# Comparison of Hygiene and Sanitation Levels by Bioluminescence Method at Different Units Producing Components for Instant Soups

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**Abstract**

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Different production units within an instant soups manufacturer facility were compared by bioluminescence method detecting surface hygiene and sanitation quality. The evaluation was based on the limits determined by test examinations in the facility. It was confirmed that the results were influenced by the surface material and its condition (damage, roughening) as well as by complexity of the surface tested. The most important factor, however, was the attitude of different persons in charge of sanitation and preventive procedures. No influence was found of the type of the raw material processed (of animal or plant origin).

**Keywords**: instant soups; hygiene; sanitation; bioluminescence method

Consumer protection guaranteed by food hygiene is in the focus of interest of food manufacturers, inspection authorities and, last but not least, also of the consumers themselves. In order to ensure food safety, the processing facilities must observe essential principles such as microbiological, chemical, and physical purity within the facilities including the interior surfaces, equipment, instruments, and devices. The failure in complying with these principles may lead to the production of an unsafe food product. The consequences may include damage to the goodwill of the food manufacturer, a penalty imposed upon the manufacturer by inspection authorities, production losses and risks for consumers health. Gerstein *et al*. (1993) emphasised the role of cleaning and disinfection during the whole production process as the procedures which are indispensable for any system of manufacturing safe food products. The effectiveness of cleaning and disinfection should be monitored by regular controls carried out by the food processing facility staff. The controls are based on microbiological tests covering in particular interior surfaces, equipment and instruments. It is possible to determine the quantity and the species of microorganisms by the traditional method of bacterial colony count evaluation. However, the time factor is a significant disadvantage of this method which works only retrospectively because the results are available in 24–48 h at the earliest. Due to this delay, the operator of the food processing plant has no chance to correct any deficits in hygiene that may keep on occurring in the ongoing procedure of food processing or distribution (Orth & Steigert 1996b).

The time delay which invariably occurs with the standard methods of cleaning and disinfection control is considerably disadvantageous. Food manufacturers are therefore ever more interested in methods that can be utilised during food processing procedures. Baumgart (1996a) reported that rapid methods in food microbiology were increasingly important. Food industry screening methods are of a particular interest. Adenosin triphosphate (ATP) detection is one of the most important methods for monitoring hygiene in food processing facilities.

Orth and Steigert (1996a) carried out an ATP evaluation in a leading meat processing plant in Germany in 1995. They used the bioluminescence technique developed by Biotrace Ltd. in the United Kingdom. Similarly to Baumgart (1996b), the authors concluded that the method was suitable in food processing industry for a rapid determination of hygiene parameters of the surfaces subject to cleaning. The method did not require much of human and material resources. The principle of the test consists in the detection of ATP from microorganisms and somatic cells. Cleaned and disinfected surfaces might be reliably evaluated within two minutes. Different pieces of equipment were tested in a laboratory and in a meat processing facility. The quality of hygienic evaluation of the cleaned surfaces clearly depended on the structure of materials and on the leftovers of the product sticking on uneven parts of the surfaces. Therefore the limiting ATP values must be determined individually for each particular production unit. If these prerequisites are met, bioluminescence method can be recommended as a suitable hygienic monitoring tool.

Seeger and Griffiths (1994) compared the efficacy of the cultivation method and of the method based on ATP determination for the purposes of cleaning and sanitation evaluation. They monitored the practical use of ATP bioluminescence method for the evaluation of cleaning and sanitation methods in meat cutters in eight different facilities. The ATP determination method was compared to the standard swab sample method using microbiological cultivation. The evaluation was carried out in the cutter prior to use, after use, and after the sanitation procedure. Both methods gave similar results but ATP determination was superior in providing data on cleanliness of the cutter because it detected meat particles left on the edge of the cutter after incorrect sanitation. The results were available within five minutes after the use of the machine for ATP analysis which means that the operator can implement a rapid corrective measure, if necessary.

Kircher *et al*. (1996) used bioluminescence method for the study of efficacy of cleaning and disinfection on the surfaces of the equipment for processing minced meat and fish as well as in the trucks used for the transport of meat. Bioluminescence method was used in their study for the determination of ATP from microorganisms and somatic cells. The results of the method were compared to those of standard analysis of swab samples. Testing with a known ATP quantity and a known concentration of bacteria was to reveal the sensitivity of bioluminescence method and to show any correlation between the microorganism count and the value of relative light units (RLU). The experiments produced results needed for the evaluation of the results of cleaning and disinfection in the facilities mentioned above as well as in the means of transport. The lowest concentrations detectable were identified. The resulting ATP value below 100 RLU indicated that cleaning and disinfection had been carried out correctly. Such values could be easily achieved on the surfaces that were easy to clean. Other surfaces, which were more difficult to clean, should have not shown values above 500 RLU. The bioluminescence method used appeared to be very suitable for the control of cleaning and disinfection because, apart from microorganisms, the organic contamination could be detected as well.

Baumgart (1996c) evaluated the factors that significantly affect the quality of cleaning and disinfection. A comparative study was carried out in a meat cutter. Aerobic colony counts were determined of swab samples. ATP concentrations were determined by HY-LITE system. High ATP values were found while the bacterial counts were low (or determined negative). According to the authors, this was due to uneven surfaces of the areas examined. Even after cleaning and disinfection some leftovers of meat remained in the small hollows of rough surfaces. Therefore the authors reported that the type of surface was a significant factor influencing the values detected by ATP analyser. ATP level was also influenced by the type of raw material used for food production. Cellular matter sticking on the surface increased the level of contamination detected by ATP analyser. According to the authors, the criteria for the introduction of this method for surface cleanliness and disinfection evaluation must be individually determined for each particular type of production.

The influence of secondary contamination of monitored surfaces by the hands of operators was studied by Worsfold and Griffith (2001). Cleaning procedures and HACCP standards were evaluated in retail butchery shops by means of visual inspection, review of cleaning procedures, and ATP bioluminescence testing. The monitoring was focused on different types of food and on the places that were in contact with operators' hands. Considerable differences in ATP values were found on different surfaces which confirmed the fact that the surfaces that had contact with operators' hands were usually more contaminated during the production process.

Upmann and Reuter (1998a) carried out a similar study dealing with the influence of tools used in food processing upon cleanliness of monitored surfaces. The authors reported that the contamination of tools and persons was an important factor influencing consumers' health and extended storage of meat products. The authors observed among others the contamination of tools and persons by means of swab samples taken prior to and after the beginning of minced meat production, using visual inspection as well. The contamination of both tools and persons reduced the level of cleanliness of the surfaces monitored by the study.

## MATERIALS AND METHODS

Hygiene and sanitation was monitored for a period of 8 months in a processing facility producing instant food. The observation was particularly focused on the level of contamination of the surfaces in contact with raw materials and foodstuffs. The products monitored were components for instant soups.

ATP analyser Uni-Lite XCEL (Rapid Cleanliness Test) manufactured by BIOTRACE (UK) was used for monitoring the level of hygiene and sanitation of the surfaces in contact with raw materials and foodstuffs. Uni-Lite XCEL is capable to determine total cleanliness of surfaces through the detection of ATP from various sources regardless to their origin (microbial, animal, plant). This method of "total ATP" detection guarantees correct hygienic control by measuring both microbial and non-microbial contamination of the surface, originating not only from the product leftovers. ATP sources in the dirt may be living microbial cells (bacteria, yeasts, fungi) or non-microbial cells (erythrocytes, somatic cells, plant cells, cells from meat). ATP may be also of extracellular origin when released from cells after their destruction.

The method is based on the determination of adenosin triphosphate (ATP) by means of luminescence measurement during enzymic oxidation of luciferin by luciferase. The emitted radiation is measured with high sensitivity. Radiation intensity coming from the swab placed in the luminometer measuring chamber is expressed in relative light units (RLU). The results of the measurement are directly related to the quantity of ATP on the surface of the swab and consequently also to the quantity of dirt and contamination remaining on the surface examined. "Dead" dirt containing no ATP is not detected (e.g. organic dirt long time after it had dried). The absence of ATP thus indicates cleanliness of the surface. The results can be read about 15 s after placing the swab into the sample chamber of the instrument.

Precise measurements require on-site calibration of the ATP analyser. Test swabbing was carried out on selected sites within the facility so as to adjust the parameters for the routine evaluation of hygiene and sanitation levels. Swabbing should be done by the same person because the method is rather sensitive and a different approach to swabbing may bias the results even if the examined area remains identical. Swab samples were taken prior to the start of the production, during the production, and after the end of cleaning and disinfection. Swabs for the examination by standard microbiological cultivation were collected as well. The results served for the determination of the limits for the given food processing facility (Table 1).

The following procedure was set up for the comparison of the levels of hygiene and sanitation at the units manufacturing components for instant soups. On the basis of the predetermined production plans, once a week in the morning of the specified day

Table 1. Limits for the values determined by ATP analyser (in RLU per 100 cm$^2$)

| Evaluation | Stainless steel and smooth surfaces | White and light plastic surfaces | Cast iron and coloured plastic surfaces |
|---|---|---|---|
| Good | 0–500 | 0–600 | 0–1000 |
| Acceptable | 501–1000 | 601–1200 | 1001–2000 |
| Unacceptable | > 1000 | > 1200 | > 2000 |

the appointed person controlled sanitation prior to the start of the production at different units. The control was carried out by visual inspection and swabbing for ATP analysis. At the units with a high risk (where raw materials of animal origin were processed and where baby food was produced), the samples were always taken prior to the start of each working day. At other units, the samples were taken at random at least once a month. The person in charge of the control made an own daily ATP sampling plan based on the knowledge of the operation, practical experience, and the assessment of the current situation. Such plan had to include a minimum of 10 sampling places. The pieces of equipment that failed to show acceptable limits were again sanitised.

Several units for the production, processing, or handling of the following items were monitored within the framework of the system described above: meat, hens and offal cooking, meat components drying line, concentrated broth, meat balls, paste products and components, bacon processing, legumes drying, instant mashes, handling packages.

The level of hygiene and sanitation was observed at different units. Based on the results obtained, the units were compared and ranked.

Essential statistical parameters determined were: number of samples, mean values, standard deviation of sample values, median, maximum, and minimum values. Due to the assumption that the values did not follow the normal Gauss distribution pattern, median values were considered. Statistical calculations were carried out using software package Unistat.

## RESULTS

Hygiene and sanitation levels were compared in a food processing facility producing components for instant soups. The level of contamination of the surfaces in contact with raw materials and foodstuffs in different units of the facility were evaluated. The units were tested by ATP analyser and were assigned the following short names: meat, hens and offal cooking (**Dehydration**), meat components drying line (**Meat Drying**), concentrated broth (**Evaporation**), meat balls (**Meat Balls)**, paste products and components (**Paste**), bacon processing (**Bacon**), legumes drying (**Legumes**), instant mashes (**Mashes**), handling packages (**Packages**).

The values detected by ATP analyser in different units are summarised in Table 2.

The units with the highest and the lowest levels of hygiene and sanitation were determined by comparison of median values determined by ATP analyser at different units. The results are shown in Figure 1.

The results shown in the graph suggest that the lowest levels of hygiene and sanitation were found at Meat Drying unit, followed by Legumes, Dehydration, Packages, Meat Balls, Mash, Evaporation, and Paste. The best mean value for hygiene and sanitation was found at Bacon unit.

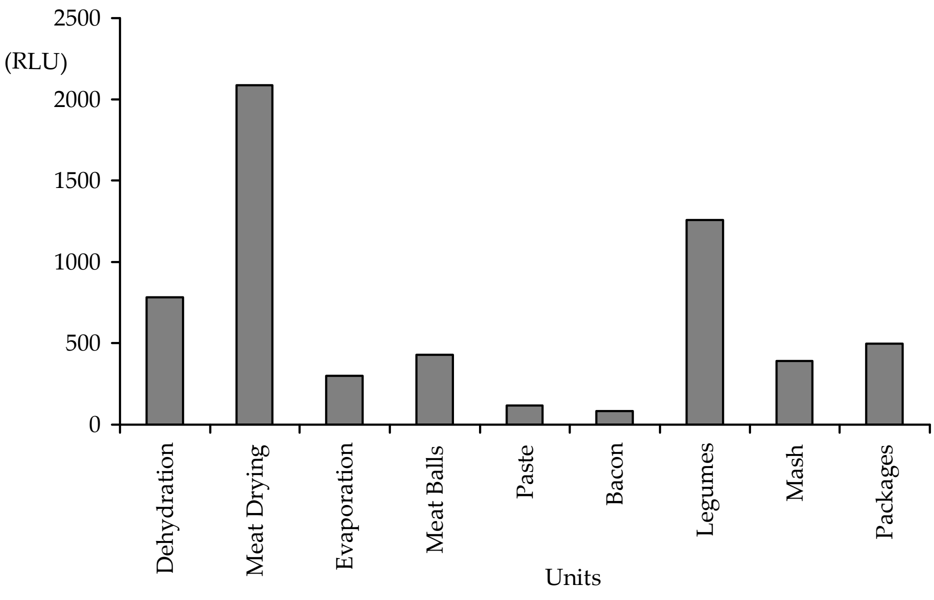


Figure 1. Comparison of median values determined by ATP analyser at different units

Table 2. Values detected by ATP analyser at different units

| | D | MD | E | MB | P | B | L | MA | PA |
|---|---|---|---|---|---|---|---|---|---|
| Number of samples | 128 | 78 | 18 | 47 | 32 | 11 | 28 | 73 | 72 |
| Mean value | 6 789 | 8 253 | 894 | 2 038 | 452 | 297 | 23 053 | 1 629 | 4 820 |
| Standard deviation | 44 352 | 14 116 | 1 166 | 4 432 | 780 | 397 | 93 818 | 4 043 | 12 230 |
| Median | 781 | 2085 | 302 | 429 | 119 | 85 | 1 259 | 390 | 496 |
| Minimum | 26 | 9 | 35 | 33 | 20 | 18 | 25 | 19 | 21 |
| Maximum | 500 000 | 84 292 | 4 105 | 23 794 | 3 693 | 1 235 | 500 000 | 21 816 | 70 717 |

D – Dehydration; MD – Meat Drying; E – Evaporation; MB – Meat Balls; P – Paste; B – Bacon; L – Legumes; MA – Mash; PA – Packages

Table 3. Frequency of cases when limit ATP values were exceeded at different units of the food processing facility

| Unit | Total number of examinations | Cases with values above the limits | Per cent of cases above the limits |
|---|---|---|---|
| Dehydration | 128 | 48 | 37.5 |
| Meat Drying | 78 | 47 | 60.3 |
| Evaporation | 18 | 5 | 27.8 |
| Meat Balls | 47 | 11 | 23.4 |
| Paste | 32 | 4 | 12.5 |
| Bacon | 11 | 1 | 9.1 |
| Legumes | 28 | 14 | 50.0 |
| Mash | 73 | 20 | 27.4 |
| Packages | 72 | 27 | 37.5 |
| Total | 487 | 177 | 36.3 |

These findings were also confirmed to a certain extent by the frequency of cases when limit ATP values were exceeded, as expressed in relative figures in Table 3. The ranking among the units with the poorest levels of hygiene and sanitation, however, did not exactly reflect the situation as determined by median values.

The results can be used to focus corrective measures for hygiene and sanitation on the weak points in the facility.

## DISCUSSION

Veterinary medicine plays an important role in public health protection, in particular as regards food production, processing, storage, distribution, and retail sale (Reuter 1997). The aspects of health safety and hygiene of raw materials and foodstuffs influence the activities of food manufacturers and inspection authorities as well as of the consumers. Most recently, a special responsibility of the food manufacturer in the areas of health safety and hygiene has been put to the forefront. Food manufacturers must have a primary interest to produce safe and hygienic foodstuffs in the context which was explained in greater details by Orth and Steigert (1996a). Inspection authorities then monitor this essential responsibility of food producers. Consumers influence the food production through the mechanisms of the market demand for certain types and forms of foodstuffs.

The essential requirement of both the consumers and the inspection authorities is to have health safety and hygiene of foodstuffs ensured in the context described by Gerstein *et al*. (1993). An important factor of health safety and hygiene of foodstuffs consists in the quality of cleaning and sanitation starting at the very beginning of the foodstuffs production and ending with their consumption. The process of cleaning and sanitation must also contain control mechanisms. Such mechanisms are principally based on standard methods of microbiological examination of swab samples. A new method of ATP determination in swabs from food processing facilities can also be used as described, for instance, by Baumgart (1996b), Hawronskyj and Holah (1997), Ogden (1993) and Davidson *et al*. (1999).

According to Kircher *et al*. (1996), correct level of cleaning and sanitation was confirmed by resulting values of 100 RLU, or 500 RLU in case of surfaces that are difficult to clean. Baumgart (1996c) reported that there were numerous factors influencing ATP values used for monitoring the level of cleaning and disinfection. These factors depended on the type of production. The author concluded that the criteria for cleanliness and sanitation evaluation should be always individually determined for the given type of production.

This opinion was also confirmed by various ATP values determined in practice at different units and with different pieces of equipment in the food processing facility during the present work. The comparison of different units revealed that hygiene and sanitation should be closely monitored in particular in Meat Drying unit as well as in Legumes, Dehydration, and Packages units.

The site of the most intensive contamination at Meat Drying unit (as well as in the total ranking) was the output head of the cutting/granulation machine. Although the machine was made of stainless steel with a smooth surface, the output part used to be more contaminated due to the lack of space around the critical parts of the equipment and its uneven complex surface structure. Baumgart (1996c) also confirmed that the efficacy of sanitation procedures was influenced by complexity and uneven nature of the surface examined. Cleaning and disinfection procedures should be more strict in requiring proper tools. The same applies to the control mechanisms for these procedures. Furthermore, at the same unit the contamination of the movable plastic belt was also evaluated. The surface structure of the belt was slightly granular and not very coarse or rough. The belt was not used continuously and the main problem was rather a secondary contamination since the belt itself was not significantly stained at all. The transport belts were always covered after cleaning. During the time when the meat drying line was out of operation and the adjacent legumes drying line was working, the dust contamination of the air was always higher than under normal circumstances. This problem could be solved by postponing the time of disinfection till just before the start of the production. The disinfection agent should be based on alcohol because of rapid drying. The transport belts should remain covered during the out-of-operation period.

A similar situation was found at Legumes unit which had the second worst evaluation. The most critical condition was found with the plastic transport belt with a rough surface and in the sieve for transferring the product which was frequently contaminated with dust.

The results found at Dehydration unit confirmed the influence of the type of material on the resulting values. The situation was found worse in the cutter made of cast iron with a coarse and rough surface than in a similar equipment made of stainless steel.

The results found with different transport packages at the respective unit were related to the history of their use and handling. The surfaces had been originally smooth but if not handled with care, even stainless steel could become uneven and rough. It must be noted that the transport packages were also used outside the facility itself.

At Mash unit, the worst results were found with the instrument used for the separation of the matter from the drying drum. The problem was in that leftovers of the dried substance remained stuck to it. Since the surface was rough the cleaning could never be perfect.

The equipment checked at units Meat Balls, Evaporation, and Paste was less complex. The surfaces in contact with the product were made of stainless steel and were undamaged. Very good results at Paste unit reflected carefully done sanitation, despite the fact that the unit was located in the area with increased dust contamination.

The separate location and a responsible approach to sanitation were most probably the main factors that contributed to the best results found at Bacon unit. The operator at this unit had many years of practice, showed a very responsible approach, was well trained, had great experience, and there were no changing shifts at this units. At some other units, the operators worked in changing shifts and any unacceptable results of cleaning and disinfection could thus not be attributed to a single person. Identical pieces of equipment (separators made of cast iron) used at units Bacon and Dehydration showed a very great difference in RLU values (58 and 1400, respectively). This suggests a significant influence of the operator although the type of raw material processed may also have contributed to the difference.

Continuously evaluated results showed that cleaning was insufficient with regard to sanitation procedures. One of the key problems consisted in the contamination of washed but uncovered surfaces. This was typical, for instance, for the transport belts which had not been used for more than one week before the production was started again. There were several factors which influenced the condition after cleaning and disinfection and which also had to be adapted to the type and condition of the surface of the equipment. Such factors include the method of cleaning (Scholtz & Steigert 1991), the type of disinfectant (Reuter 1998), and mechanical aspects of the cleaning procedure (Van Klingeren *et al*. 1998). If the surface is damaged and not smooth any more due to long-term wear, it can be expected that the results of monitoring the efficacy of cleaning and disinfection procedures will be worse.

However, the most important factor of all is a responsible approach of the individual operators to the sanitation procedures. The hygiene of the equipment and instruments is significantly influenced by the working and hygienic habits of the personnel as reported by Upmann and Reuter (1998b), and Gerstein *et al*. (1993). The levels of qualification and further training of personnel are closely related to this topic as well, as reported by Mortlock *et al.* (2000).

## Conclusion

Due to a wide range of products, food processing facilities typically contain different types of contamination which require a suitable technology of sanitation and cleaning agents. No universal cleaning procedure can be determined because of the considerable variability of the facilities themselves. Each part of production and technology is specific and its features must be respected in order to achieve maximum efficacy of the sanitation procedures. The success in the determination of a correct procedure for cleaning and sanitation can be controlled by methods based on different principles. The control of the efficacy of cleaning and sanitation procedures using an ATP analyser is a novelty in this area.

Different units were compared in a food processing facility producing components for instant soups. The levels of hygiene and sanitation were evaluated using an ATP analyser. Units with the worst levels of hygiene and sanitation within the facility were identified and possible reasons were discussed.

With regard to the results presented, it is necessary to consider some measures which would lead to improved cleanliness at the units in question. Different aspects have to be taken into account: uneven surfaces of the areas examined, type of surface material, method of cleaning, type of disinfectant, mechanical aspects of cleaning procedures, frequency of the exchange of cleaning cloths, impregnation of the cloths with disinfectant agents, contact of raw material with the surfaces and with the hands of operators, habits of the personnel (cleaning of hands, general hygiene, contamination of instruments) as well as their qualification and further training.

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## Souhrn

Grbalová S., Večerek V., Tremlová B., Chloupek P., Pištěková V. (2003): **Porovnání úrovně hygieny a sanitace pracovišť na výrobu polévkových polotovarů využitím bioluminiscenční metody**. Czech J. Food Sci., **21**: 129–136.

V potravinářském provozu se zaměřením na výrobu polévkových polotovarů byla pomocí bioluminiscenční metody porovnávána úroveň hygieny a sanitace na různých pracovištích. Hodnocení bylo založeno na limitech určených při zkušebním vyšetření jednotlivých zařízení. Bylo potvrzeno, že výsledky sanitačních postupů ovlivňuje materiál povrchu (nerovnosti, druh) a podmínky provedení (způsob čištění, druh použitého prostředku). Nejvýznamnějším faktorem však byl přístup různých pracovníků k provádění preventivních a sanitačních postupů. Nebyl zjištěn vliv druhu zpracovávaného materiálu (živočišného nebo rostlinného původu).

**Klíčová slova**: instantní polévky; hygiena; sanitace; bioluminiscenční metoda

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