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Alcohol During the Nursing Period – A Risk Assessment under Consideration of the Promotion of Breastfeeding

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Bundesinstitut für Risikobewertung

Imprint

BfR Wissenschaft

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Federal Institute for Risk Assessment
Press Office
Max-Dohrn-Str. 8–10
10589 Berlin

Berlin 2013 (BfR-Wissenschaft 01/2013)
46 pages, 8 illustrations, 5 tables
€ 5.-

Printing: cover, content pages and bookbinding
BfR-Hausdruckerei Marienfelde

ISBN 3-938163-99-2
ISSN 1614-3795 (Print) 1614-3841 (Online)






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1 Introduction

Alcoholic beverages have been part and parcel of social and cultural life in Germany for centuries (Burger & Mensink 2003; Schmidt 2005) and the moderate consumption of these beverages is socially accepted among large parts of the population. Table 1 shows the alcohol contents (concentration of pure ethanol) and the drinking quantities listed in the literature.

Tab. 1: Alcohol contents of alcoholic beverages and drinking quantities listed in the literature (regular glass)

		Alcohol content in % alc/vol	Drinking quantities (regular glass)	Alcohol intake*
	Beer Pils Lager Wheat beer	approx. 5% alc/vol	0.33–0.5 l	13.3–20 g
	Wine White wine Red wine	10–13% alc/vol	0.125–0.25 l	10–26 g
	Sparkling wine German sparkling wine	approx. 11% alc/vol	0.1 l	8.8 g
	Spirits Liqueur Whisk(e)y Cognac	20–45% alc/vol	0.02–0.03 l	3.2–9.6 g
	Alcopops Spirit-based mixers	approx. 5.5% alc/vol	0.275 l	11.8 g

*Based on the drinking quantity specified in the literature (regular glass)
(modified according to Feick et al. 2006; Lachenmeier et al. 2006; Working Group for Alcohol and Responsibility 2010)

The motivation to drink alcohol is based on the disinhibiting, euphoriant but also relaxing effect attributed to this substance due to its psychoactive potential (Federal Centre for Health Education (BZgA) 2002; Burger & Mensink 2003; Schmidt 2005; Rist & Demmel 2005; German Centre for Addiction Issues (DHS) 2007).

Individual drinking quantities and frequencies as well as drinking patterns are determined by experiences of the positive and negative effects of alcohol within the framework of a learned behaviour (Rist & Demmel 2005). High-risk and dangerous alcohol consumption such as binge drinking (DHS 2010) – e.g. \geq five glasses of alcohol \approx 70 g ethanol within an extremely short space of time – and chronic alcohol consumption (at least 12–40 g of pure alcohol per day by women) result in damage to organ systems such as the central nervous system, the

cardiovascular system, the liver and the gastro-intestinal tract. A further risk is posed by the carcinogenic effect of chronic and excessive alcohol consumption (BZgA 2002; Bode et al. 2005; Harder et al. 2005; Gass et al. 2005; Siegmund et al. 2005; Strotmann & Ertl 2005; Feick et al. 2006). The different drinking quantities and patterns result in qualitatively and quantitatively different effects on health (Rehm & Frick 2011). Moreover, alcohol has considerable addictive potential, with an estimated 1.6 million alcohol-dependent people in Germany (Rist et al. 2005).

With an annual per capita alcohol consumption of around ten litres of pure alcohol, Germany is in the upper middle section of the European rankings (Berghöfer & Willich 2006) and one of the high-consumption countries by international comparison (Burger et al. 2003; Rist et al. 2005; Bühringer & Kraus 2011). Evaluations of the 1998 Federal Health Survey show that alcohol consumption clearly varies as a function of sociodemographic factors, in particular gender, age and socioeconomic status. According to these evaluations, the most significant influencing factor on alcohol consumption among women is age: women in the age group from 18 to 29 consumed an average 1.03 g of alcohol a day in the form of beer (alcohol content 4.8% alc/vol) and 1.89 g of alcohol in the form of wine (alcohol content 11% alc/vol). The figures for the 50 to 59 age group were 1.45 g per day of pure alcohol in the form of beer and 3.51 g in the form of wine (Burger & Mensink 2003; Burger et al. 2003; RKI 2004). Behaviours such as smoking and physical activity, as well as personal characteristics such as Body Mass Index (BMI) are also linked to the consumption of alcohol. Higher alcohol consumption was found with higher social status and smaller household size, for example. Moreover, female smokers and ex-smokers consume more alcohol. Higher BMI was, however, negatively correlated to alcohol consumption in women, and pregnancy also resulted in lower alcohol consumption (Burger et al. 2003).

Although there are hardly any data on the effect of alcohol consumption by the mother on breastfeeding behaviour, recent studies in Berlin and Bavaria indicate that the desire to smoke or drink alcohol and/or coffee during the nursing period is a frequent reason why mothers either primarily decide against breastfeeding or wean their babies off breast milk earlier than recommended. In addition, epidemiological studies show that some of the women feel the desire to drink a glass of wine or beer on certain occasions during the nursing period and that alcohol consumption during this phase is not infrequent (Alvik et al. 2006; Rebhan et al. 2009).

There is currently a range of differing information on the topic of alcohol during the breastfeeding phase in the German-speaking countries (Federal Ministry of Health (BMG) 2000; Neumann & Friese 2006; Friese et al. 2006; Schaefer et al. 2006; Rhineland-Palatinate State Centre for Health Promotion (LZG-RLP) 2009; Koletzko et al. 2010; Peters 2010; Rasenack & Zink 2011; BZgA 2011; Gundert-Remy et al. 2012). The National Breastfeeding Committee at the Federal Institute for Risk Assessment is of the opinion that women should be informed about the health-related effects of alcohol consumption during the breastfeeding phase and be provided with clear recommendations on the use of alcohol during this period.

The following report is designed to provide an overview of the pharmacokinetics of alcohol among (breastfeeding) women and infants, as well as of the effects of alcohol consumption on mother and child in the breastfeeding phase as published in the scientific literature. Against this backdrop and based on the 2011 Expert Meeting of the National Breastfeeding Committee at the Federal Institute for Risk Assessment (BfR), recommendations are formulated for alcohol consumption during the breastfeeding phase.

2 Alcohol Consumption after Childbirth and while Nursing

The final survey of the study on breastfeeding behaviour in Bavaria, a prospective cohort study focusing on the breastfeeding rates and breastfeeding behaviour of Bavarian mothers (Kohlhuber et al. 2008) rather than specifically on the issue of "alcohol consumption during the breastfeeding phase", asked respondents about the consumption of alcoholic beverages during pregnancy and the nine months following childbirth. There were three answer categories: "no alcoholic beverages", "only on special occasions (without information on quantity consumed)" and "occasional/regular consumption with details of number of glasses per week". It was assumed that a 0.1 l glass of sparkling wine, 0.2 to 0.3 l of beer or 4 cl of spirits is equivalent to roughly 9 to 10 g of pure alcohol. Other questions, such as that concerning the number of alcoholic beverages consumed per drinking session (binge drinking) were not asked in the study, and occasional and regular alcohol consumption were not recorded in separate categories. The publication by Rebhan et al. (2009) contains details of the study collective. Exclusive breastfeeding was defined as feeding the infant with mother's milk without the additional use of other fluids or baby food.

According to the findings of this study, between 30 and 80% of the interviewed women drank alcohol during the first nine months after childbirth (compared to approx. 25% during pregnancy). Most of the respondents said they only drank alcohol on a special occasion during the breastfeeding phase (Rebhan et al. 2009). The results show that around 5% of women ($n = 58$ mothers) drank one to three glasses per week during the first three months after their child was born; 0.7% occasionally or regularly drank more than three glasses of alcoholic beverages a week. Between the seventh and ninth month after their child was born, the percentage of women who drank one to three or more than three glasses of alcohol a week increased to 15% and 4% respectively (see figure 1).

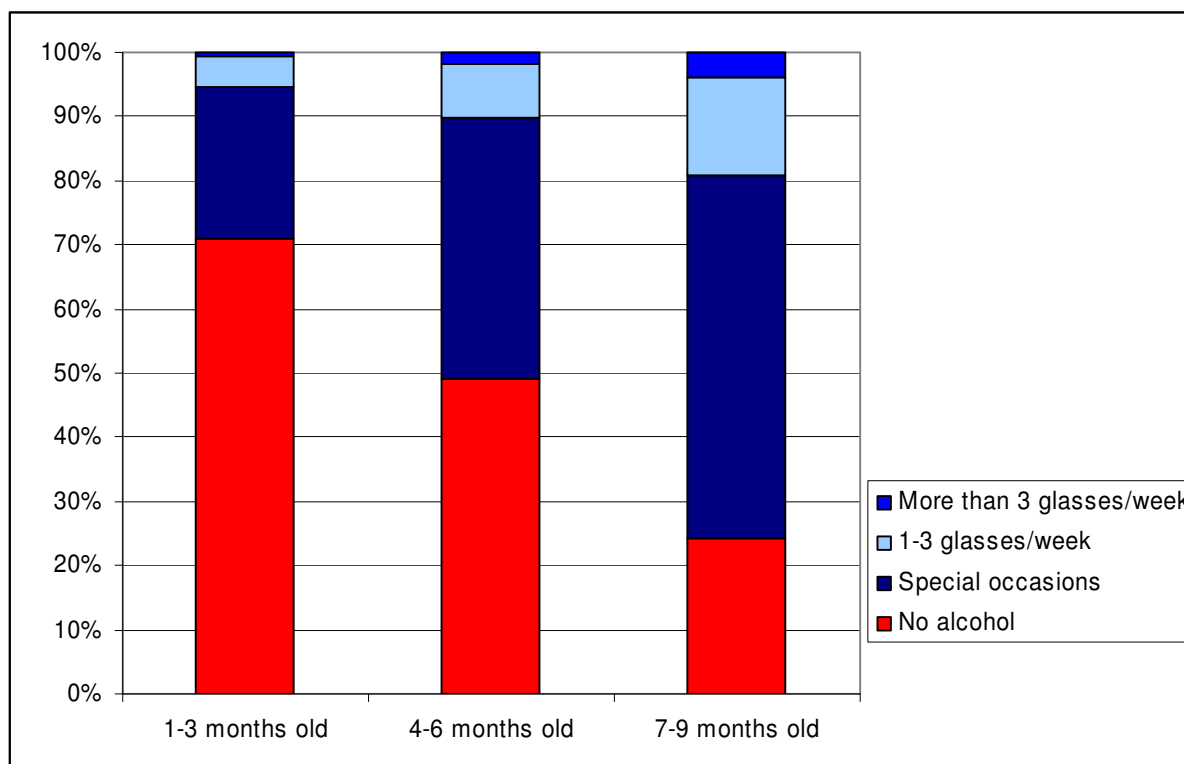


Fig. 1: Alcohol consumption of women during the first nine months of the child's life (data source: Study of Breastfeeding Behaviour in Bavaria; $n = 3,822$)

Of the 117 women who had already drunk one to three glasses of alcohol a week during pregnancy occasionally or regularly, 95 % also did so during the first three months after the birth of their child (Kohlhuber, personal communication, 2011). This study found no differences in alcohol consumption during pregnancy and after childbirth among smokers, ex-smokers and non-smokers. The non-smoking women were defined as those who had "never smoked", the ex-smokers as those who "smoked before pregnancy but not during and after pregnancy" and smokers as those who "smoked before and after pregnancy". However, older mothers and higher-educated mothers consumed alcohol more frequently during pregnancy and after childbirth (Rebhan et al. 2009; Kohlhuber, pers. comm., 2011). As shown in Fig. 2, non-breastfeeding mothers drank alcohol more frequently in the first and fourth month of the child's life than women who exclusively breastfed their baby.

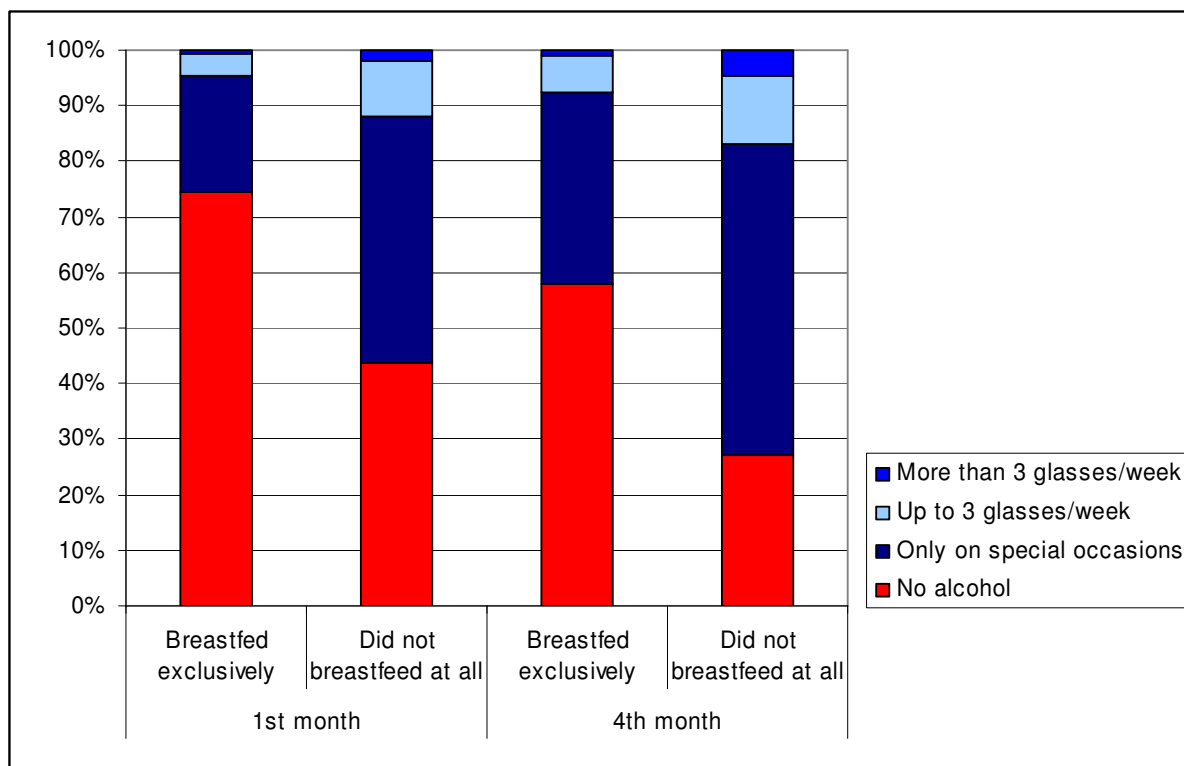


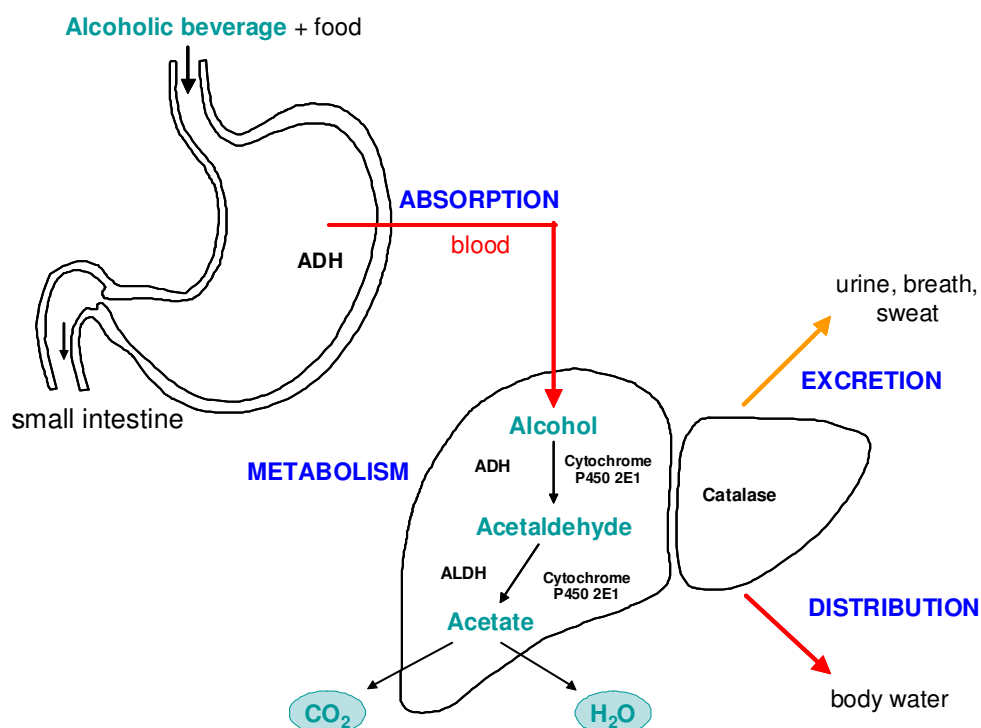
Fig. 2: Alcohol consumption of mothers by breastfeeding status (data source: Study of Breastfeeding Behaviour in Bavaria; n = 3,822)

Data from the USA and Australia also confirm that around 40% of woman occasionally drank alcohol during the first few months after the birth of their child (Breslow et al. 2007; Maloney et al. 2011). Between 43 and 48% of women in Australia consumed alcohol in the first four to six months after childbirth, regardless of whether or not they were breastfeeding (Giglia & Binns 2007a; Giglia & Binns 2008). A study by Little et al. (1989) showed that women in the USA increasingly drank alcohol from the third month after their child was born. However, a further North American study observed that breastfeeding mothers of three-month-old babies consumed large amounts of alcohol (at least two alcoholic beverages a week) less often than non-breastfeeding mothers to a statistically significant degree (Breslow et al. 2007). It was found that breastfeeding for a period of at least six months, irrespective of breastfeeding intensity, also prompted Norwegian women to refrain from excessive alcohol consumption (at least five alcoholic beverages per session) (Alvik et al. 2006).

3 Pharmacokinetics of Alcohol

The pharmacokinetics of ethanol (= alcohol) following oral intake are based on resorption, metabolism and distribution in the human organism (Li et al. 2001; Ramchandani et al. 2001a). Figure 3 contains a schematic summary of the relevant information.

Ethanol is resorbed along the entire length of the gastro-intestinal tract. Resorption via the oral cavity and the oesophagus is low, while resorption via the stomach is as high as 10 to 30% (Norberg et al. 2003; Hendriks 2005). The main part is absorbed in the small intestine by passive diffusion (Norberg et al. 2003; Hendriks 2005; Gilg 2005). How much alcohol is resorbed in the body following oral intake depends among other things on the composition of the alcoholic beverage, the way in which it is drunk (fast or slow intake etc.), the time of day when alcohol is consumed, the individual blood sugar level and how long the alcohol stays in the stomach (Norberg et al. 2003; Roine et al. 1993). For example, Gilg (2005) found that the CO₂ content in sparkling wine and wheat beer irritates the gastric mucosa and therefore promotes blood circulation in the mucosa, thereby speeding up gastric emptying. As a result, the alcohol is resorbed more quickly and the blood alcohol concentration rises faster than following consumption of wine and normal beer with the same alcohol content. Alcohol is resorbed more rapidly in the morning, probably due to a circadian rhythm, and this results in higher blood alcohol levels than at other times of the day (Lötterle et al. 1989; Yap et al. 1993; Danel & Touitou 2004; Gilg 2005). The retention time in the stomach is influenced by the stomach filling level, smoking, sympathetic tone or the intake of certain medications like Domperidone or Erythromycin (Norberg et al. 2003; Gilg 2005; Rommelspacher 2011). According to Johnson et al. (1991) smokers display delayed alcohol absorption, probably due to slower passage through the stomach. Of the alcohol resorbed, 96% is forwarded to the body water and 4% to the fatty tissue (Gilg 2005).



ADH = Alcohol dehydrogenase;
 ALDH = Aldehyde dehydrogenase;
 Cytochrome P450 2E1 = Cytochrome P450 isoenzyme 2E1-dependent monooxygenase

Fig. 3: Pharmacokinetics of alcohol

The total body water content in women accounts for around 60% of the body mass. In the first step, biotransformation of alcohol takes place via alcohol dehydrogenase (ADH). This leads to the creation of the metabolite acetaldehyde, which is seen as being responsible for many of the harmful effects of alcohol. In humans, ADH is a polymorphic enzyme system with various isoenzyme classes, the alcohol affinity of which varies and which are variously distributed in the body's tissues. The stomach, for example, contains γ -ADH (class I), χ -ADH (class III) and δ -ADH (class IV) (Yokoyama et al. 1995; Jelski et al. 2002; Ramchandani et al. 2001a). In addition, there are different genotypes in class I which determine the different metabolic rates of different people. The liver metabolises alcohol extremely efficiently (90 to 98% of the absorbed alcohol quantity) (Jones 2010), whereas 2–10% are exhaled, and the remainder is excreted in unconjugated form via the kidneys or in the form of glucuronide or sulphate conjugates via the urine and saliva (Norberg et al. 2003; Jones 2010). The liver is responsible not only for the main cytosolic pathway via class-I-ADH (Norberg et al. 2003) but also for two pathways with a lower metabolic performance: via microsomal cytochrome P450 isoenzymes (primarily CYP2E1) and via catalase (see figure 3) (Rommelspacher 2011). While part of the alcohol is metabolised already in the stomach and during its first passage through the liver (first-pass effect), the remainder is distributed in the body by the circulation of the blood (Oneta et al. 1998). The degree of metabolism during the first-pass effect depends among other things on the retention time of the alcohol in the stomach (Oneta et al. 1998). This correlates positively with the stomach filling level, which is why test persons with an empty stomach showed higher blood levels of the non-metabolised alcohol than test persons who had eaten before consuming alcohol (Jones et al. 1997; Ramchandani et al. 2001a, b). Jones (2010), however, estimates the percentage of the dose that is subject to a first-pass effect following moderate alcohol consumption after food to be low (4.6 to 13.7% of the alcohol dose). In contrast, Pastino & Conolly (2000) assume that the first-pass effect is of greater significance and report, for example, that 15 to 26% of the dose given to male test persons was metabolised (0.5 g of alcohol per kg body weight). According to Baraona et al. (2001), the first-pass effect in women is lower than in men due to the reduced χ -ADH activities in the stomach.

In a second step, acetaldehyde is generally oxidised via aldehyde dehydrogenase (ALDH), but also via monooxygenase CYP2E1 to acetate, which is then metabolised into carbon dioxide and water in the citrate cycle (DFG 1998; Hendriks 2005; Agarwal-Kozlowski 2005; Jones 2010; Rommelspacher 2011). ALDH also exhibits an enzyme polymorphism that influences the efficiency of alcohol elimination by different individuals to different degrees (Agarwal-Kozlowski 2005; Ramchandani et al. 2001a). The genetic variability of the ADH and/or ALDH alleles, which are distributed with different frequencies in different populations, is one of the reasons for the ethnic variations in alcohol metabolism (Thomasson 1995; Ramchandani et al. 2001a; Rommelspacher 2011). Overall, these genetically based differences in enzyme activity result in major inter-individual differences in alcohol elimination (Thomasson 1995; Norberg et al. 2003).

The process of elimination of alcohol from the blood is often described using Michaelis-Menten kinetics, which corresponds to first-order kinetics with low alcohol concentrations up to 0.2 g/l of blood. The decline in blood alcohol level depends on the concentration, as the enzymes are not saturated. With higher concentrations of 0.5–5 g/l, the substrate saturation of the enzyme means that the kinetics follow a zero order; in other words, the elimination rate is now concentration-independent or constant (Wagner et al. 1976; Mumenthaler et al. 2000; Jones 2010). The elimination rate is expressed in g alcohol per kg body weight (BW) and hour. Other parameters used for the description of the blood alcohol concentration course are maximum blood alcohol concentration, the time until the maximum concentration is reached and the area under the blood concentration curve (area under the curve = AUC). The parameters used to describe Michaelis-Menten kinetics are the maximum elimination rate (V_{\max} = saturation of the enzyme system, transition to zero order) and the Michaelis-Menten constant (K_m = concentration reached at half the maximum elimination rate) (Wagner

et al. 1976), while b_{60} describes the quantity of alcohol that can be removed from the body in 60 minutes.

Alcohol biotransformation via the monooxygenases CYP2E1 and ADH also follows Michaelis-Menten kinetics, and the K_m of CYP2E1 is greater than the K_m of ADH, which means that this catabolic pathway is dominant following one-time intake of large quantities of alcohol (e.g. 100 g alcohol per day) (Norberg et al. 2003; Jones 2010). In addition, this enzyme can be induced by repeated exposure to alcohol; in other words, the enzyme quantity increases. This means that alcohol is eliminated from the blood more rapidly in some alcoholics (Norberg et al. 2003; Rommelspacher 2011). Together with other changes (central nervous tolerance), this increased biotransformation (metabolic tolerance) leads to a situation where it is necessary to increase the dose of alcohol to achieve the alcohol-related effects (Gilg 2005).

3.1 Pharmacokinetics of alcohol in women

There are differences between men and women in the metabolism of alcohol (Thomasson 1995, 2000; Müller 2006; Jones 2010). The following only presents the pharmacokinetic data determined in women. In the study conducted by Ramchandani et al. (2001b), four healthy non-smoking women consumed a 95% ethanol solution on an empty stomach or after breakfast until the alcohol concentration in the exhalation air was 40 mg%. The average elimination rate for the women with an empty stomach was around 5 g per hour and 7 g per hour after breakfast. The composition of the breakfast (rich in protein, fat or carbohydrates) had no effect on the elimination rate (Ramchandani et al. 2001b).

In healthy non-pregnant women who had consumed an average dose of 0.67 g of ethanol per kg BW in four individual doses over a period of 90 minutes after eating a meal, Mumenthaler et al. (1999, 2000) found a distribution volume of 482 ± 102 ml/kg BW (1st half of menstrual cycle) and 465 ± 65 ml/kg KG (2nd half of menstrual cycle), which more or less corresponds to the total body water volume. A distribution volume of comparable magnitude, namely 592 ± 87 ml/kg BW, was found by Klockhoff et al. (2002), after 12 women with a body weight of approx. 75 kg had consumed a dose of 0.3 g of alcohol per kg BW on an empty stomach within five minutes. The beverage used was 95% alcohol mixed with orange juice to make a 12% alc/vol alcoholic drink (\approx intake of 220 ml of a 12% alc/vol table wine by a person weighing 70 kg).

Based on the pure body mass, it is possible to estimate an average body water content of 500 ml/kg BW (Hendriks 2005).

Table 2 provides an overview of kinetic parameters used in other studies, but the studies are not fully comparable due to different research methods, study groups and assessment approaches. In all four studies, the elimination constant for the reduction of the blood alcohol concentration was of the same order (0.1 to 0.2 g/kg BW and hour). In women ($n = 114$) who had drunk alcohol, Jones (2010) calculated an average alcohol elimination rate of 0.21 g/l and hour. The average time to maximum blood alcohol concentration with a full stomach varied between 34 minutes and 109 minutes with alcohol doses between 0.3 and 0.67 g/kg BW. Pepino et al. (2007) showed in the same study population that stomach filling in the form of breakfast increased the time until the maximum blood alcohol concentration was reached by 44% compared to alcohol consumption on an empty stomach. Maximum blood alcohol concentration was between 0.5 and 0.9 g/l. After consumption of 0.3 g of alcohol per kg BW, the time until total depletion to the range of the normal blood alcohol concentration caused by endogenous ethanol formation (DFG 1998) was approx. 3.8 hours (Klockhoff et al. 2002). The b_{60} values were estimated as 6 to 7 g of alcohol per hour. Conversion of this figure shows that the quantity of alcohol a woman can metabolise per hour is equivalent to 69 to 79 ml of 11% alc/vol sparkling wine or 150 to 174 ml of 5% alc/vol beer.

Tab. 2: Kinetic variables in non-breastfeeding women in dependence on exposure conditions

	Klockhoff et al. (2002)	Mumenthaler et al. (1999)	Pepino et al. (2007)	
Exposure				
Stomach filling	empty stomach	Breakfast	empty stomach	Breakfast
Dose of alcohol (g/kg BW)	0.3	0.67	0.4	0.4
Form of administration	1 alc. beverage (20% alc/vol alcohol-orange juice) within 5 minutes	4 sub-quantities of alc. beverage (20% alc/vol alcohol-soda) within 90 minutes	2 sub-quantities of alc. beverage (15% alc/vol alcohol-kiwi juice) within 5 minutes	2 sub-quantities of alc. beverage (15% alc/vol alcohol-kiwi juice) within 5 minutes
Collective				
N	12	24	15	15
Age (years)	40.3 ± 9.0	30.9 ± 5.1	not specified	not specified
Body weight (kg)	78.1 ± 10.0	66.3 ± 10.0	67.2 ± 3.2	67.2 ± 3.2
BMI (kg/m ²)	28.2 ± 3.8	24.0 ± 3.8	24.4 ± 0.9	24.4 ± 0.9
Number per week	not specified	not specified	9.5 ± 2.7	9.5 ± 2.7
Number of drinks per occasion	not specified	not specified	2.8 ± 0.7	2.8 ± 0.7
Parameters				
V _d (l/kg)	0.592 ± 0.097	0.482 ± 0.10	not specified	not specified
C _{max} (g/l)	0.58 ± 0.11	0.92 ± 0.15	0.84 ± 0.04	0.46 ± 0.03
t _{max} (h)	0.3–0.8	1.83 ± 0.10	0.58 ± 0.06	0.84 ± 0.08
AUC (g/l x h)	54.6 ± 10.2	2.91 ± 0.66	1.58 ± 0.07	0.86 ± 0.07
k (g/kg x h)	0.081 ± 0.013	0.11 ± 0.03	0.10 ± 0.01	0.10 ± 0.01
t (0) (min)	227 ± 9.8	not specified	not specified	not specified
b ₆₀ (g/h)	not specified	7.33 ± 1.79	6.38 ± 0.50	6.9 ± 0.58
V _{max} (g/h)	not specified	0.15 ± 0.10	not specified	not specified
K _m	not specified	0.11 ± 0.15	not specified	not specified

3.2 Pharmacokinetics of alcohol in breastfeeding women

In the mammary gland, ethanol passes from the mother's blood into the breast milk independently of pH. One parameter for the description of passive diffusion from the mother's plasma into the milk is the milk-plasma distribution coefficient. According to Anderson & Wolff (2000) this coefficient is in the order of 1 for ethanol; in other words, about the same alcohol concentrations in the milk are expected as are measured in the mother's plasma. In breastfeeding women, for example, blood alcohol concentrations between 80 and 90 mg/100 ml were measured (see figure 4; black squares modified according to Kesäniemi 1974) following an intake of a dose of 0.6 g of ethanol per kg BW (empty stomach, 15% alc/vol alcohol-water solution) within 30–60 minutes of alcohol consumption. Comparable alcohol levels were measured in the milk of these women (see figure 5). The highest alcohol concentrations in blood and milk were found if the test persons had not eaten anything (see figures 4, 5).

The lower values in figures 4 to 6 are from a study by Lawton (1985), who measured the alcohol contents in the blood and breast milk (mainly fore milk) of eight breastfeeding women with children aged between six weeks and 2¾ years over a period of up to 5.5 hours after the women had consumed alcohol in doses from 0.46 to 1.5 g/kg BW within 45–60 minutes after breakfast. These data also show a high correlation between the level of alcohol concentrations in the blood and in the breast milk. Moreover, inter-individual differences in internal loads are also clearly discernible, as in some cases the intake of different alcohol doses resulted in the same blood alcohol level. In three of the four breastfeeding women who had consumed larger quantities of alcohol, the alcohol concentration in the breast milk was approx. 22 to 29 % higher than in the mother's blood (Lawton 1985). If mothers are given

alcohol doses of 1.05 to 1.2 g/kg BW (i.e. 60 to 75 g of alcohol \approx 0.7 l of wine), increased blood and milk alcohol levels (50 mg of alcohol per 100 ml of fluids) are still detectable after 5–5½ hours (see test person 1 in fig. 6 and test person 2 in the publication by Lawton (1985, not shown here).

Large inter-individual variations were also found in a Chinese breast milk study. Slightly lower alcohol levels in the blood and breast milk (31 ± 10.3 mg/100 ml) than in other studies were determined with an alcohol dose in mothers of 0.3 g/kg BW. It was estimated that, with this dose, it took 175 minutes for the blood alcohol concentration to fall to the endogenous basal level (Chien et al. 2005).

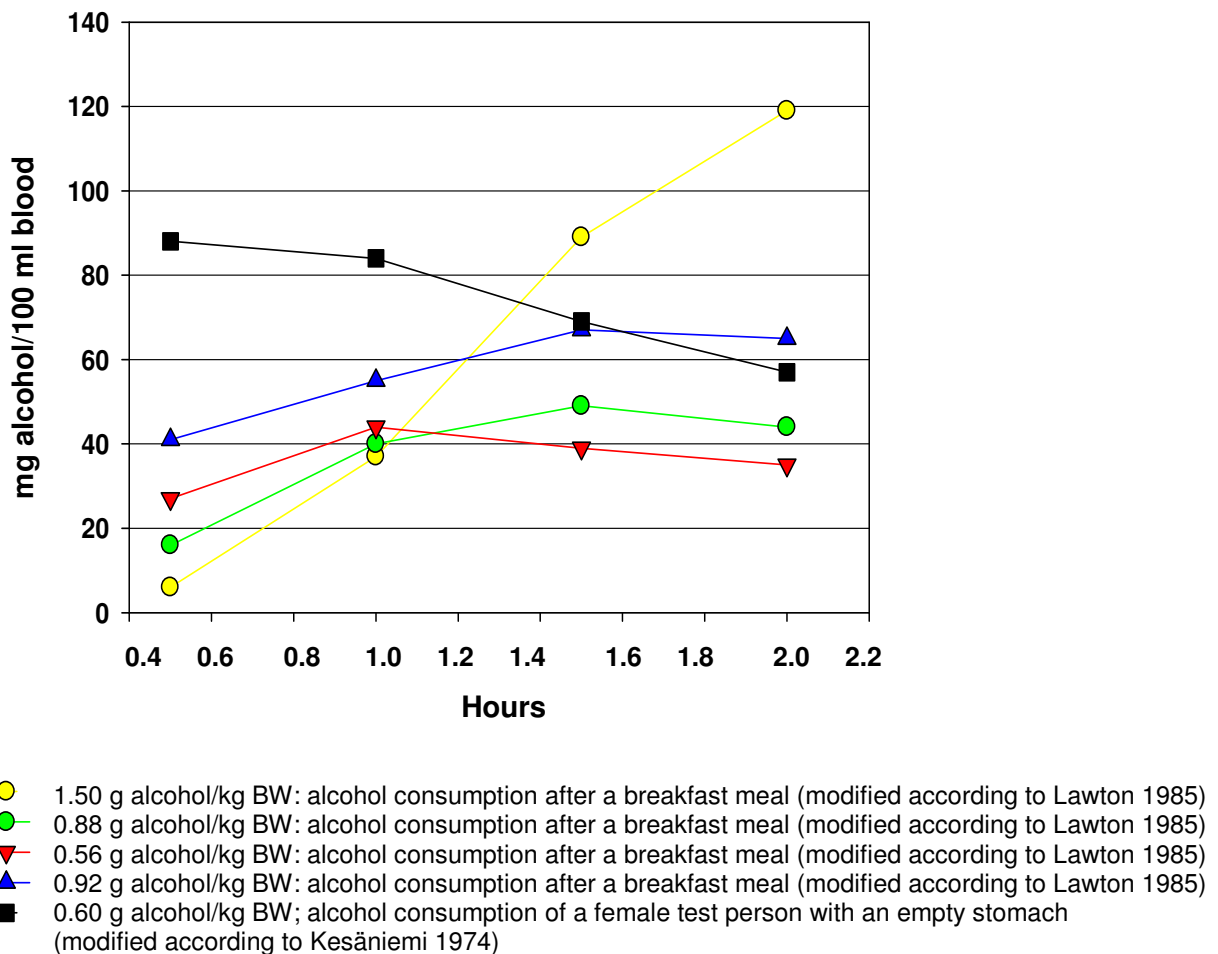
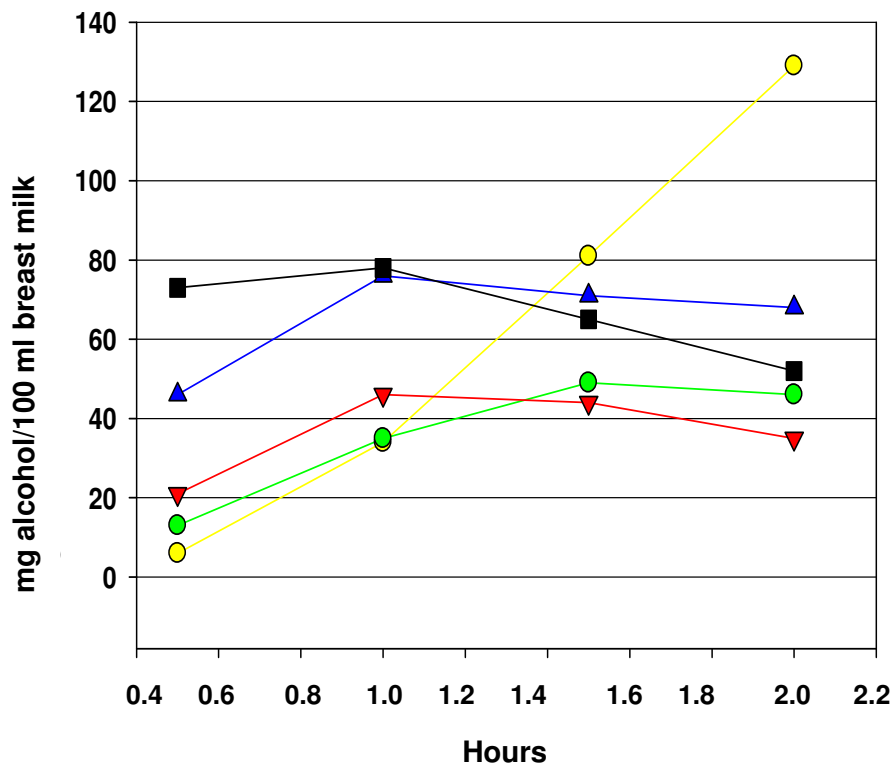


Fig. 4: Course of blood alcohol concentrations



- 1.50 g alcohol/kg BW: alcohol consumption after a breakfast meal (modified according to Lawton 1985)
- 0.88 g alcohol/kg BW: alcohol consumption after a breakfast meal (modified according to Lawton 1985)
- ▼ 0.56 g alcohol/kg BW: alcohol consumption after a breakfast meal (modified according to Lawton 1985)
- ▲ 0.92 g alcohol/kg BW: alcohol consumption after a breakfast meal (modified according to Lawton 1985)
- 0.60 g alcohol/kg BW; alcohol consumption of a female test person with an empty stomach (modified according to Kesäniemi 1974)

Fig. 5: Course of alcohol concentrations in breast milk

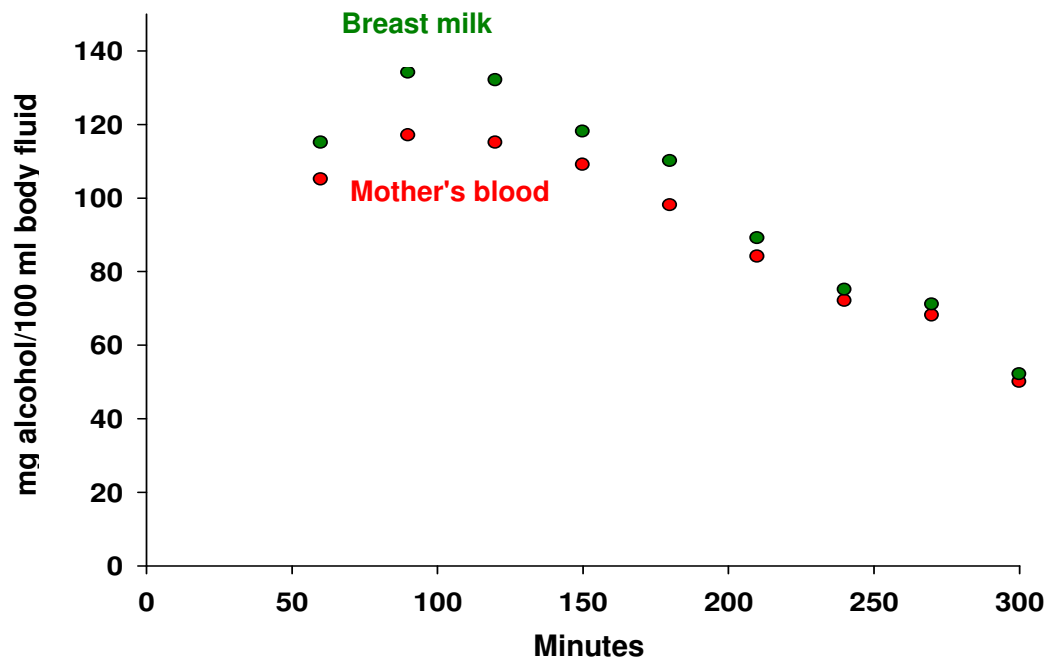


Fig. 6: Course of alcohol concentration in the blood and breast milk (beginning one hour after oral intake of 1.05 g of alcohol per kg body weight) (modified according to Lawton 1985)

Pepino et al. (2007) found that nursing mothers who had consumed alcohol on an empty stomach showed far higher blood alcohol concentrations than those who had eaten breakfast beforehand (blood alcohol concentration: empty stomach 0.69 ± 0.03 g/l; after breakfast 0.39 ± 0.03 g/l).

Comparison of blood alcohol concentration curves of breastfeeding and non-breastfeeding women and women who have never been pregnant (nulliparas) shows that the maximum blood alcohol concentration was reached by all groups at the same time. However, breastfeeding women had significantly lower blood alcohol concentration levels (area under the curve, AUC) than non-breastfeeding women. After alcohol consumption and breakfast, the maximum blood alcohol concentration and the AUC were statistically significantly lower in breastfeeding women than in non-breastfeeding women and nulliparas (see table 2 and table 3).

A study by da-Silva et al. (1993) found comparable maximum blood alcohol concentrations in breastfeeding women with the same alcohol dose but with different drinking behaviours. However, in this study it took longer for the breastfeeding women than for the women without children (nulliparas) to reach the maximum blood alcohol concentration. The b_{60} values averaged between 6.4 (empty stomach, nulliparas) (see table 2) and 9.14 g per hour (after breakfast with the non-breastfeeding women, table 3) (Pepino et al. 2007).

Tab. 3: Kinetic parameters of breastfeeding and non-breastfeeding women (non-fasting condition)

	Pepino et al. (2007)		da-Silva et al. (1993)	
	Breastfeeding	Not breastfeeding, after pregnancy	Breastfeeding	Nullipara
Exposure				
Dose of alcohol (g/kg BW)	0.4	0.4	0.4	0.4
Form of administration	2 sub-quantities of alc. beverage (15% alc/vol alcohol-kiwi juice) within 5 minutes	2 sub-quantities of alc. beverage (15% alc/vol alcohol-kiwi juice) within 5 minutes	1 ml vodka per kg consumed as rapidly as possible, followed by 80 ml of water	1 ml vodka per kg consumed as rapidly as possible, followed by 80 ml of water
Collective				
N	20	9	7	8
Age (years)	Not specified	Not specified	31.4 ± 7.7	29.9 ± 7.5
BW (kg)	65.0 ± 1.5	69.0 ± 4.9	58.0 ± 9.1	55.7 ± 9.1
BMI (kg/m ³)	24.1 ± 0.7	24.8 ± 1.8	23.1 ± 3.3	22.0 ± 2.9
Usual alcohol consumption				
Number per week	4.0 ± 1.5	4.0 ± 1.9	≤0.5	≤0.5
Number of drinks per session	2.5 ± 0.9	1.6 ± 0.6	≤2	≤2
Parameter				
C _{max} (g/l)	0.38 ± 0.03	0.50 ± 0.04	0.44 ± 0.11	0.51 ± 0.11
t _{max} (h)	0.93 ± 0.07	0.92 ± 0.10	0.8 ± 0.18	0.52 ± 0.27
AUC (g/l x h)	0.68 ± 0.06	0.90 ± 0.09	0.64 ± 0.20	0.85 ± 0.22
B ₆₀ (g/l x h)	0.18 ± 0.02	0.22 ± 0.02	Not specified	Not specified
b ₆₀ (g/h)	7.27 ± 0.70	9.14 ± 0.79	Not specified	Not specified

The average elimination rate in all three groups was around 0.1 g/kg BW and hour or around 0.2 g/l and hour. To explain the observed differences during lactation, Pepino et al. (2007) hypothesised that increased levels of regulatory proteins are released during the breastfeeding phase and that these proteins delay the passage of the alcohol from the stomach to the small intestine and liver, thereby increasing the first pass effect. The findings were confirmed in a further study by Pepino & Mennella (2008) among mothers who pumped off their milk.

Child alcohol doses of between roughly 0.3 and 6% of the mother's alcohol dose were estimated on the basis of the various studies. Following intake by the mother of 0.6 g of alcohol per kg BW, Kesäniemi (1974), for example, proposed alcohol intake by the baby through breast milk in the order of 36 mg/kg BW (≈ 6%). Mennella & Beauchamp (1991) calculated that 4 to 30-week-old babies of breastfeeding non-smokers consumed between 14 and 66 mg of alcohol or 1.6 to 9.9 mg/kg BW through breast milk (= 0.5 and 3.3% of the mother's alcohol dose) over around three hours after the mothers had drunk 0.3 g of alcohol per kg BW (15% alc/vol alcoholic orange juice drink) within 15 minutes.

According to the data collected by Chien et al. (2005), infants whose mothers practice a traditional Chinese ritual that includes the drinking of alcohol ingested between 3 and 59 mg or 0.9 to 17 mg/kg BW (≈ 0.3 to 6% of the mother's dose) with breast milk at an age of around two weeks.

According to Kesäniemi (1974), acetaldehyde is not detectable in breast milk following the consumption of alcohol by the mother and despite detectable acetaldehyde concentrations in the mother's blood. No studies are available on acetaldehyde in children's blood.

3.3 Pharmacokinetics of alcohol in infants

3.3.1 Literature data

The pharmacokinetics of alcohol in infants has not been examined sufficiently. Whereas total body water content in women amounts to roughly 60 % of body mass, it is approx. 90 % in newborns and roughly 80 % in 6-month-old babies (Ritschel 1986). This means that the distribution volume is greater in infants.

ADH activity is reduced in newborns and infants because the activity level of the enzyme that is normal in adults is only reached in early childhood (specifics: newborn 55 %, 1 week to 2nd month 10–27 %, 6th month to 1st year 32 %) (Pikkarainen & Rähkä 1967; Idänpää-Heikkilä et al. 1972; Ginsberg et al. 2004).

The biotransformation of alcohol via CYP2E1 and catalase in infants is also discussed in the literature (Tran et al. 2007; Kearns 1995). CYP2E1 activity is also lower in the first months of life and only reaches 20–45 % of the adult level (Ginsberg et al. 2004; Hines 2007). No data have been published on the metabolic competence of catalase in infancy. The enzyme activity of foetal liver is of the same magnitude as that of adults, however (Tran et al. 2007), which permits the assumption that catalase in infants is also of the same magnitude as in adults. No data have been published on ALDH activity in infancy.

An hourly ethanol breakdown in the blood of 0.15 ± 0.011 per mille after the intravenous administration of a fructose-ethanol infusion solution (100 g/l fructose, 50 g/l ethanol) was determined with ten infants aged up to 12 months by Schipphan et al. (1975); this included three children aged 1–10 days who had an hourly ethanol breakdown of 0.13 ± 0.003 per mille per day.

3.3.2 Physiologically based toxicokinetic modelling of alcohol concentrations (in line with Gundert-Remy et al. 2012)

The assessment of the risk for the breastfeeding child through the intake of alcohol by the mother depends on the internal dose of the child, i.e. the alcohol concentration in the child's blood. Although this dose cannot be established experimentally for ethical reasons, the possibility exists of using the method of physiologically based toxicokinetic modelling to simulate these concentrations. Physiologically based toxicokinetic modelling provides the option of combining existing physiological knowledge (body weight, organ weight, blood flow through organs) in different phases of life/age groups and different metabolising capacities on the one hand with knowledge of the substance (in this case alcohol) on the other in one model, before examining the behaviour of the substance in this model. The result of this is simulated concentrations in blood and tissue which are detected in the structure of the model. Whether or not the model produces correct predictions can be tested by comparing the simulated concentration time courses with existing experimental data on the behaviour of the substance in the human body. The advantage of a validated model of this kind lies in the fact that various scenarios (here drinking scenarios) and various doses (e.g. $\frac{1}{4}$ l wine or $\frac{1}{2}$ l beer) can be entered into the model and the resultant concentrations simulated in the tissues under examination (in this case blood, brain).

Simulations of alcohol concentration after the mother had ingested various alcoholic drinks were conducted with the help of a physiologically based toxicokinetic model consisting of a submodel for the mother and a submodel connected to the mother for the child.

Simulations were made of (1) the concentration time course in the blood and brain of the breastfeeding mother and a newborn that is only a few days old and a three-month-old infant after consumption of an alcoholic drink by the mother and (2) the alcohol concentration in the blood and brain of a newborn and three-month-old infant after the administration of an authorised herbal medicinal product for the treatment of flatulence (Carminativum Hetterich®; a phytotherapeutic agent containing 34 % alc/vol) in accordance with the dose instructions of the manufacturer. In addition to this, a modelling for the unborn child was conducted in utero. The result was intended to outline the difference between exposure of the child in utero and through breastfeeding. The methodical details and individual results can be found in Gundert-Remy et al. (2012) and are only presented here in their essential aspects:

The structure of the breastfeeding mother model consists of nine organs/tissues connected by arterial inflow and venous outflow; the circulatory system is closed by the heart and lung (figure 7). This model structure has already been used several times in earlier studies, the only difference being that a compartment for the breast tissue has now been added. The structure of the model for the infant is identical to the adult model, but there are only eight organs/tissues because no breast compartment is modelled for the infant (figure 7).

The models for the breastfeeding mother and the infant are connected with each other. Lactation is modelled out of the breast at the beginning and flows into a reservoir from which breastfeeding is simulated by means of intermittent run-off into the infant in the one model and alcohol intake in the other. A ratio of the alcohol concentrations in the blood and milk of 1:1 was used for calculation in compliance with the experimental data of Chien et al. (2005), da-Silva et al. (1993), Lawton (1985) and Kesäniemi (1974). The physiological parameters (organ weights, blood flows) were taken from the manual of the International Commission on Radiological Protection (2002) and have been previously described in detail (Abraham et al. 2005).

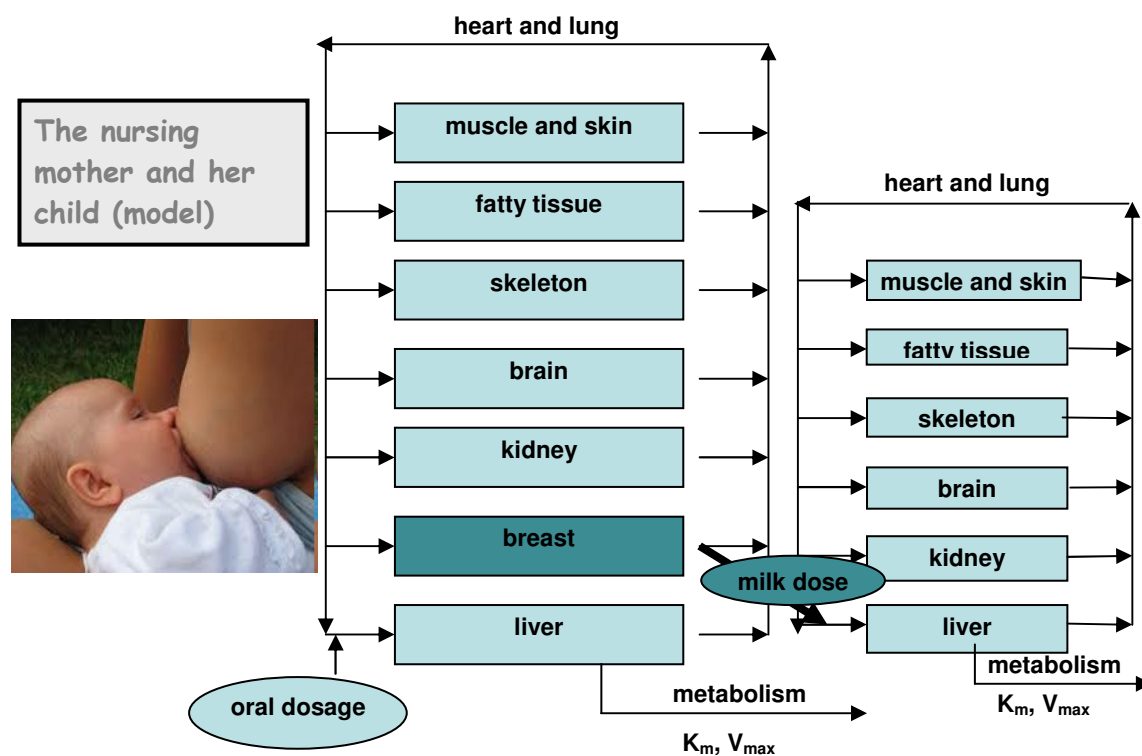


Fig. 7: Structure of the model for the nursing mother and infant

The excretion of alcohol was described as a metabolism in the liver using Michaelis-Menten kinetics, where V_{\max} represents the maximum turnover rate and K_m the concentration in venous blood at which the turnover rate is $\frac{1}{2} V_{\max}$. The age-specific values for V_{\max} were taken from the literature (Schipphan et al. 1975 for infants [newborn and three-month-old child]; Baraona et al. 2001 for adults); they take into account the lower activity of the alcohol dehydrogenase in the infant.

The entire empirical value for K_m und V_{\max} was put into the simulation. It would appear that essentially, only the class I-ADH plays the decisive role in metabolism in the liver, i.e. the empirical values describe this activity sufficiently correctly. Other alcohol-metabolising enzymes such as catalase were not taken into consideration either because they are of no quantitative significance or because, just like CYP2E1, a cytochrome-dependent monooxygenase, they only make up a significant part of metabolism at high alcohol concentrations which are not reached at the doses examined here (Pastino et al. 2000). The oral half-life was assumed to be 20 minutes in compliance with the maximum plasma concentrations in published data (Pepino et al. 2007). The metabolism of the alcohol in the stomach and small intestine as prehepatic elimination was not taken into consideration because the reduction of the dose through this process only accounts for 4.6 % to 13.7 % of the dose according to Jones (2010). The extent of absorption was set at 100 %. This procedure leads to a low overestimation of the quantity of alcohol which reaches the liver and consequently to a low overestimation of the alcohol concentration in the blood.

The structure of the expectant mother model also consists of nine organs/tissues, where the uterus, which as an overall organ also includes the placenta and foetus, is modelled as the ninth organ instead of the breast tissue (figure 8). Data on the uterus weight, including placenta and foetus (16th week of pregnancy), and blood flow were taken from the manual of the International Commission on Radiological Protection (2002).

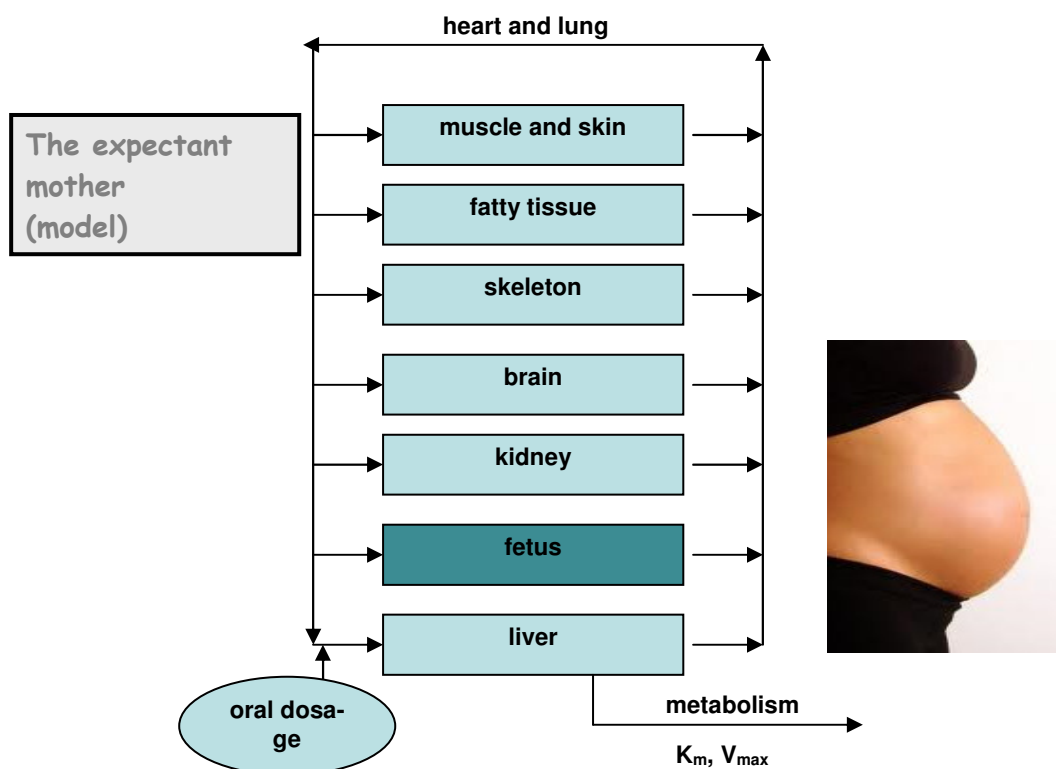


Fig. 8: Structure of the expectant mother model

A model was also made of an infant being administered an authorised herbal medicine for the treatment of flatulence (Carminativum Hetterich®). This medicine is administered directly to the infant. The doses used in the simulation are the same as those stipulated by the manufacturer (3 x 5 drops a day [newborn] and 3 x 10 drops a day [three months old]). In this case, it was assumed that the mother had not drunk any alcohol.

The following findings were recorded: after drinking a quarter of a litre of wine (12.5 % alc/vol) within 30 minutes, a maximum blood alcohol concentration of 0.63 g/l (equivalent to 0.59 per mille) was recorded in the breastfeeding mother roughly 40 minutes after commencement of drinking. If breastfeeding begins directly after the intake of alcohol, the maximum alcohol concentration in the newborn amounts to 0.003 g/kg BW (equivalent to 0.0028 per mille) after the first breast feeding and 0.0035 g/kg BW (equivalent to 0.0033 per mille) after the second feeding (breastfeeding every two hours). With the three-month-old infant (breastfeeding every three hours with a greater volume of milk), the maximum alcohol concentration after the second breast feeding was 0.004 g/kg BW (equivalent to 0.0038 per mille). Due to the significantly lower alcohol quantities compared to 0.25 l of wine, the consumption of 0.1 l of sparkling wine over a 30-minute period, 0.5 l of non-alcoholic beer (\leq 0.5 % alc/vol), juice (\leq 0.08 % alc/vol) or zero alcohol beer (0.01 % alc/vol) results in lower peak concentrations in the blood of the mother (table 4).

If the same alcohol quantities are ingested by a pregnant woman over the same period of time with the same concentration time course in the pregnant woman as in the nursing mother, the concentrations in the uterus/foetus are 100 times higher than in the breastfed infant (table 4). Due to these concentration differences, effects on the central nervous system caused by alcohol exposure during pregnancy which have been observed clinically and in experiments with animals cannot be transferred to the situation with breastfeeding.

The modelling and simulation process was validated by making comparisons with published experimental data. The simulated concentration-time profile with expectant and nursing mothers showed a high level of conformity with the corresponding studies conducted by da-Silva et al. (1993).

The administration of a herbal medicine in the dosage prescribed by the manufacturer results in a maximum alcohol concentration of 0.015 g/kg (0.014 per mille) in a newborn (3 x 5 drops) and 0.015 g/kg (0.014 per mille) in a three-month-old infant (3 x 10 drops) thereby reaching significantly higher blood and brain concentrations than through the intake of alcohol via breast milk.

Tab. 4: Alcohol concentration (peak concentration) in nursing mothers and breastfed infants and in utero by way of comparison. Total alcohol intake (in mg)

	Maximum Concentration (per mille)				Total Alcohol Intake (in mg)		
	Newborn	3-month-old infant	Nursing/expectant mother	Uterus/foetus	Newborn	3-month-old infant	Nursing/expectant mother
0% alcohol beer (0.5 l)	—*	—*	0.00005	—*	0.04	0.08	100
Juice (0.5 l)	—*	—*	0.0002	—*	0.18	0.32	400
Non-alcoholic beer (0.5 l)	0.0002	0.00014	0.0135	0.009	1.2	2.1	2500
Sparkling wine (0.1 l)	0.0008	0.0008	0.15	0.09	6.8	12.0	11000
Beer (0.5 l)	0.0023	0.0028	0.36	0.23	19.8	35.7	25000
Wine (0.25 l)	0.0034	0.0039	0.59	0.35	30.5	55.0	32500
Carminativum Hetterich®	0.014	0.0014	—	—	138	276	—

*Concentration less than 0.00015 per mille

4 Health Effects of Alcohol Consumption in the Nursing Period

4.1 Effects of alcohol on the composition, quantity and odour of breast milk

Influences of alcohol on the composition of milk, e.g. increased protein content, changes in the fatty acid composition and concentrations of micronutrients such as chloride and retinol (vitamin A), were determined in experiments with animals (Albuquerque et al. 1998; Heil et al. 1999; Azara et al. 2008). It has not yet been examined whether alcohol consumption also changes the nutrient composition of human breast milk. All that is known is that there is no change in the total fat content of the milk of nursing mothers after the consumption of alcohol (Mennella & Pepino 2008).

Regular consumption of alcoholic beverages such as beer during the nursing period used to be commonplace because alcohol was said to have properties which promote lactation (Backstrand et al. 2004; Koletzko & Lehner 2000; Mennella & Beauchamp 1993; Giglia & Binns 2007b). Alcoholic drinks were sometimes prescribed for relaxation in order to facilitate the triggering of the let-down reflex (Davidson et al. 1981).

There is agreement today from a scientific point of view that alcohol does not lead to an increase in milk quantity. As Mennella & Beauchamp (1993) and Mennella (1998, 2001) observed in studies with nursing mothers, where intake of alcohol was moderate (dose: 0.3 g of alcohol per kg BW either as alcohol in orange juice or as beer with 4.5 % alc/vol consumed within 15 minutes), a reduction of the milk volume by roughly 20 % can even be expected within the first four hours after alcohol consumption. It was also recognised that on average, infants drank significantly less milk when their mothers had drunk alcohol (Mennella & Beauchamp 1991, 1993). The differences in the quantities of milk drunk were not noticed by the mothers during breastfeeding (Mennella & Beauchamp 1993).

According to Mennella & Beauchamp (1993), the odour of breast milk is also changed by beer containing alcohol as well as – partially and to a lesser extent – non-alcoholic beer (< 0.5 % alc/vol). The strongest odour intensity occurred one hour after the consumption of beer with 4.5 % alc/vol with an alcohol concentration of 31.5 mg/100 ml milk. No alcohol was detected in breast milk after the consumption of non-alcoholic beer (< 0.5 % alc/vol).

4.2 Effect of alcohol on lactation hormones and milk let-down reflex

As Mennella et al. (2005) and Mennella & Pepino (2008, 2010a, b) showed, the hormonal interplay of oxytocin and prolactin is influenced even by one-time alcohol consumption.

Accordingly, after consumption of an alcoholic drink (dose: 0.4 g of alcohol per kg BW as orange juice containing 15 % alc/vol consumed within five minutes in each instance) and stimulation of the lactating breast by pumping off milk, a significant reduction of the oxytocin level and increase of the prolactin level in plasma was measured in exclusively breastfeeding, non-smoking mothers of two to four-month-old infants who had drunk a little alcohol during pregnancy but drank regularly during the nursing period (0.2 ± 0.1 and 1.5 ± 0.6 alcoholic drinks per month) (Mennella et al. 2005).

The effects of alcohol consumption on the prolactin level are not consistent, however, as the prolactin increase depends on when the milk is pumped off. If it was pumped off while the blood alcohol level was rising, prolactin levels were increased in the first minutes after pumping, whereas prolactin levels were lower once the maximum blood alcohol levels had been reached and milk was pumped off while the alcohol level was dropping (Mennella et al.

2008). In all cases, the prolactin level was lower three to four hours after the intake of alcohol irrespective of when the milk was pumped off.

In a study by Mennella and Pepino (2010a), after consumption of 0.4 g/kg BW of alcohol in orange juice or orange juice alone, and stimulation of the lactating breast by pumping off milk (35 minutes after the drink was consumed), a significantly lower and shorter prolactin increase was measured in women who were not themselves alcohol-dependent but had a positive family history of alcoholism than in women without a positive family history.

A delay of the milk let-down reflex is not associated with prolactin, however, but rather with a reduced oxytocin level in the first minutes of the pumping process (Mennella et al. 2008). A negative influence on the milk let-down reflex was also determined by Mennella (1998), Chien et al. (2009) and Cobo (1973) where the impairment was low after the consumption of up to 0.9 g of alcohol per kg BW and a partial to total blockage of the milk let-down reflex was observed with a consumption of 1 g of alcohol per kg BW and more. In the study by Cobo (1973), however, the alcohol was not drunk but administered intravenously and the milk let-down reflex was induced by sucking and not by pumping.

An impairment of the milk let-down reflex under the influence of alcohol is also known from experiments with animals (Subramanian 1999).

4.3 Effects on breastfeeding behaviour (initiation and duration of nursing)

According to data taken from the Bavarian nursing study, the occasional or regular consumption of one to three glasses as opposed to less alcohol per week had no influence on the nursing rate at the beginning (93 vs. 95 %). There was no negative influence on nursing motivation either and no significant overall influence on nursing duration (exclusive, full or partial breastfeeding) if up to three glasses of alcohol per week were consumed during the nursing period and other influencing factors on nursing behaviour were taken into account in the multivariate statistical analysis. According to Rebhan et al. (2009), alcohol consumption during pregnancy had no statistically significant influence either on whether at least full breastfeeding was still being practiced in the fourth month of the child's life.

With women who drank alcohol occasionally or regularly (at least one to three glasses per week), differences in nursing behaviour (less frequent breastfeeding, nursing intensity, and pattern, i.e. on demand versus scheduled feeding) and more frequent nursing problems (sore nipples, not enough milk) were observed in comparison to women who did not drink any alcohol, but the differences were not significant (Kohlhuber, pers. comm. 2011, results of the study on breastfeeding behaviour in Bavaria). In the first three months after giving birth, for example, the majority of mothers who occasionally or regularly consumed one to three glasses of alcohol per week ($n = 58$ mothers) stated that they had fed less frequently with time delay of one to six hours (range one to twelve hours). A statement on whether breastfeeding behaviour and the frequency of nursing problems are influenced by the quantity of alcohol consumed (one to three glasses or more per week) cannot be made on the basis of these study results, however, due to the small number of women with higher alcohol consumption.

In a Brazilian study, Chaves et al. (2007) established that mothers who consumed alcohol during the nursing period breastfed exclusively for shorter periods than mothers who did not drink any alcohol. How alcohol consumption was defined in this study is not shown in the publication.

In another study conducted in the USA, regular alcohol consumption of 12 g or one-time consumption of large quantities (roughly 60 g of alcohol) during pregnancy or after giving birth had no significant influence on breastfeeding behaviour (Little et al. 1989).

4.4 Effects of alcohol in (nursing) women

Schuetze et al. (2002) described changed reactions in the mother-child interaction, such as suboptimal latching on and irritability of the mother, after the intake of 0.3 g of alcohol per kg BW. Mennella et al. (2005) observed stronger sedation, inebriation and dysphoria (discontent) in nursing mothers who had consumed 0.4 g of alcohol per kg BW. Contrary to this, Pepino et al. (2007) established that nursing mothers were less susceptible to the sedating effect of alcohol after consuming 0.3 g/kg BW compared to women without children (nulliparas). The stimulating effects of alcohol were not reduced in nursing mothers. These observations could be connected with the mothers' sleep deficit. It is known from sleep research, for example, that sleep deprivation influences the strength of the effect of alcohol (Roehrs & Roth 2001).

4.5 Effects of alcohol on breastfed infants

4.5.1 Effects of alcohol on infants' sleep

Changes in the sleeping patterns of infants after alcohol intake via breast milk were established in two studies.

Mennella & Garcia-Gomez (2001) got non-smoking mothers who had consumed an average of 1.5 ± 0.7 alcoholic drinks per month during pregnancy and an average of 4.9 ± 2.1 during the nursing period to feed their three to five-month-old infants 100 ml of alcohol-free breast milk in the one instance and 100 ml of pumped off breast milk with 32 mg of alcohol in the other. The alcohol concentrations ingested by the infants ranged from 3.5 to 5.9 mg/kg BW and were comparable with the quantities that resulted after the mother had consumed 0.3 g/kg BW of alcohol prior to breastfeeding. After ingesting these quantities of alcohol, the children's sleeping time was shortened in the first 3.5 hours. The sleep deficit was compensated in the course of the next 17 hours, however, by longer and more frequent periods of sleep. The mothers themselves did not notice these changes in their children's sleeping patterns.

Schuetze et al. (2002) repeated the experiment with four to eleven-week-old infants. The women involved here ($n = 14$) consumed 0.3 g of alcohol per kg BW within 15 minutes as an alcoholic drink (vodka and tonic) while the alcohol concentrations in the breast milk fluctuated between 12 and 48 mg/100 ml. The authors observed that the infants had shorter quiet sleep phases after consuming the breast milk containing alcohol, that the waking and crying phases were extended and that they wakened with a start more frequently and were more irritable.

Whether the effect on the children's sleeping patterns are attributable to alcohol alone or also to the changed mother-child interaction cannot be assessed on the basis of the available data. It should be noted that intervention into the regulatory processes of infants' sleep should be viewed particularly critically where young infants are concerned, because the sleep-wake phases only develop into a stronger day-night rhythm in most infants from the second month of their lives when a longer sleep period during the night sets in (Rivkees 2003; Scher 2008). This means that compared to adults, who only show a change in their sleep architecture from 0.6 g of alcohol per kg BW (Hörmann & Riedel 2005; Hörmann et al.

2011), this impairment occurs in a very much lower dosage range (a few mg/kg BW) in infants.

4.5.2 Effects of alcohol on psychomotor development of infants

In an American study, the infant's intake of alcohol via breast milk (mainly exclusive breastfeeding over one to three months) was roughly estimated on the basis of the mother's drinking habits and associated with effects on motoric development in the first year of the child's life. With an intake by the mother of roughly 12 g of alcohol per day in the first three months of the child's life, no significantly negative effect on gross motoric skills were observed, but they were after the consumption of around 24 g of alcohol per day. The infants had been exposed before birth, however, because the mothers had drunk alcohol during pregnancy. In a further study by Little et al. (2002), no negative effects on functions such as hearing, speech, hand-eye coordination and psychomotor development were determined in children aged 18 months, most of whose mothers (95%) had consumed less than 20 g of alcohol per day but had occasionally drunk to excess.

In yet another observational study in Mexico, 32 children of mothers who had regularly drunk a traditional alcoholic Aloe Vera drink (pulque) while nursing, thus ingesting a dose of 5-58 g of alcohol per day, were examined. The children exposed to alcohol drank significantly less milk but did not weigh less or show any signs of delayed growth during the observation period which lasted up to the age of six months (Flores-Huerta et al. 1992). Contrary to this, in a study conducted in rural Mexico with 58 mother-child pairs and pulque consumption with an average alcohol intake by the mother of 114 g per week, delayed weight and height increase was established in children aged one to 57 months exposed via breast milk. At the end of the observation period, the children of the mothers whose alcohol intake was greater than 10 g per day showed signs of delayed growth irrespective of alcohol consumption during pregnancy (Backstrand et al. 2004).

5 International Recommendations on Alcohol Consumption while Nursing

The following table shows an overview of recommendations from other countries regarding alcohol consumption while breastfeeding. The recommendation in most countries is that nursing mothers should abstain from alcohol. The most that is tolerated is the occasional consumption of small quantities of alcohol.

Tab. 5: Overview of recommended action on the topic “Alcohol while Nursing” from all over the world

Country	Recommendations	Source
Austria	Nursing mothers should avoid alcoholic beverages to the greatest possible extent and dispense completely with drinks with high alcohol content.	Bundesministerium für Gesundheit (2009)
France	Occasionally, 1–2 glasses	Agence Nationale d'Accréditation et d'Évaluation en Santé (2002)
UK	Same recommendation for nursing as for expectant mothers: avoid alcohol, never drink more than 1–2 alcoholic drinks once or twice a week.	National Health Service (2006)
Switzerland	Avoid alcohol while breastfeeding as regular alcohol consumption or the consumption of larger quantities can impair psychomotor development.	Schweizerische Gesellschaft für Ernährung (2008)
Australia	Best to do without alcohol completely, which is safest. Under no circumstances should women drink alcohol in the first month of the child's life while breastfeeding is not yet well established. Thereafter less than 20 g of alcohol per day. No alcohol consumption immediately before breastfeeding. Nursing mothers who want to drink alcohol should pump off sufficient quantities of milk in advance.	Australian Government & National Health and Medical Research Council (2009) Australian Breastfeeding Association (2009)
Canada	Excessive or daily alcohol consumption is rejected. No damaging effects were observed in children after the occasional consumption of an alcoholic drink by the mother.	Public Health Agency of Canada (2005)
New Zealand	Alcohol should be avoided in the nursing period. If it is not possible to do without it completely, consumption should be reduced to an occasional one to two standard drinks (10–20 g alcohol). Excessive alcohol consumption should be avoided.	Ministry of Health New Zealand (2008)
USA (California; Sonoma County)	The occasional alcoholic drink on a special occasion is acceptable, but the child should not be breastfed for up to two hours thereafter.	American Academy of Pediatrics (2005) (http://www.aap.org/)
USA	No more than 0.5 g of alcohol per kg BW per day (\approx two glasses of wine with a woman weighing 60 kg, equivalent to 30 g of pure alcohol) should be drunk and the child should not be breastfed for up to two hours after consumption of an alcoholic drink.	American Academy of Pediatrics and the American College of Obstetricians and Gynecologists (2006)

6 Summary and Recommendations of the National Breastfeeding Committee at the BfR

The objective of this report was to compile and evaluate the scientific findings on the influence of alcohol consumption during the nursing period and derive recommendations on this basis.

In synopsis, it can be ascertained that no controlled studies are available on the long and short-term effects of alcohol consumption during the nursing period on the organism of the child, which means that the data situation is not sufficient to derive a dose-effect relationship.

On the basis of the available data, however, it can be determined that alcohol passes into breast milk and that the alcohol concentrations in the milk and blood of the nursing mother rise virtually in parallel with each other, reaching a maximum concentration after roughly 30 minutes. The decline in the alcohol concentration depends essentially on the quantity of alcohol ingested. When the blood alcohol level drops, the concentration in the breast milk drops too.

It can also be established that even small quantities of alcohol influence the release of hormones so that a tangible reduction in the quantity of milk can result after drinking alcohol. This in turn can be one of the reasons why nursing mothers who drink alcohol several times a week complain about breastfeeding problems (above all sore nipples, not enough milk and galactostasis) more often than those who do not drink any alcohol.

Exposure estimates on the basis of experimental tests and toxicokinetic modelling show that the alcohol concentration in the blood of breastfed infants after the mothers had consumed moderate quantities of alcohol (up to ¼ l of wine) is low, as only a part of the alcohol contained in the milk consumed by the infant passes into its blood.

Exposure to alcohol via breast milk can result in altered sleep patterns in infants, however, (shorter sleep phases, lighter sleep). Apart from this though, no reliable statements on how alcohol consumption by the mother during the nursing period affects the short and long-term health and development of the child can be made on the basis of the available scientific data.

National and international committees recommend that mothers abstain from alcohol completely or only drink it occasionally in small quantities during the nursing period. Under consideration of the positive aspects of breastfeeding for the mother and the child, the National Breastfeeding Committee at the BfR is making the following recommendation on alcohol consumption during the nursing period:

“Breastfeeding and alcohol consumption? – Preferably not!”

Recommendation of the National Breastfeeding Committee

Breastfeeding lowers the risk of diarrhoea, otitis media and overweight in the child's later life and can also have positive impact on the mother's health, because it can help the involution of the uterus after pregnancy and reduce the risk of breast and ovarian cancer. Many nursing mothers ask themselves whether they can risk having a glass of wine or champagne on a special occasion or whether it's better to do without it while they are breastfeeding.

Alcohol consumption during pregnancy has known disadvantages for the course of the pregnancy itself as well as the development and growth of the child. Less well known and investigated, on the other hand, are the health risks of alcohol consumption during the nursing period.

In the following paragraphs, the National Breastfeeding Committee would like to provide nursing mothers and their partners with information on the health effects of alcohol consumption in the nursing period, thereby giving them the basis to help them decide whether or not to consume alcoholic beverages.

1 For what length of time and in what quantities does alcohol pass into breast milk?

Nursing mothers should know that some of the alcohol they ingest in an alcoholic drink passes into their breast milk via the blood. The alcohol concentrations in the milk and blood rise virtually in parallel with each other, reaching a maximum concentration after roughly 30 minutes. When the blood alcohol level drops, the concentration in the breast milk drops too.

2 Influence of alcohol on lactation and breastfeeding problems

Even small quantities of alcohol influence the release of lactation hormones in the mother. This means that a tangible reduction in the quantity of milk can result after drinking alcohol. This in turn can be one of the reasons why nursing mothers who drink alcohol several times a week complain about breastfeeding problems (above all sore nipples, not enough milk and galactostasis) more often than those who do not drink any alcohol.

3 Influences on the child

Exposure to alcohol via breast milk can result in altered sleep patterns in infants (shorter sleep phases, lighter sleep). Apart from this, no reliable statements on how alcohol consumption by the mother during the nursing period affects the short and long-term health and development of the child can be made on the basis of the available scientific data.

Conclusion

It is safest for the health of the mother and child if no alcoholic drinks of any kind are consumed during the nursing period. This applies in particular to the period during which the baby is exclusively breastfed.

If, as an exception, you drink a glass of wine, champagne or the like during the nursing period, you should heed the following:

Breastfeed your child before you drink alcohol so that the time to the next breast feed is sufficiently long. If you notice that your baby does not have a steady breastfeeding rhythm, i.e. that it often drinks small quantities of milk in short intervals so that the next breast feeding cannot be anticipated, it is better to do without alcohol completely as a precaution.

Plan at least one to two hours between the consumption of an alcoholic drink and the next breast feeding to allow the alcohol in your blood and in the milk to degrade to the greatest possible extent.

If you are still exclusively breastfeeding, you should not take breaks of several hours between feeds because long breaks can cause breastfeeding problems under certain circumstances.

If you want to take your child into your own bed, you and your partner should not drink any alcohol beforehand. Alcohol diminishes your ability to react or may cause you to sleep more deeply so that you might not be able to respond properly to the child's signals.

Breast milk is important for your child, so don't stop breastfeeding, even if you take an occasional alcoholic drink!

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