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ALCOHOL CONSUMPTION DURING LACTATION: EFFECTS ON MOTHER AND CHILD

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Abstract

Although there is evidence of the adverse consequences of alcohol consumption during pregnancy, the effects of alcohol consumption during lactation have not been that widely established. Consequently, due to this lack of information about the effects of alcohol during lactation, mothers do not receive guidance about alcohol intake during this period and they are unaware of the risks that alcohol intake might have both on them and their developing infant. The aim of this review is to summarize the scientifically demonstrated adverse effects of alcohol consumption during lactation both on mother and child. In spite of the fact that the available data in this field is scarce and contradictory, there is evidence that alcohol intake during lactation is harmful for mothers' lactational performance and their infants' development and behaviour. Thus, more research is needed in order to clarify the effects of different doses of alcohol during lactation and to provide educational support for health professionals and mothers so as to ensure secure alcohol intake during this crucial period of infant development.

Key words: lactation, breastfeeding, maternal alcohol intake, alcohol's adverse effects.

1. Introduction

There is a wide variety of scientific literature regarding the effects of alcohol consumption during pregnancy and its repercussion on well documented Fetal Alcohol Spectrum Disorders' (FASD) development (May et al., 2014). Prenatal alcohol exposure has been related to alterations in the developing brain (Riley & McGee, 2005), leading to an ample assortment of neuropsychological (Mattson, Crocker & Nguyen, 2011), neurodevelopmental (Sampson et al., 1997), neurobehavioral (Mattson et al., 2013), neurocognitive (Kodituwakku, 2009) and medical (Williams, Smith & Committee on Substance Abuse, 2015) disturbances. Although only 40 years have passed since the first studies in this field were developed, there is general consensus that there is no known safe amount of alcohol to drink while pregnant (Green, 2007).

Yet, the effects of alcohol consumption during lactation have not been that widely researched (Haastrup, Pottegårt & Damkier, 2014). There is evidence that alcohol has harmful effects both on the mother and the child, but it still remains controversial and poorly consistent. Nonetheless, alcohol has been shown to alter women's lactational performance (Giglia & Binns, 2006), as well as disturbing infant's sleep (Mennella & Garcia-Gomez, 2001), development (Jansson, 2018) and contributing to infant's alcohol preference after exposure to its flavour (Breslow, Falk, Fein & Grummer-Strawn, 2007).

Breastfeeding has been accepted as the best and safest method so as to protect infant's development, health and growth (Giglia & Binns, 2006). Yet, only the 43% of lactating women worldwide have been found to continue exclusively breastfeeding their infants in the 6th month. Despite there are limited manners of monitoring breastfeeding mothers in Spain, a research developed in 2012 showed that the average of breastfeeding duration was 6 months. This same research indicated that the 28,5% of the mothers exclusively and the 46,9% partially were breastfeeding their children in the 6th month, which corresponds to global European prevalences (Aeped.es, 2016), being below the professional advice of exclusively breastfeeding until 6 months postpartum and partially breastfeeding until 2 years after birth (May et al., 2016).

In terms of mothers consuming alcohol during breastfeeding period, research has shown that most breastfeeding women drink low-to-moderate quantities of alcohol, less than three standard drinks per week (Wilson et al., 2017) (a standard drink in Spain corresponds to 10 ml of pure alcohol). A study carried out in South Africa (May et al., 2016) concluded that the 71% of the mothers consumed alcohol during breastfeeding, which was more common than in pregnancy, with 42% of prenatally abstinent mothers having reported to drink during lactation. Furthermore, another study indicated that breastfeeding and non-breastfeeding mothers were equitably likely to consume alcohol during lactation period, but differing in the quantity. Consequently, breastfeeding women consumed minor amounts of alcohol comparing to non-breastfeeding mothers (Breslow et al., 2007). Another research (Wilson et al., 2017) determined that the 61% of mothers consumed alcohol within 8 weeks of giving birth, rising to 70% at 12 months after birth. However, the 88.8% of these mothers were shown to consume within recommended limits. Nevertheless, maternal alcohol consumption during lactation does not necessarily imply infant's alcohol exposure, depending on the strategy that each mother has executed so as to protect their infant from alcohol vulnerability (Breslow et al., 2007). These strategies, such as not drinking alcohol during the first month, and after that, not drinking more than two standard drinks per day, avoiding alcohol intake immediately before breastfeeding or expressing milk before alcohol consumption, are known as avoidance practices (Giglia & Binns, 2006).

Although there are many restrictive instructions for pregnant women regarding alcohol consumption, there are no consistent recommendations for lactating women (Haastrup et al., 2014). Traditionally, alcohol was believed to be beneficial both for the mother and the breastfed child, and this idea seems to remain nowadays. Women in Mexico used to be encouraged to drink a low alcoholic beverage called *pulque*, both during pregnancy and lactation (Mennella, 1998). Moreover, Mennella & Garcia-Gomez (2001) indicated that the 35% of breastfeeding women were recommended to drink alcohol by their health professional with the aim of facilitating lactation and promoting infant's sleep. Even folklore has described that drinking small quantities of alcohol shortly before breastfeeding increases milk yield, promotes milk let-down and helps both mother and infant's relaxation (Mennella & Beauchamp, 1991). An Australian research determined that women were unaware of the risks that alcohol consumption during lactation could have on their developing infant, requiring more information to provide knowledge and guidance during this period (Giglia & Binns, 2007). Taking into account that there is no scientific evidence of the galactagogue quality of alcohol, the American Academy of Pediatrics recommends abstaining totally from alcohol consumption during breastfeeding, or at least accomplishing avoidance practices so as to protect the infant from alcohol exposure (Haastrup et al., 2014).

The primordial aim of this literature review is to assemble data from different studies so as to clarify the scientifically concluded harmful effects of alcohol in terms of the breastfeeding mother and the breastfed infant. For accomplishing this objective, this review is organized in two main sections. The first one is referred to the physiological basis of lactation and alcohol's effect on it, while the second section alludes to the benefits of breastfeeding on the developing child and the harmful effects due to alcohol exposure via breast milk.

2. Mother, lactation and alcohol consumption

2.1 Physiological basis of lactation

2.1.1 Lactogenesis

Breast, as not many other organs, experiences the largest part of its development after birth. In the beginning, it is solely characterized by a nipple (Neville & Morton, 2001), even though specialized glands that secrete breast milk are already present (Giglia & Binns, 2006). Nonetheless, it is not until puberty and the secretion of estrogens that the gland initiates a complex developmental process (Neville & Morton, 2001). Once these mammary glands are utterly matured, they get entirely functional during pregnancy (Giglia & Binns, 2006). Specifically, the secretion mechanisms' development phase begins in the mammary gland during the second half of pregnancy (Jones & Spencer, 2007). The development process of these mammary glands, as well as the initiation and preservation of milk secretion is regulated by endocrine control (Mennella, 2001). The whole lactogenesis process is divided in two stages: Lactogenesis Stage I and Stage II. The first stage makes reference to the beginning of secretory differentiation during pregnancy. However, these mammary glands endure inactive until the first to fourth day postpartum, giving rise to the second stage of lactogenesis, which starts with milk secretion (Giglia & Binns, 2006).

Lactogenesis is mainly regulated by the pituitary hormones oxytocin and prolactin (Haastrup et al., 2014). Prolactin levels increase during pregnancy so as to allow secretory mechanisms' development. Furthermore, placental progesterone levels increment as well, inhibiting prolactin, in order to compensate its effect by preventing mammary glands from initiating milk secretion during pregnancy. Thus, progesterone is considered as a lactogenic trigger (Neville & Morton, 2001), due to the fact that once the infant is born, progesterone levels decrease, permitting prolactin to take effect on the mammary tissue, initiating Lactogenesis Stage II (Giglia & Binns, 2006). Moreover, prolactin also plays a crucial role in galactopoiesis (maintenance of lactation) (Buhimschi, 2004). During each feeding session, prolactin is released from the anterior pituitary gland and permits mammary glands to produce milk (Giglia & Binns, 2006), which is regulated by infant's suckling intensity, so that the milk quantity is adequate to satiate infant's needs (Mennella, 2001). Oxytocin regulates lactogenesis transversely, by engaging milk ejection reflex and emptying of the breast. This removal of milk from the breast, itself, controls milk secretion, through a local inhibitory feedback control (autocrine control) over milk secretion. Thus, the completeness of removal of milk from the breast regulates the rate of milk secretion (Giglia & Binns, 2006).

2.1.2 Milk ejection reflex

Milk ejection reflex, also known as 'milk let down', is principally regulated by oxytocin (Giglia & Binns, 2006), by producing contractions of some cells located around the mammary gland that expel the milk from the alveoli into small ducts that lead to the nipple (Mennella, 2001). Oxytocin is released from the posterior pituitary gland to bloodstream in response to infant's suckling or another stimuli (such as baby crying) so as to ensure an efficient removal of milk from breast and to meet infant's needs (Giglia & Binns, 2006).

2.2 The effect of alcohol on breastfeeding

2.2.1 Maternal blood and milk alcohol concentration

Alcohol enters breast milk by passive diffusion nearly in the same concentration as in maternal blood, peaking after 30-60 minutes of alcohol intake (Haastrup et al., 2014) and decreasing linearly in the same proportion as in blood (Mennella, 2001) (approximately 15-20 mg/dL/h (Haastrup et al., 2014)). However, both the time for concentration peak and for concentration decrease are influenced by individual differences (Mennella, 2001), such as body weight, stomach content during alcohol intake, quantity of adipose tissue, and the rate and strength of alcohol intake (Giglia & Binns, 2006).

Alcohol's toxic metabolite, acetaldehyde, does not pass into the milk (Haastrup et al., 2014) and alcohol is not stored in breast milk. However, breast milk and blood alcohol levels remain equal (Mennella, 2001), due to the dynamic equilibrium between plasma and breast milk (Haastrup et al., 2014). Consequently, as long as maternal blood contains alcohol, milk will contain too (Mennella, 2001). Although the infant being exposed to a small proportion of the consumed alcohol, infant's capacity to detoxify alcohol during the first weeks has been shown to be half the rate of an adult (Ho, Collantes, Kapur, Moretti & Koren, 2001). These last authors created a nomogram determining the necessary time for alcohol elimination from breast milk depending on mother's body weight and number of standard drinks (Table 1).

2.2.2 Effects of alcohol on lactational performance

Alcohol has been found to have an inhibitory effect on lactational performance. A research developed by Mennella (1998) determined that lactational performance was reduced in 9,3% after 2 hours of consuming the alcoholic beverage (in a 0.3 g/kg dose), comparing to the non-alcoholic one. Another research by Mennella & Beauchamp (1991) concluded that breastfed infants consumed 20% less milk from 3 to 4 hours after maternal alcohol intake, which was associated with lower lactational performance. Moreover, alcohol has been shown to alter the duration of breastfeeding as well (Giglia & Binns, 2006). An Australian study (Giglia, Binns, Alfonso, Scott & Oddy, 2008) determined that women that self-reported consuming more than 2 standard drinks per day were twice likely to disrupt breastfeeding before 6 months. Furthermore, other Brazilian research (Chaves, Lamounier & Cesar, 2007) similarly concluded that alcohol intake during lactation was negatively correlated to both exclusive and partial breastfeeding duration.

Studies with lactating rats have shown that alcohol has an inhibitory effect on suckling-induced oxytocin release, leading to a reduced milk yield (Mennella, 2001). In a research that was developed in Colombia (Cobo, 1972), ethanol, in doses higher than 0.5 g/kg, was determined to dose-dependently reduce oxytocin release, leading to a decreased milk ejection reflex. Nonetheless, there were individual differences from 1.0 to 2.0 g/kg alcohol doses on oxytocin release, differing between partial or total milk ejection reflex block. This same study suggested that ethanol, in doses higher than 2.0 g/kg could totally inhibit suckling-induced oxytocin release. However, Fuchs (1969) determined that intermediate doses of ethanol (2.0-3.0 g/kg) partially reduced oxytocin levels. Although the dose for complete inhibition remains unclear, researchers have come to an agreement in terms of the inhibitory effect of alcohol on oxytocin release (Subramanian, 1999).

Mennella, Pepino & Teff (2005) found that moderate alcohol intake (0.4 g/kg dose of alcohol) was related to a reduced oxytocin release during the imminent hours after alcohol intake. In contrast, prolactin levels increased during this time period, which was related to milk ejection latency, but no connection was found in terms of the quantity of milk production. Another research (Heil & Subramanian, 2000) that was focused on chronic alcohol administration (8 days, with 1.0-2.0 g/kg alcohol doses) concluded that alcohol exposure inhibited suckling-induced prolactin release after 30 minutes of suckling. However, this study determined that alcohol's primary effect might be via oxytocin, which started being inhibited after 1 day of alcohol intake. In addition, Mennella & Pepino (2008) concluded that alcohol's (0.4 g/kg dose) effect on suckling-induced prolactin release is biphasic in nature. If breast stimulation (suckling) happened during the period that alcohol concentration in blood was increasing, it produced higher prolactin levels. However, if breast stimulation occurred during the decrease of blood alcohol concentration, prolactin levels reduced as well (Table 2).

There are many hypotheses regarding alcohol's effect on lactation, including the hypothalamic, pituitary and mammary gland levels (Heil & Subramanian, 2000). Mammary glands-wise, alcohol might inhibit milk secretion by its direct effect on the contractility of myoepithelial cells of the mammary glands (Subramanian, 1999). Furthermore, alcohol might affect the posterior pituitary directly, disrupting oxytocin and prolactin release (Giglia & Binns, 2006). Moreover, taking into account the inhibitory control of the hypothalamus on prolactin and the excitatory control on oxytocin (Mennella et al., 2005), it has been hypothesized that alcohol could affect the central nervous system through a general depression of central activity or by inhibition of synaptic transmission of afferent impulses to the hypothalamus (Subramanian, 1999), leading to reduced oxytocin release and increased prolactin release. Lastly, ethanol neurotoxicity, which promotes dehydration and hyperosmolarity owing to supraoptic hypothalamic nucleus deterioration, might also lead to reduced milk production (Oyama, Couto, Dâmaso & do Nascimento, 2000).

3. Breastfed infant and effects of alcohol exposure

3.1 Benefits of breastfeeding on the child

Breastfeeding is acknowledged as the best method of infant nutrition (Clark & Bungum, 2003) and exclusive breastfeeding is recognized as the norm which all other forms of breastfeeding should be compared to (Salone, Vann Jr & Dee, 2013). This is related to the short- and long-term benefits of breastfeeding (Allen & Hector, 2005), including developmental, economic, health, nutritional, immunological and psychological profits (Salone et al., 2013).

Breastfeeding is beneficial for short-term infectious diseases such as acute otitis media, gastrointestinal illnesses and respiratory tract infections (Allen & Hector, 2005), due to its antimicrobial and immunological properties in breast milk (Gertosio, Meazza, Pagani & Bozzola, 2016). Lactating women face infectious agents by immunoglobulin production, which is passed to the infant through breast milk, providing protection against infectious diseases and stimulating the immune system (Clark & Bungum, 2003). Breastfeeding is also protective in serious infections and diseases, such as respiratory syncytial virus bronchiolitis, necrotizing enterocolitis, leukemia and sudden infant death syndrome (Salone et al., 2013). In addition, longer duration of breastfeeding is beneficial for chronic conditions such as asthma, obesity, type 1 and 2 diabetes mellitus, ischemic heart disease, atherosclerosis (Gertosio et al., 2016) and for preventing oral malocclusions (Salone et al., 2013).

Breastfeeding has been demonstrated to be beneficial for the mother as well. Hormonal changes related to breastfeeding support recovery and protect fertility postpartum, depending on the intensity, frequency and duration of breastfeeding (Allen & Hector, 2005). Furthermore, breastfeeding is beneficial for both breast and ovarian cancer (Gertosio et al., 2016), as well as having a protective effect on rheumatoid arthritis (Allen & Hector, 2005).

Regarding the psychological benefits of breastfeeding, it is advantageous for both mother and child, due to the fact that the mother is highly involved in nursing the child, providing a sense of belonging and achievement. Thus, the infant develops a warm and pleasant physical connection with the mother. In addition, breastfeeding has been shown to be positively correlated to mental and psychomotor development and IQ levels, as well.

Moreover, head circumference, which is related to cognitive development, physical growth and school achievement, was found to be smaller for mixed-fed and formula-fed infants at six months, comparing to those that were breastfed (Salone et al., 2013). Whitehouse, Robinson, Li & Oddy (2010) concluded that language development of infants that were breastfed for more than 6 months was significantly higher comparing to those that were not breastfed. Goldman, Hopkinson & Rassin (2007) summarized all the health outcomes of breastfed infants in the categories that can be found in Table 3.

3.2 Effects of maternal alcohol consumption during lactation on the breastfed child.

3.2.1 Developmental abnormalities

Ethical reasons-wise, there are not many experimental studies about the effects of alcohol on infant's development. Nevertheless, observational research has provided important information regarding infant's developmental effects of small amounts of maternal alcohol intake (Giglia & Binns, 2006). Gibson & Porter (2018) determined that maternal alcohol consumption was associated with reduced abstract reasoning ability at 6 to 7 years after birth, in a dose-dependent manner. In addition, May et al. (2016) determined that maternal alcohol intake during breastfeeding was related to lower weight and IQ average levels at seven years. Nevertheless, Wilson et al., (2017) concluded that alcohol intake during lactation period was not related to adverse social, motor and cognitive developmental outcomes for the offspring either at 8 weeks or 12 months postpartum. However, there was a high proportion of women who drank at low levels, leading to difficulties to conclude the potential adverse effects of higher levels of alcohol consumption on infant's development.

In addition, a correlation between maternal alcohol intake during breastfeeding and infant's decreased psychomotor development at one year postpartum was found, in a dose-dependent manner (Little, Anderson, Ervin, Worthington-Roberts & Clarren, 1989). However, alcohol exposure was not related to lowered mental development, which was also measured. Another research (Little, Northstone, Goldin & ALSPAC Study Team, 2002) with the aim of measuring infant's psychomotor development at 18 months postpartum could not replicate the results of the previous study. In contrary, maternal alcohol consumption was weakly but positively correlated to various facets of development. Another study compared the infants of mothers that daily consumed 1-2 litres of pulque during lactation with the infants of mothers that did not daily consume. They concluded that there were no significant differences in the rate of growth in children at 6 months of age (Flores-Huerta, Hernández-Montes, Argote & Villalpando, 1992). However, a similar study demonstrated that children of mothers with the highest levels of daily pulque intake during lactation were related to slower weight and linear growth from 1 to 57 months, as well as smaller attained size at 57 months (Backstrand, Goodman, Allen & Pelto, 2004).

Animal studies have shown long-term effects of alcohol intake on infant's development, body weight and metabolism. Pups whose dams consumed ethanol during postnatal period were associated with retarded physical growth, lower average litter, liver and brain weight, later opening of their eyes and alterations in the metabolic homeostasis (Giglia & Binns, 2006).

Researchers have suggested a wide variety of hypotheses regarding the effects of alcohol through breast milk, although there is no general consensus yet. For instance, some of them have proposed that the developing brain is remarkably sensitive even to small amounts of alcohol. Others have suggested that alcohol is concentrated in the infant due to slower excretion than adults. Lastly, other suggestions are related to infant's lower capacity to metabolize alcohol (Mennella, 2001). However, these developmental alterations could also be associated with environmental or genetic factors, which are highly difficult to measure, such as insensitive maternal care as a consequence of alcohol intake, or even maternal age. Furthermore, a mother who uses alcohol during lactation could have an alcohol use disorder, which could lead to problems of self-regulation, impulsivity and the ability to make correct elections for herself or her child. Mothers with substance use disorders are more likely to have associated cognitive or psychiatric comorbidities or to be exposed to violent environments, producing both physical and developmental alterations (Jansson, 2018).

3.2.2 Preference to alcohol after having tasted alcohol flavour in breast milk

Infants, from the first hour of life, are capable of identifying and distinguishing between a vast assortment of qualitatively different odours and flavours, which is one of the first postnatal sensory experiences of the newborn (Mennella & Beauchamp, 1998). Prenatal and neonatal exposure to different flavours has been found to modify infant's responsiveness to that flavour during the following breastfeeding sessions (Mennella & Beauchamp, 1996).

Alcohol alters the odour of the milk, peaking after 30 minutes to 1 hour after having consumed (Mennella & Beauchamp, 1991). Preferences and aversions have been proposed to be learnt during developmental process. Furthermore, it has been shown that sensory experiences of ethanol during breastfeeding period in rats takes effect on voluntary alcohol consumption in the adult age (Mennella & Beauchamp, 1998). Thus, being exposed to alcohol during breastfeeding increments the possibility that the pup will consume similarly flavoured foods (Mennella & Beauchamp, 1996). Phillips & Stainbrook (1976) determined that previous exposure to wine during breastfeeding increased the daily fluid intake in rats during taste preference testing. Other animal model studies concluded that pups that were exposed to alcohol through breast milk had more mouthing reactions in response to alcohol's odour and they were more likely to consume alcohol-based solutions (Mennella & Beauchamp, 1998).

Regarding human studies, Mennella and Beauchamp (1998) demonstrated that infants aged from 6 to 13 months, who were previously exposed to alcohol through breast milk, responded differently to ethanol scented-toys, observing increased levels of ethanol-scented toys' mouthing. These same authors, in another study (Mennella & Beauchamp, 1991), concluded that infants suckling activity increased during the first minutes when their mother had consumed an alcoholic beverage. Mennella (1997) developed a research outside the context of breastfeeding, concluding that infants' alcohol-flavoured milk consumption was significantly higher comparing to the plain breast milk consumption, suggesting that infants are capable of identifying this flavour after being exposed to it. Thus, prior experience with alcohol affects consequent responsiveness, which is consistent with responses to other flavours such as vanilla in maternal breast milk (Mennella & Beauchamp, 1996).

Some hypotheses can be found about the underlying reason of this preference to alcohol after being exposed to it through breast milk. The first hypotheses are related to the flavour itself, which propose that, in low levels, alcohol is perceived as a sweet taste, increasing milk's sweetness intensity at mixing with it. Furthermore, it has been suggested that infants are responding to a new flavour, but this hypothesis seems improbable due to the long-term effects on flavour preferences. Finally, it is possible that infants prefer alcohol-flavoured milk due to associations and prior experiences that make this flavour attractive (Mennella, 1997).

3.2.3 Behavioral disturbances

Alcohol exposure through breast milk directly affects infant's behaviour, including sleep patterns, behavioural regulation and mother-infant interactions (Giglia & Binns, 2006). Regarding sleep patterns, Mennella & Gerrish (1998) concluded that acute alcohol exposure produced an alteration in infants' sleep patterns, disposing infants to sleep faster, but sleeping for shorter periods of time in the 3.5 hours after alcohol exposure, comparing to those that were not exposed to alcohol. This was referable to less active sleeping amount of time. Another research that was developed by Mennella & Garcia-Gomez (2001) replicated that exposure to alcohol through breast milk altered sleep patterns, but they concluded that alterations were related to the last half of the 3.5 hours testing session. Furthermore, they determined that infants were less active during wakefulness in the next hours of alcohol exposure and that infants compensated this lack of active sleep 20.5 hours after being exposed to alcohol in breast milk. Thus, infants' sleep patterns were altered during the 24 hours after alcohol exposure. Schuetze, Eiden & Chan (2002) demonstrated that small quantities of alcohol were capable of affecting infant arousal, leading to less amount of time in quiet sleep and more time in an alert state. In addition, infants also manifested higher levels of startles, abrupt motor discharges that usually occur during sleeping period.

There are many hypotheses in terms of these changes on infants' sleeping patterns. These changes might be associated with the flavour of breast milk. However, Mennella & Gerrish (1998) repeated the study with a non-alcoholic vanilla-flavoured beverage, which has similar hedonic and flavour characteristics as small concentrations of alcohol. They concluded that the time of active sleep did not differ in the 3.5 hours after exposure to this flavour. Another hypothesis is related to changes on mother-infant interactions, but it seems improbable due to the fact that these environmental and psychological factors were controlled in both the first two studies mentioned above, by maintaining the same time and location for each testing procedure, as well as mothers not being acknowledged about the testing order (Mennella & Garcia-Gomez, 2001).

Another research by Mennella (2001) determined that milk intake was reduced in the next period after alcohol exposure through breast milk, but it was not related to infants feeding less, due to similar amount of breastfeeds comparing to the ones that drunk plain breast milk. However, infants compensated this reduction, once mothers stopped from drinking alcohol, during the 8 to 12 hours after alcohol exposure.

Schuetze et al. (2002) demonstrated behavioural states' stability alterations after acute postnatal exposure to alcohol (0.3 g/kg dose of alcohol), with a larger number of behavioural state changes, more time in a crying state and longer periods of fussiness. These results propose that small amounts of alcohol are not associated with sedative effect, which has been extensively believed. Furthermore, this study also demonstrated that alcohol exposure immediately before breastfeeding affected mother-infant interactions negatively. Mothers exhibited increased levels of non contingency (improper positioning, intrusiveness and missing infant's behaviours) and dyadic conflict (critical and negative comments to the infant, angry and distressed appearance, and infant's food refusal, crying and angry behaviour), comparing to their behaviour without having consumed alcohol. If these behaviours became usual, it could difficult breastfeeding over time and endanger infant growth (Table 4).

4. Conclusions

Although alcohol has traditionally been believed to be beneficial for breastfeeding, there is no sufficient scientific evidence supporting this idea. In the contrary, as it has been analysed through this review, alcohol has adverse effects on the mother's lactational performance, on infant's development, growth, sleeping and feeding behaviours, on mother-infant interactions and also on infant's alcohol preference after having been exposed to ethanol's odour and flavour.

However, although scientific data is available, this topic still remains controversial and inconsistent, leading to a devoid of information in terms of recommendations to provide mothers that are breastfeeding their infants. As a consequence, mothers that breastfeed their infants do not have clear guidance in terms of the protocols that they should follow in order to protect their infant from alcohol exposure. Not only are they unaware of the risks of alcohol, but they also tend to think that alcohol is beneficial due to the myths about its galactagogue quality. Thus, taking into account all these myths of alcohol consumption and breastfeeding benefits, interventions and educational support are crucial in order to promote secure alcohol intake.

Moreover, the majority of human studies are done using observational procedures with mothers that have low levels of alcohol intake, which hinders the process to conclude the adverse effects of higher levels of alcohol consumption. Thus, it should be mentioned that more research in this area is needed in order to rise an agreement about the harmful effects of alcohol during lactational period, both on mother's lactational performance and different areas of the infant.

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6. Appendix

Table 1
Time (hour:minute) for reaching the zero level of alcohol in breast milk , depending on body weight and standard drinks quantity

	Drinks											
Maternal weight (Kg)	1	2	3	4	5	6	7	8	9	10	11	12
40.8	2:50	5:40	8:30	11:20	14:10	17:00	19:51	22:41				
45.4	2:42	5:25	8:08	10:51	13:34	16:17	19:00	21:43				
49.9	2:36	5:12	7:49	10:25	13:01	15:38	18:14	20:50	23:27			
54.4	2:30	5:00	7:30	10:00	12:31	15:01	17:31	20:01	22:32			
59.0	2:24	4:49	7:13	9:38	12:03	14:27	16:52	19:16	21:41			
65.8	2:16	4:33	6:50	9:07	11:24	13:41	15:58	18:15	20:32	22:49		
70.3	2:12	4:24	6:36	8:48	11:01	13:13	15:25	17:37	19:49	22:02		
74.8	2:07	4:15	6:23	8:31	10:39	12:47	14:54	17:02	19:10	21:18	23:26	
79.3	2:03	4:07	6:11	8:14	10:18	12:22	14:26	16:29	18:33	20:37	22:40	
86.2	1:58	3:56	5:54	7:52	9:50	11:48	13:46	15:44	17:42	19:40	21:38	23:36
90.7	1:54	3:49	5:43	7:38	9:32	11:27	13:21	15:16	17:10	19:05	20:59	22:54
95.3	1:51	3:42	5:33	7:24	9:16	11:07	12:58	14:49	16:41	18:32	20:23	22:14

Adapted from Ho et al. (2001)

Table 2

Evidence table of key articles regarding the effects of alcohol on lactational performance

Reference	Key findings
Mennella (1998)	Lactational performance was reduced in 9,3% after 2 hours of consuming the alcoholic beverage (0.3 g/kg), comparing to the non-alcoholic one.
Mennella & Beauchamp (1991)	Breastfed infants consumed 20% less milk after 3-4 hours of maternal alcohol intake. This decrease was related to lowered lactational performance.
Giglia & Binns (2007)	Women that self-reported a higher consumption that 2 standard drinks per day were twice likely to disrupt breastfeeding before 6 months.
Chaves et al. (2007)	Alcohol intake during lactation was negatively correlated to both exclusive and partial breastfeeding duration.
Cobo (1972)	Ethanol, in doses higher than 0.5 g/kg was determined to dose-dependently reduce oxytocin release. There were measurable individual differences (total or partial block) in doses between 1,0 to 2,0 g/kg. Ethanol, in doses higher than 2 g/kg was suggested to totally inhibit suckling induced oxytocin release.
Fuchs (1969)	Alcohol (in doses between 2.0 and 3.0 g/kg) partially inhibited oxytocin release.
Subramanian (1999)	Alcohol (above 1 g/kg dose) inhibited suckling-induced oxytocin release in lactating rats.
Mennella et al. (2005)	Moderate alcohol intake (0.4 g/kg dose) was related to a reduced oxytocin release the imminent hours after alcohol intake (reduced milk yield and milk ejection). In contrast, prolactin levels increased (related to milk ejection latency, but no correlation was found related to milk production).
Heil & Subramanian (2000)	Chronic alcohol administration (in doses from 1.0 to 2.0 g/kg) during eight days inhibited suckling-induced prolactin release after 30 minutes of suckling. However, alcohol's primary effect was determined to be through oxytocin, which was inhibited after 1 day of alcohol intake.
Mennella & Pepino (2008)	Alcohol's effect (0.4 g/kg dose) on suckling-induced prolactin is biphasic in nature: ● If breast stimulation occurred during the period that blood alcohol concentration was increasing, prolactin release increased as well. ● If breast stimulation occurred during the period that blood alcohol concentration was decreasing, prolactin release decreased as well.

Table 3

Superior health outcomes in breastfed infants

Protection during breastfeeding	Protection after weaning in early childhood	Protection later in childhood
Gastrointestinal and respiratory infections Urinary infections Sepsis and meningitis Atopic dermatitis Food allergies Wheezing Necrotizing enterocolitis Celiac disease Growth faltering Visual acuity	Gastrointestinal and respiratory infections Wheezing Celiac disease Growth faltering Cognition Visual acuity	Obesity Types I and II diabetes mellitus Leukemia/lymphomas Crohn disease Cognition

Adapted from Goldman et al. (2007)

Table 4

Evidence table of key articles regarding the effects of alcohol on the breastfed infant

Reference	Key findings
Effects on infant's development	
Gibson & Porter (2018)	Maternal alcohol consumption was associated with later negative effects on infant's development at abstract reasoning ability at 6 to 7 years after birth, in a dose-dependent manner.
Wilson et al. (2017)	Alcohol intake during lactational period was not related to adverse social, motor and cognitive developmental outcomes for the offspring from 8 weeks to 12 months after birth.
May et al. (2016)	Infant's postnatal alcohol exposure was correlated to lower weight and average IQ levels at 7 years postpartum.
Little et al. (1989)	Maternal alcohol intake during breastfeeding was associated with infant's decreased psychomotor development at 1 year postpartum, in a dose-dependent manner.
Little et al. (2002)	Maternal alcohol intake during breastfeeding was weekly but positively related to various facets of development at 18 months postpartum.
Flores-Huerta et al. (1992)	There was no significant difference in the rate of growth in children at 6 months of age between infants of mothers that daily consumed 1 to 2 litres of pulque and those that did not daily consume.
Backstrand et al. (2004)	Children of mothers with the highest levels of daily pulque intake during lactation were related to slower weight and linear growth from 1 to 57 months, as well as smaller attained size at 57 months.
Effects on infant's alcohol preference after previous exposure to alcohol	
Phillips & Stainbrook (1976)	Previous exposure to wine during breastfeeding increased the daily fluid intake in rats during taste preference testing.
Mennella & Beauchamp (1998)	Infants, aged from 6 to 13 months, that were highly exposed to alcohol were more likely to change their behaviour while interacting with ethanol-scented toys, observing a differential response in increased levels of ethanol-scented toys' mouthing.
Mennella & Beauchamp (1991)	Infant's suckling activity increased during the first minutes when their mothers had consumed an alcoholic beverage. Alcohol altered the intensity of odour of the milk, peaking after 30 minutes to 1 hour after alcohol intake.
Mennella (1997)	Prior experience with alcohol affects consequent responsiveness. In this research infant's alcohol-flavoured milk consumption was significantly higher outside the breastfeeding context.
Effects on infant's behavior	
Mennella & Gerrish (1998)	Acute alcohol exposure produced an alteration in infant's sleep patterns, leading to faster sleeping but in shorter period of time during the next 3.5 hours after alcohol exposure, which was referable to less active sleeping amount of time.
Mennella & Garcia-Gomez (2001)	Acute alcohol exposure altered infant's sleep as in the previous research but in the second half of the 3.5h testing session. Infants were less active during wakefulness and they compensated that lack of active sleep 20.5 hours after being exposed to alcohol in breast milk.
Schuetze et al. (2002)	Small quantities of alcohol were capable of altering infant arousal, leading to less amount of time in quiet sleep, more time in alert state and higher levels of startles. Postnatal exposure to alcohol altered the stability of behavioural states, leading to more frequent changes of behavioral state, more time in a crying state, longer periods of fussiness and negative mother-infant interactions (higher levels of non contingency and dyadic conflict).
Mennella (2001)	Infants compensated the lower level of milk intake during the first hours of alcohol exposure after 8 to 12 hours.