 2 applications of 1.12 kg ai/ha with a PHI of 10 days. Three trials were available from USA on peas matching US GAP from which residues found were: 0.48, 1.45 and 1.99 mg/kg.

Three trials on peas hay (dry) were considered insufficient for maximum residue level estimation.

Bean forage (green)

The critical GAP for bentazone on beans, except broad bean and soya bean in France is for one application of 1.22 kg ai/ha with a PHI of 42 days. Five trials were available from Southern Europe on green beans matching French GAP with residues found in forage of < 0.01(3), 0.01 and 0.02 mg/kg. Three trials were available from Northern Europe on green beans against French GAP with residues in forage of < 0.01 and 0.01(2) mg/kg.

As the residues from the European trials were considered similar, the Meeting decided to that the data may be combined, median underlined, < 0.01(4), 0.01(3) and 0.02 mg/kg. The Meeting estimated median and highest residue for bentazone in green beans forage of 0.01 and 0.02 mg/kg.

Soy bean forage (green)

The GAP for bentazone on soya bean (dry) in the USA is for two applications of 1.12 kg ai/ha, with no grazing or cutting for forage or hay for at least 30 days after the last treatment. Four trials were available from USA on soya bean forage matching US GAP with residues of < 0.05(2), 0.06 and 0.15 mg/kg.

The Meeting considered four trials an insufficient number for the estimation of median and the highest residue levels for soya bean forage.

Soya bean straw and fodder

The critical GAP for bentazone on soya bean (dry) in USA, two applications of 1.12 kg ai/ha, not graze or cut for forage or hay for at least 30 days after the last treatment. Four trials were available from USA on soya bean hay against the GAP of the USA with residues of < 0.05, 0.10, 0.45 and 0.62 mg/kg.

The Meeting considered four trials an insufficient number for the estimation of median and the highest residue levels for soya bean straw and fodder.

Alfalfa forage (green)

The critical GAP for bentazone on legume animal feeds in France is one application of 0.6 kg ai/ha, BBCH 12 or 1 trifoliate leaf; in the Netherlands the GAP is one application of 1.44 kg ai/ha, 1-2 trifoliate (true) leaves. Four trials were available from Southern Europe on alfalfa forage matching French GAP with residues of 0.01(2) and 0.03(2) mg/kg. Two trials were available from Northern Europe on alfalfa forage matching French GAP with residues of 0.06 and 0.07 mg/kg.

Considering residues from European trials were comparable, the Meeting decided they could be combined. The combined residues, in rank order, were: 0.01(2), 0.03(2), 0.06 and 0.07 mg/kg. The Meeting estimated a median of 0.03 mg/kg and the highest residue of 0.07 mg/kg, respectively.

Alfalfa fodder

The critical GAP for bentazone on legume animal feeds in France is one application of 0.6 kg ai/ha, BBCH 12 or 1 trifoliate leaf; the GAP of the Netherlands is one application of 1.44 kg ai/ha, 1–2 trifoliate (true) leaves. Four trials were available from Southern Europe on alfalfa hay matching French GAP with residues of 0.04, 0.07, 0.08 and 0.12 mg/kg. Two trials were available from Northern Europe on alfalfa hay matching French GAP with residues of 0.10 and 0.23 mg/kg.

As the residues from the European trials were considered parable, the Meeting decided to they could be combined. The residues in rank order were: 0.04, 0.07, <u>0.08</u>, <u>0.10,</u> 0.12 and 0.23 mg/kg. Noting the residues from European trials were consistent and based on an average dry-mass of 89% residues in alfalfa fodder (dry weight) were: 0.04, 0.08, 0.09, 0.11, 0.13 and 0.26 mg/kg. The Meeting estimated a median of 0.09 mg/kg, the highest residue of 0.23 mg/kg and a maximum residue level of 0.5 mg/kg for alfalfa fodder (dry), respectively.

Clover

The critical GAP for bentazone on clover in the US is one application of 1.12 kg ai/ha with a PHI of 50 days (for grazing of forage or hay). Two trials were available from the US on clover forage against US GAP with residues of < 0.05 and 0.06 mg/kg.

The Meeting considered two trials an insufficient number for the estimation of median and the highest residue levels for clover forage.

Clover hay or fodder

The critical GAP for bentazone on clover in US is one application of 1.12 kg ai/ha with a PHI of 50 days (for grazing of forage or hay). Two trials were available from the USA on clover forage against US GAP with residues of < 0.05 and 0.07 mg/kg.

The Meeting considered two trials an insufficient number for the estimation of STMR and a maximum residue levels for clover hay.

Peanut fodder

The critical GAP for bentazone on peanut in the US is two application of 1.12 kg ai/ha, up to 28 days after ground crack stage for the second application. Noting that no trials were in line with US GAP the Meeting agreed that the maximum residue level for peanut fodder could not be recommended.

Grass forage

The critical GAP for bentazone on grasses in Sweden is one application of 1.0 kg ai/ha with a PHI of 21 days. Thirteen trials were available from Northern Europe on grass forage matching Swedish GAP from which residues found were: < 0.02, 0.03, 0.04(2), 0.12, <u>0.17</u>(2), 0.20(2), 0.22 and <u>0.37</u> mg/kg.

The Meeting estimated a median and the highest residue for bentazone in grass forage of 0.17 and 0.37 mg/kg, respectively.

Hay or fodder (dry) of grasses

The critical GAP for bentazone on grasses in Sweden is one application of 1.0 kg ai/ha with a PHI of 21 days. Ten trials were available from Northern Europe on grass hay matching Swedish GAP with residues of < 0.02, 0.03, 0.07, 0.08, <u>0.16</u>, <u>0.22</u>, 0.39, 0.48, 0.61 and 1.02 mg/kg.

Based on an average dry-mass of 88% residues in grass hay (dry weight) were: < 0.02, 0.03, 0.08, 0.09, <u>0.18</u>, <u>0.25</u>, 0.44, 0.55, 0.69 and 1.16 mg/kg.

The Meeting estimated a maximum residue level, an STMR and the highest residue for bentazone in grass hay of 2 mg/kg (DM based), 0.215 mg/kg and 1.16 mg/kg (air dry), respectively.

Straw and fodder (dry) of cereal grain

Barley, millet, oats, rye, triticale, and wheat straw and fodder, dry

The critical GAP for bentazone on cereal grains in Finland is one application of 1.48 kg ai/ha, 2–3 leaf stage Five trials were available from southern Europe on barley matching Finnish GAP with residues of 0.04(2), 0.06(2) and 0.14 mg/kg.

Residue from one German oat trial, at higher application rate than that of the Finnish GAP, was below the LOQ (0.05 mg/kg).

Three trials were available from southern Europe on wheat matching Finnish GAP with residues of 0.03(2) and 0.04 mg/kg.

As the residues from the Southern and Northern European trials were comparable, the Meeting decided to combine these datasets. The residues from the combined European residue trials in rank order, median underlined, were: 0.03(2), 0.04(3), < 0.05, 0.06(2) and 0.14 mg/kg.

Based on an average dry-mass of 88% residues in grass hay (dry weight) were: 0.03(2), 0.04(3), < 0.06, 0.07(2) and 0.16 mg/kg.

The Meeting estimated a maximum residue level, an STMR and a highest residue for bentazone in barley, millet, oats, rye, triticale, and wheat straw and fodder (dry) of 0.3 mg/kg (DM based), 0.05 mg/kg and 0.16 mg/kg (air dry), respectively.

Maize fodder

The critical GAP for bentazone on cereal grains in Italy is one application of 1.48 kg ai/ha, at the 2-4 true leaf growth stage for dicotyledonous weeds. The GAP of the Netherlands is one application of 1.44 kg/ha, (at the 5-leaf stage). Thirteen trials were available from southern Europe on maize straw matching Italian GAP with residues of < 0.01, 0.01, < 0.02(6), 0.02, 0.05, 0.13, 0.14 and 0.24 mg/kg. Seven trials were available from northern Europe on maize straw against Dutch GAP with residues of 0.01, < 0.02(2), 0.03(2), 0.06 and 0.08 mg/kg.

As the residues from the southern and northern European trials were comparable, the Meeting decided to combine the two datasets. The residues from the combined European residue trials in rank order, were: < 0.01, 0.01(2), < 0.02(8), 0.03(2), 0.04, 0.05, 0.06, 0.08, 0.13, 0.14 and 0.24 mg/kg.

Based on an average dry-mass of 83% residues in maize fodder (dry weight) were: < 0.01, 0.01(2), < 0.02(8), 0.04(2), 0.05, 0.06, 0.07, 0.10, 0.16, 0.17 and 0.29 mg/kg.

The Meeting agreed to estimate a median of 0.02 mg/kg, the highest residue 0.24 mg/kg and a maximum residue level of 0.4 mg/kg for maize fodder replacing its previous recommendation of 0.2 mg/kg.

Rice straw, dry

The critical GAP for bentazone on rice in China is one application of 1.44 kg ai/ha, no PHI; The GAP in Greece is one application of 1.44 kg ai/ha, BBCH 12-21. The GAP in Japan is one application of 2.80 kg ai/ha, up to 60 days before harvest. Two trials were available from China on rice straw against Chinese GAP with residues of < 0.02(2) mg/kg. Two trials were available from Japan on rice straw against Japanese GAP with residues of 0.06 and 0.07 mg/kg.

The Meeting considered the number of trials insufficient for the estimation of a maximum residue level for rice straw.

Fate of residues during processing

The Meeting received information on the fate of bentazone residues during the food processing of rice.

Portion Analysed		Mean Processing Factor	STMR (mg/kg)	STMR-P (mg/kg)
Rice	hulls	8.9	0.01	0.089
	bran	0.37		0.0037
	polished rice	0.08		0.0008

Residues in animal commodities

Estimated maximum and mean dietary burdens of farm animals

Dietary burden calculations for beef cattle, dairy cattle, broilers and layers are provided in Annex 6. The calculations were made according to the animal diets from US-Canada, EU, Australia and Japan in the OECD Feed Table 2009.

The calculations are then summarized and the highest dietary burdens are selected for MRL and STMR estimates on animal commodities.

	Animal dietary burden, bentazone, ppm of dry matter diet							
	US-Canada		EU		Australia		Japan	
	max	mean	max	mean	max	mean	max	mean
Beef cattle	0.24	0.06	11.3	0.54	32 [a]	0.8 [b]	0.57	0.14
Dairy cattle	5.94	0.41	11.4	0.60	22 [c]	0.76 [d]	1.0	0.24
Poultry-broiler	0.0091	0.0091	0.013	0.013	0.019	0.0019	0.018	0.012
Poultry-layer	0.091	0.091	5.4 [e]	0.17 [f]	0.019	0.019	0.01	0.01

[a] Highest maximum beef or dairy cattle dietary burden suitable for MRL estimates for mammalian meat.

[b] Highest mean beef or dairy cattle dietary burden suitable for STMR estimates for mammalian meat.

[c] Highest maximum dairy cattle dietary burden suitable for MRL estimates for mammalian milk.

[d] Highest mean dairy cattle dietary burden suitable for STMR estimates for mammalian milk.

[e] Highest maximum poultry dietary burden suitable for MRL estimates for poultry meat and eggs.

[f] Highest mean poultry dietary burden suitable for STMR estimates for meat and eggs.

Lactating goats were orally administered bentazone at the equivalent to 15 ppm and 75 ppm on the basis of an individual feed intake of 3 kg of feed per animal per day and incorporating an allowance for the difference in dry matter percentage between the type of diet offered (cereal/protein concentrate feed and hay) and fresh herbage, respectively. Residues of bentazone in the whole milk of goats in the 15 and 75 ppm groups were < 0.02 mg/kg and < 0.02 mg/kg respectively, goat tissues were not analysed.

Since no analysis of tissues was carried out in the goats feeding study, the Meeting decided that no recommendations could be made on the basis of this study.

In the animal metabolism study on lactating goats, residues in fat were significantly higher than that in muscle. However, it is not expected that bentazone, with a log P_{ow} of -0.45, would accumulate in fat. The Meeting decided not to estimate maximum residue levels for animal tissues on the basis of this study.

Residues in poultry tissues and eggs are estimated using the data from the poultry metabolism study in which the dose rate was 100 ppm and the highest and mean residues in tissues and eggs were determined.

Estimation of residues in poultry tissues and eggs

	Feed level (ppm) for egg residues	Residues (mg/kg) in egg	Feed level (ppm) for tissue residues	Residues (mg/kg) in		
				Muscle	Liver	Fat
Maximum residue level broiler or layer poultry						
Feeding study[a]	100	0.15	100	0.42	1.1	0.11
Dietary burden and residue estimate	5.4	0.008	5.4	0.023	0.059	0.006
STMR broiler or layer poultry						
Feeding study[b]	100	0.15	100	0.42	1.1	0.11
Dietary burden and residue estimate	0.17	0.0003	0.17	0.0007	0.002	0.0002

[a] Highest residue for tissues and mean residue for egg

[b] Mean residues for tissue and egg

The Meeting noted that the LOQ of the analytical method was 0.01 mg/kg, and agreed to estimate maximum residue level of 0.03 mg/kg for poultry meat (fat) and estimate maximum residue level of 0.01* for eggs and estimated a maximum residue level of 0.07 mg/kg for poultry edible offal. The Meeting estimated STMRs of 0 mg/kg for poultry meat (fat), edible offal and for eggs.

DIESTARY RISK ASSESSMENT

Long term intake

The evaluation of bentazone resulted in recommendations for MRLs and STMR values for raw and processed commodities. Data on consumption were available for 17 food commodities and were used to calculate dietary intake. The results are shown in Annex 3.

The International Estimated Daily Intakes (IEDIs) of bentazone, based on the STMRs estimated, were 0% of the maximum ADI of 0.09 mg/kg bw for the thirteen GEMS/Food cluster diets. The Meeting concluded that the long-term intake of residues of bentazone resulting from its uses that have been considered by JMPR is unlikely present a public health concern.

Short-term intake

The 2012 Meeting decided that an ARfD for bentazone is unnecessary and concluded that the short-term intake of residues resulting from the use of bentazone is unlikely to present a public health concern.