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Untreated and formaldehyde treated skimmilk powder as a protein supplement for dairy cows

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Abstract. Twenty four high producing dairy cows were used in an experiment in which the value of fat free spray-dried milk powder, untreated or formaldehyde treated (0.4 g formaldehyde/100 g crude protein), was studied as a protein supplement in a protein deficient diet. The groups were: 1) Protein shortage group, 1) Untreated milk powder group and 3) Formaldehyde treated milk powder group.

Rations were made for all groups from hay, grass silage. barley, oats and mineral and vitamin mixtures according to nutrient requirements excepting that of protein. In the rations of the protein shortage group 25 % of the DCP required for milk production was omitted. In the other groups this deficiency was filled with untreated or formaldehyde treated milk protein. The experiment lasted 15 weeks. The feed consumption and utilization, milk production and composition, and blood contents were determined.

In eliminating the protein deficiency with fat free milk powder positive results were found in milk yields, the protein content of the milk and in the liveweight of the cows. The differences in the utilization of untreated and formaldehyde treated milk powder were not significant. Only small amounts of formaldehyde (0.11 mg/kg milk), were found in the milk of the cows receiving formaldehyde treated protein. The values of the blood analyses remained within the normal ranges on all diets.

The over-production and marketing difficulties of milk powder have led Finland to a situation wherein the government has ordered the addition of fat free milk powder not only to the feed mixtures of calves, pigs and poultry, but also to those of dairy cows. Since 1976 the feed industries have had to add 2 % skimmilk powder to the complete feeds of dairy cows, 6 % to the semi-protein concentrates and 16 % to the protein concentrate mixtures. It is most probable that this situation will continue for some years to come.

There are no exact figures on the utilization of skimmilk powder by dairy cows. The feeding of this valuable milk protein to adult ruminants has not been regarded as sensible. Basically it is only known that the casein of milk which represents about 80 % of milk protein, is degraded quite fast in the rumen, which can cause quite low utilization of that high quality protein (Chalmers et al. 1954, Hume 1974, Asplund 1975, Ferguson 1975).

The investigations of the utilization and value of fat free milk powder with dairy cows started in 1977 and consisted of *in vitro* investigations (Syväoja and KREULA 1978), physiological experiments with rumen fistulated dairy cows (SYRJÄLÄ et al. 1978), and the milk production experiments explained in this paper. The main purpose of this study was to find out the value of fat free milk powder as a protein supplement for high producing dairy cows when there is a shortage of protein in the diet. At the same time the utilization of untreated and formaldehyde treated spray-dried fat free milk powder was compared. No economical calculations were done.

Experimental procedures

Experimental feeds and feeding

The experiment was performed with 24 high producing dairy cows. 21 of the cows were Ayrshire and 3 of the Friesian breed.

At the beginning of the experiment the average time from calving was 45 days and at the end 150 days. The experiment lasted 15 weeks. Two first weeks formed a standardization period when all the animals received the same feeding regimen consisting of 3 kg hay, grass silage *ad libitum* and a grain concentrate mixture, according to milk production, ranging from 7—9 kg per day. At the end of this period the cows were divided into 3 groups according to their fat corrected milk (FCM) yields, days after calving, liveweights and breed. The groups were:

1) Protein shortage group
2) Untreated milk powder group
3) Formaldehyde treated milk powder group

Over one week the animals were gradually changed to the experimental feeds.

As basic feeds during the comparison period were hay, grass silage, barley and oats preserved with propionic acid (Table 1), plus mineral and vitamin mixtures. Rations were made for all the groups from those basic feeds according to nutrient requirements except that of protein. In the rations of the protein shortage group 25 % of the digestible crude protein (DCP) required for milk production was omitted. In the other groups this deficiency was filled with untreated or formaldehyde treated milk protein. The amount of formaldehyde used in treatment was about 0.4 g/100 g crude protein. The energy the animals received in the milk powder was taken into account in the corresponding decrease of basic feed.

The cows were fed individually twice a day at 5 a.m. and at 2 p.m. Refusals were collected after morning feeding. The animals were weighed every second week after morning feeding.

The rations were corrected every week accordind to need using the preceding weeks milk yield and liveweight, and analyses results of milk and feeds.

Sampling and analyses

Aliquots of grains and milk powders were taken just before making a weeks concentrate mixture and that of hay every day. A silage sample was taken once a week. All the aliquots were bulked into fortnightly samples. The dry

Table 1. The mean chemical compositions and feeding values of the feeds[1])

	Hay	Grass silage	Barley	Oats	Milk powder Untreated	Milk powder Formaldehyde treated
Dry matter	82.8	27.7	75.8	73.4	96.5	96.0
% of dry matter:						
Ash	7.3	9.8	2.6	3.6	8.2	8.4
Organic matter	92.7	90.2	97.4	96.4	91.8	91.6
Crude protein	12.9	16.0	13.2	14.0	36.4	35.9
True protein	9.7	8.6	7-8	11.1	36.4	35.9
Crude fat	2.5	5.8	2.2	5.8	0.1	0.2
Crude fibre	32.0	24.1	5.5	11.4	—	—
N-free extract	45.3	44.3	76.5	65.2	55.3	55,5
kg/f.u.	2.19	5.58	1.14	1.34	0.87	0.87
DM kg/f.u.	1.81	1.55	0.86	0.98	0.84	0.84
DCP % in DM	6.6	9.6	9.9	10.9	32.7	32.3
DCP g/kg	54	27	75	80	316	310
DCP g/f.u.	119	148	85	107	274	271

[1]) Feeding values were calculated by using the digestibility coefficients and value numbers as expressed by Nehring et al. (1970).

matter (DM) content of silage was, however, determined for each weeks sample. The DM content of the silage was corrected according to the volatile fatty acids (VFA) content, adding 80 % of acetic acid and total amounts of the other VFA (Jarl and Helledey 1948, Presthegge 1959, Ulvesli and Breirem 1960).

The DM contents were determined in an oven at +103 — +105° C. The food analyses were made on the samples, after drying in a vacuum oven at +50° C, by standard procedures (Paloheimo 1969) and watersoluble sugars were determined according to Somogyi (1945), modified by Salo (1965).

The VFA in silage samples were determined with a Perkin Elmer F 11 gas chromatographer (Huida 1973) from water extract of fresh samples, lactic acid (Barker and Summerson 1941) and ammonia nitrogen (McCullough 1967) with a Beckman B spectrofotometer. Soluble N was determined by the Kjelldahl method (Table 2).

The formaldehyde contents of the treated milk powder and milk samples were determined by the method of Walker (1964).

Milk produced was weighed at every milking. Once a week a days milk sample was taken. Fat, protein and lactose contents of the samples were determined with an infra red analyser by Valio (IRMA).

Blood samples were taken from the jugular vein 3 1/2 hours after the beginning of morning feeding every forth week. Haemoglobin and haematocrit values and ammonia nitrogen (McCullough 1967) were determined from whole blood. Glucose was determined by the o-toluidin-method (Hultmann 1959), modified by Hyvärinen and Nikkilä (1962), total protein by the biuret method (Reinhold 1953) and urea-nitrogen by the method of Chaney and Marbach (1962) from the plasma.

Table 2. The mean quality criteria of the grass silage.

pH	3.92
% of dry matter:	
Acetic acid	0.05
Propionic acid	0.03
Butyric	+
Lactic acid	10.29
Sugars	6.38
NH_3-N	0.11
% of total N	
NH_3-N	4.3
Soluble N	45

Calculation and statistical procedures

The weekly data of feed and nutrient consumption, milk yield and composition were calculated for each cow. Feed unit (1 f.u. = 0.7 starch unit) consumption per kg FCM was calculated using the maintenance requirement for energy, 4 f.u. per 500 kg liveweight and for protein, 75 g DCP per maintenance f.u. (Breirem 1969). The energy requirement for liveweight change was taken as 2 f.u./kg liveweight change. The effect of time was excluded in the calculating of correlations. For each cow average yield and nutrient composition data for both the standardization and the comparison periods were calculated. Yield data was tested by one-way covariance analysis. Nutrient consumption was tested by one-way variance analysis and the differences between treatment means by the Tukey-test (Steel and Torrie 1960).

Results and discussion

Palatability of feeds and nutrient supply

The average intake of feeds varied quite considerably in different groups (Table 3). In the formaldehyde treated milk protein containing group the palatability of the concentrate mixture was low, especially in the beginning of the comparison period. This was the main reason for the fact that nutrient supply was deficient in this group (Table 4). The protein deficiency was thus on the average 6 % of the total requirement. Untreated milk powder was, in this experiment, more palatable than formaldehyde treated milk powder. The individual differences in intake between the different animals were smaller in the untreated milk powder receiving group than in the formaldehyde treated milk powder receiving group.

The reason for the decreased intake in the formaldehyde group is difficult to say. No decrease is found in intake even with higher formaldehyde treatments although there are also opposing results (Barry 1976). In a physiological trial (Syrjälä et al. 1978) when the same formaldehyde treatments for milk powder were used the formaldehyde did not seem to effect on the palatability. The distribution of the formaldehyde in milk powder should not be the reason

Table 3. Average intake of different feeds in the comparison period, kg/day.

	Protein shortage group	Untreated milk powder group	Formaldehyde treated milk powder group
Hay	3.7	2·6	2.7
Grass silage	13.1	13.6	13.8
Barley	4.3	4.7	3.9
Oats	4.2	4.7	3.9
Untreated milk powder	—	1.0	—
Formaldehyde treated milk powder	—	—	0.7

Table 4. The mean nutrient requirements and supplies in the comparison period.

	Protein shortage group	Untreated milk powder group	Formaldehyde treated milk powder group
DM supply, kg/day	13.0	13.9	12.5
from forages, %	52	42	47
» concentrates, %	48	58	53
Energy requirement, f.u./day	11.7	12.7	11.9
Energy supply, f.u./day	11.0	12.5	10.9
from forages, %	38	30	34
» concentrates, %	62	70	66
Energy requirement — supply, f.u./day	−0.7	−0.2	−1.0
Protein requirement, DCP g/day	1 463	1 543	1 415
Protein supply g/day	1 198	1 536	1 326
from forages, %	46	32	37
» grain, %	54	48	46
» milk powder, %	—	20	17
Protein requirement — supply, DCP g/day	−265	−7	−89

for the decreased palatability, although it could have some influence. The formaldehyde content determined for the samples taken from different sacks (30 kg) varied 0.38 ± 0.08 g formaldehyde/100 g crude protein.

Production of the cows

The differences in FCM yield between the groups during the standardization period, when the feeding was similar in each group, were on the average 1—2 kg/day (Table 5, Figure 1). These differences were kept equal during the whole comparison period. The average decrease in milk yield from the standardization period to the comparison period was exactly the same in both milk powder groups, 4.4 kg FCM, whereas in the protein shortage group it was a little higher, 4.7 kg FCM. The effect of untreated and formaldehyde treated milk powder on the milk production was thus similar.

Table 5. The mean yields in the different groups.

	Standardization period			Comparison period			Changes in yields		
	Protein shortage group	Untreated milk powder group	Formaldehyde treated milk powder group	Protein shortage group	Untreated milk powder group	Formaldehyde treated milk powder group	Protein shortage group	Untreated milk powder group	Formaldehyde treated milk powder group
Liveweight, kg	546	531	522	525	523	508	−21	−8	−14
Milk, kg/day	21.6	21.7	21.1	17.8	18.6	17.6	−3.8	−3.1	−3.5
Fat corrected milk, kg/day	23.9	24.9	22.9	19.2	20.5	18.5	−4.7	−4.4	−4.4
Milk fat-%	4.72	4.96	4.54	4.58	4.75	4.35	−0.14	−0.21	− 0.19
» protein-%	3.35	3.32	3.23	3.36	3.56	3.29	+0.01	+0.24	+0.06
» lactose-%	4.92	5.05	5.10	4.91	4.97	4.92	−0.01	−0.08	−0.12
f.u./kg FCM	0.36	0.39	0.38	0.37	0.39	0.35	+0.01	0.00	−0.03
DCP g/kg FCM	49	51	49	47	60	56	−2	+9	+7

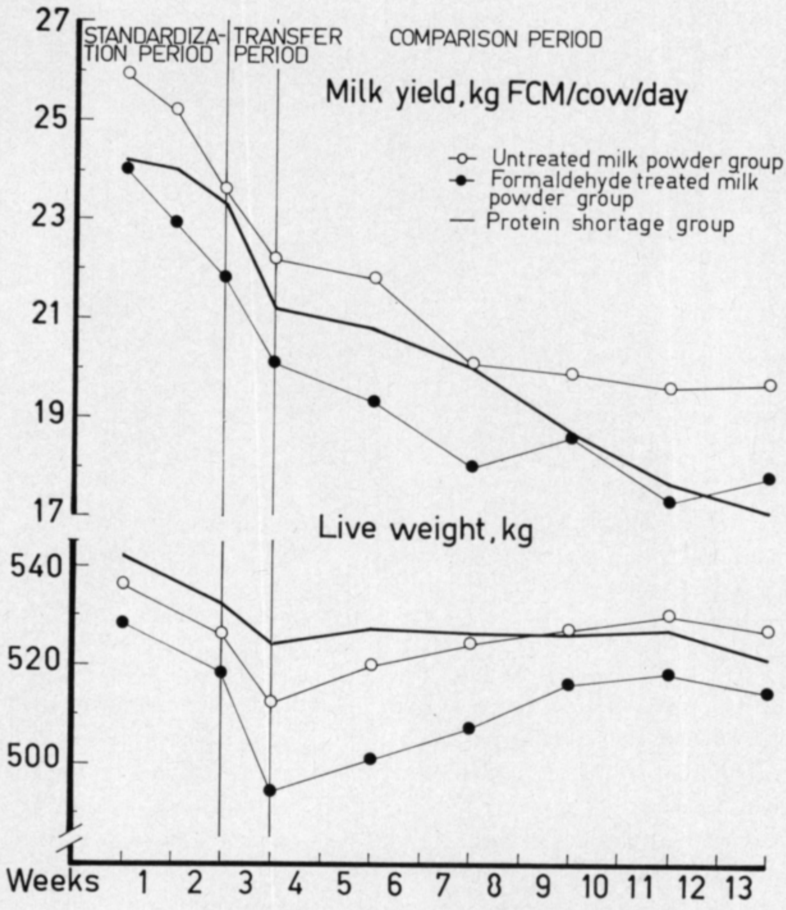

Fig. 1. Milk yields and live-weights of the cows in different groups.

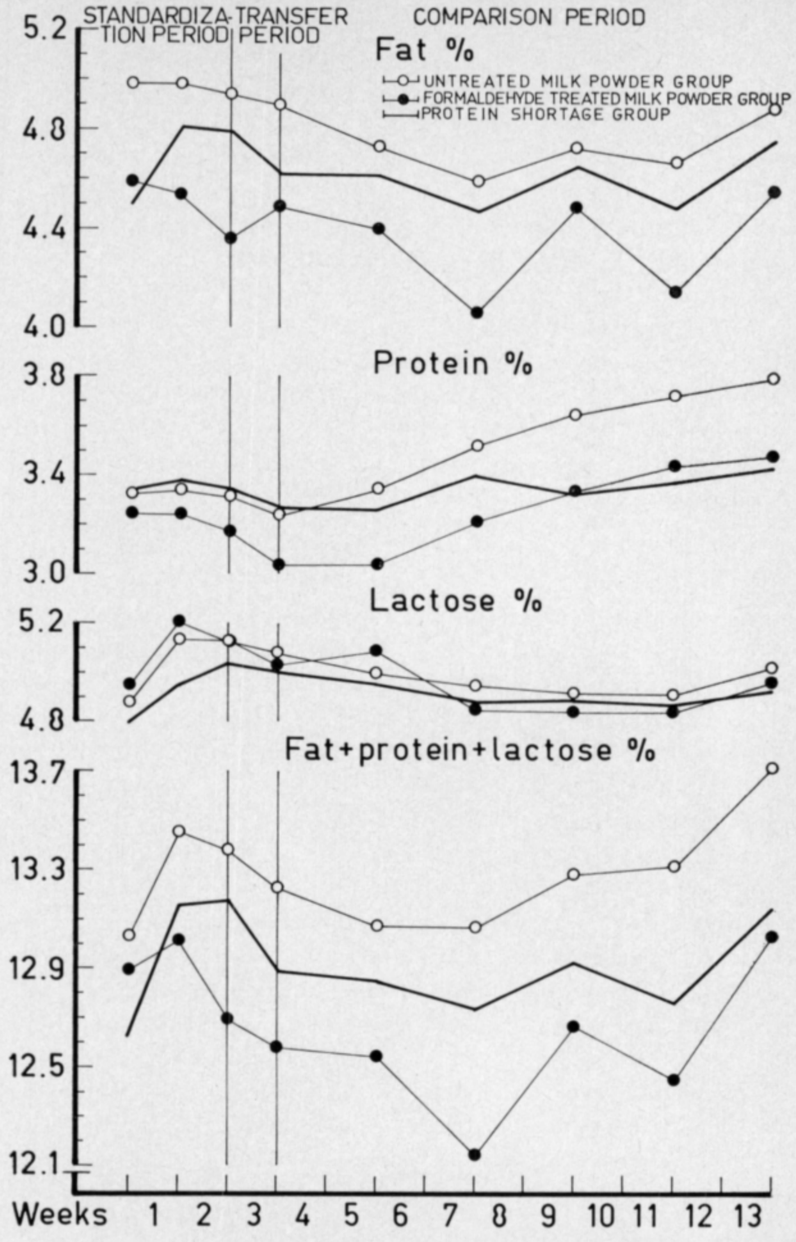

Fig. 2. Chemical composition of milk in different groups.

The treatment of milk powder used as feed did not have a noticeable effect on the fat and lactose contents of milk (Table 5, Figure 2). In the protein content of milk, some differences were found between the groups. The protein content increased in the untreated milk powder group, more so than in the formaldehyde treated group. The reason for that probably does not lie in the different treatments of the milk powder, but more probably in the differences in the intake and supply of protein, which was lower in the formaldehyde treated than in the untreated group (Table 4). The deficiency of protein in the diet has been shown to decrease the protein content of milk (Isaachsen et al. 1956, Rook and Line 1962). This was also clearly found in the protein shortage group of this experiment, where the effect on the protein content of milk was still more unfavourable than in formaldehyde group.

When comparing the different feeding of the dairy cow, it is not sufficient to concentrate only on the milk yields or milk composition, but the changes in the liveweight have to be taken into account too. The importance of the use of tissue energy and protein for milk production is difficult to know, especially if the experiment does not last long enough. In this experiment the loss in liveweight was highest for the cows in the protein shortage group and lowest for those in the untreated milk protein group. The loss of liveweight was thus correlated to the supply of protein. The liveweight changes leveled the differences in milk production found between the different groups.

Utilization of feeds

As measures of feed utilization we have used in this study f.u. and DCP consumption per kg of fat corrected milk, f.u. and DCP needed for maintenance being subtracted from those of the total supply. The changes in the liveweight of the animal have been taken account in calculations of energy utilization as explained earlier. In the calculation of protein utilization no corrections were used.

No significant differences ($P > 0.05$) in energy utilization were found between the different groups, as the changes from standardization period to comparison period showed (Table 5).

Protein utilization was best in the protein shortage group, followed by the formaldehyde treated and untreated milk powder groups, although the differences were not significant ($P > 0.05$). What proportion of this is due to the protein supply and to the use of tissue protein for milk production or, on the other hand, to the treatments of feeds is difficult to say. It appears, however, that there were no noticeable differences in the protein utilization of untreated and formaldehyde treated milk powder. This conclusion is also supported by the results of rumen fermentation experiments (Syrjälä et al 1978).

Formaldehyde content of milk

Transfer of formaldehyde from feeds to milk was studied by determining the formaldehyde content of milk three times in the comparision period from cows of both milk powder groups. Milk from cows receiving formaldehyde treated milk powder in their feeds contained small amounts of formaldehyde, on the average 0.11 mg/kg milk (Table 6). This means that about 0.2 % of the formaldehyde of the feed was transfered to the milk. Formaldehyde content of milk was highest at the beginning of the comparison period, but decreased later. Milk from cows of the untreated milk powder group did not, however, contain formaldehyde at all.

Table 6. Formaldehyde content of the milk of cows on the formaldehyde treated milk powder containing diet during the comparison period.

Sampling time	Formaldehyde in mik, mg/kg
22/3 1977	0.16 (0.12 – 0.20)
19/4	0.09 (0.05 – 0.12)
17/5	0.07 (0.05 – 0.10)
Average	0.11 (0.05 – 0.20)

Table 7. Haematological criteria and chemical constituents of the plasma of cows in the comparison period.

	Protein shortage group	Untreated milk powder group	Formaldehyde treated milk powder group
Haematocrit	30.23	31.38	29.92
Hb, g/100 ml	11.24	11.89	11.10
Glucose, mg/100 ml	57.04	57.21	59.09
Urea-N »	12.21	12.69	12.40
NH_3-N »	0.11	0.10	0.14
Total-N, g/100 ml	7.60	7.36	7.67

There are quite a few experiments concerning the transfer of formaldehyde from feeds to milk. Beck and Gross (1973) found that about 1 % of formaldehyde of feed, formaldehyde treated silage, transfered to milk. The formaldehyde levels in milk increased from 0.2 mg to 2.5 mg/kg milk during the first 5–6 days. Kreula and Rauramaa (1976) fed dairy cows with fresh cut grass treated with formaldehyde, 490 mg/kg fresh weight, and found 0.6–2.2 mg formaldehyde/kg milk. Before and after this feeding there was no formaldehyde in the milk.

Composition of blood

There were no significant differences, between the different diets, in the concentration of the blood constituents determined (Table 7). All the values fall within the normal ranges (Rauen 1964).

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SELOSTUS

Käsittelemätön ja formaldehydillä käsitelty maitojauhe lypsylehmien valkuaisvajauksen täydentäjänä

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Tutkimuksen tarkoituksena oli selvittää maitovalkuaisen sopivuutta runsastuottoisen lypsylehmän valkuaisvajauksen täydentäjäksi. Samalla verrattiin rasvattoman maitojauheen valmistuksessa yleisimmin käytetyn sumutuskuivauksen sekä sumutuskuivatun, formaldehydillä suojatun maitojauheen hyväksikäyttöä. Tämä tutkimus kuuluu osana laajempaan maitovalkuaisen hyväksikäyttöä täysikasvuisella naudalla selvittelevään tutkimukseen, jossa on ollut osallisena Helsingin yliopiston kotieläintieteen laitos, Suomen Akatemia, Valio, Farmos ja Vaasan Höyrymylly.

Koe tehtiin 24 runsastuottoisella lypsylehmällä joista muodostettiin kolme ryhmää:
1) Valkuaisvajausryhmä
2) Maitojauheryhmä
3) Formaldehydiryhmä

Koe kesti yhteensä 15 viikkoa ja käsitti kahden viikon vakiointikauden, viikon siirtokauden ja 12 viikon vertailukauden.

Perusrehuina vertailukaudella olivat heinä, säilörehu ja propionihapolla säilötty ohra ja kaura sekä kivennäis- ja vitamiinirehut. Rehuannokset muodostettiin kaikissa ryhmissä perusrehuista joka suhteessa ravinnontarvetta vastaavaksi lukuunottamatta valkuaista. Valkuaisvajausryhmään jätettiin 25 %:n vajaus maidontuotantoon tarvittavasta sulavasta raakavalkuaisesta. Maitojauheryhmässä tämä vajaus täytettiin käsittelemättömällä sumutuskuivatun maitojauheen valkuaisella ja formaldehydiryhmässä vastaavasti formaldehydillä käsitellyllä maitojauheen valkuaisella. Suojauksessa käytetty formaldehydimäärä oli noin 0.4 g/100 g maitojauheen valkuaista.

Kokeessa määritettiin rehujen maittavuus ja hyväksikäyttö, maidon määrä ja koostumus sekä veriarvoja.

Tulosten perusteella voidaan esittää seuraavat johtopäätökset:

— Maitovalkuainen soveltui lypsylehmän rehuannoksen valkuaistäydennykseen.
— Poistettaessa valkuaisvajausta maitovalkuaisella saatiin positiivinen vaikutus maitotuotokseen maidon valkuaispitoisuuteen sekä eläinten elopainoon.
— Sumutuskuivatun käsittelemättömän maitojauheen ja formaldehydillä käsitellyn maitovalkuaisen hyväksikäytön välillä ei ollut mainittavia eroja.
— Formaldehydillä käsiteltyä maitovalkuaista käytettäessä pieniä määriä formaldehydiä havaittiin maidossa.